Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

A single copy of this document is licensed to

smu

On

27/11/2020

This is an uncontrolled copy. Ensure use of the most current version of the document by searching the Construction Information Service.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

30 Offices

Frank Duffy with Jack Pringle, Angela Mullarkey and Richard Finnemore of Pringle Brandon Perkins+Will

CI/SfB: 32

Frank Duffy was a founder of DEGW, a leading workplace design practice.
Pringle Brandon Perkins+Will is a global design firm with a specialism in corporate interiors

KEY POINTS:

- *Rapidly developing and widening range of types of office accommodation*
- *Office work can be accommodated in many ways, both physical and electronic, and at many scales and locations*
- *Improvements in information technology are continuing to have a huge impact on the workplace*
- *Twentieth century workplace conventions in the use of space and time are obsolete*
- *The office can no longer be considered as an autonomous building type but must take maximum advantage of location, adjacencies, and access to complementary functions and communications*
- *No single process of linking office supply and demand can be assumed to be dominant*

Contents

1 Introduction
2 Matching supply and demand
3 Standard method of building measurement
4 The time-based nature of the office environment
5 The office shell
6 Building services
7 Scenery and setting options
8 Trading floors
9 Conclusion
10 Bibliography

1 INTRODUCTION

1.1 The historical office

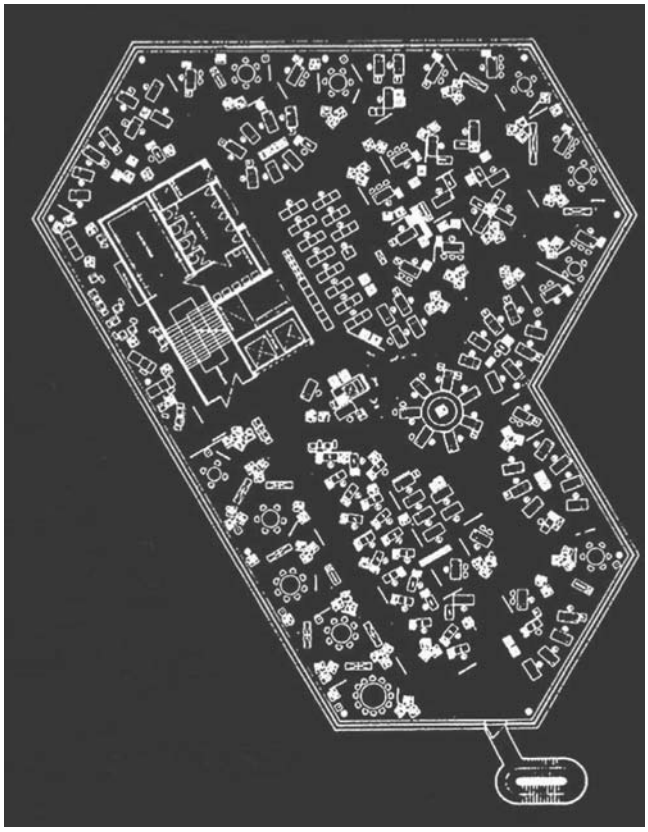
The office emerged as a distinct building type in the latter half of the nineteenth century. Previously, what would now be classed as office functions, especially those that were an adjunct to government, had often been accommodated literally in palaces such as the Uffizi in Florence. Somerset House in London, partly built to accommodate the Admiralty, followed a similar model. In the private sector, lawyers had worked for centuries in the quasi-collegiate environment of the Inns of Court. Sir John Soane's Bank of England is an early example of a very large, purpose built office complex of a very specific kind. By contrast, much early office work was peripatetic. Early members of the Corporation of Lloyds, the pioneer of the insurance market, conducted much of their business in adjacent, publicly accessible coffee houses, the Starbucks of their day.

1.2 The office building type

When the office building emerged as an independent building type in the United States in the latter part of the nineteenth century, it was distinctive physically in terms of large floor plates and increasingly high rise structures, but also in the very specific ways in which such purpose-designed office buildings were financed, designed, constructed and operated. For the first time, large floor plates were required to accommodate a rising number of clerical workers, equipped with the increasingly sophisticated technology of the typewriter and the telegraph followed quite quickly by the telephone and the copier.

The complementary roles of both office developer and facilities manager first emerged here along with a series of divisions of labour between the roles of architects, mechanical and electrical engineers, space planners and facilities managers, defined by how long each layer of designed artefacts was intended to last.

North American offices continued to become ever larger and more sophisticated, both architecturally and technologically, during the first half of the twentieth century, as is evident in many magnificent, very often high rise structures, designed by such architects as Frank Lloyd Wright, Mies van der Rohe, Philip Johnson and SOM. Meanwhile, British office buildings remained until the early 1980s a provincial variant of US practice, smaller, less efficient in construction and plan form, less well serviced, and more influenced by developers, letting agents and external planning considerations than by the internal operational requirements of occupiers.



30.1 *Burolandschaft (office landscaping) at Ninoflax, Germany*

1.3 European office innovation

Two very different and original office design concepts developed in Northern Europe in the 1960s and 1970s:

- *Burolandschaft* (office landscaping) – introduced by the *Organisationteam Schnelle* in the early 1960s in Germany, Figure 30.1. This was largely based on studies of internal patterns of communication within organisations. User data led to free-flowing, open plan arrangements of workstations and meeting areas. One external corollary was a deliberately non-orthogonal architecture. Such developments were fuelled both by the presence of more independently owned businesses in Germany compared to the US, who were in a position to develop their own office buildings, and by the power of Workers' Councils with the constitutional right to be consulted on changes in working conditions. Consequently it became customary from the 1960s onwards, not just in Germany but also in Holland and Scandinavia, for office buildings to be purpose-designed from the inside out. Not only were many of the resulting buildings striking in architectural terms but internally they became spatially generous, often carpeted (rare until the 1970s in both the UK and USA) and much more domestic in feeling than corporate. Plants and colour were important interior features as were informal rest areas, called *Pausenraumen*, for refreshment, relaxation or informal, extempore conversations with colleagues.
- Office as city – A similar divergence from the top down culture of the corporate office was experienced in Holland and Scandinavia in the 1970s and 1980s. A key project in Holland was Herman Hertzberger's office for Centraal Beheer, an independent insurance company in Apeldoorn. This was conceived as a microcosm of an Italian hill town with strong internal as well as external architectural features – mini atria, columns and low walls – intersected and held together by internal streets. This created a network of small, semi-enclosed, interlocking places that the 'inhabitants' were encouraged to appropriate in their own way in order to make the office as homelike and personal as possible. This created a radically different, user sensitive, and to many workers, a highly attractive office culture. Niels Torp's celebrated headquarters buildings for the airline SAS on the outskirts of Stockholm, Figure 30.2 and for British Airways near Heathrow were also conceived as little cities, with office pavilions on either side of an attractive, top-lit, internal 'street'. Many similar offices were erected in Scandinavia, Holland and Germany, but far fewer in the United Kingdom and the rest of Europe.

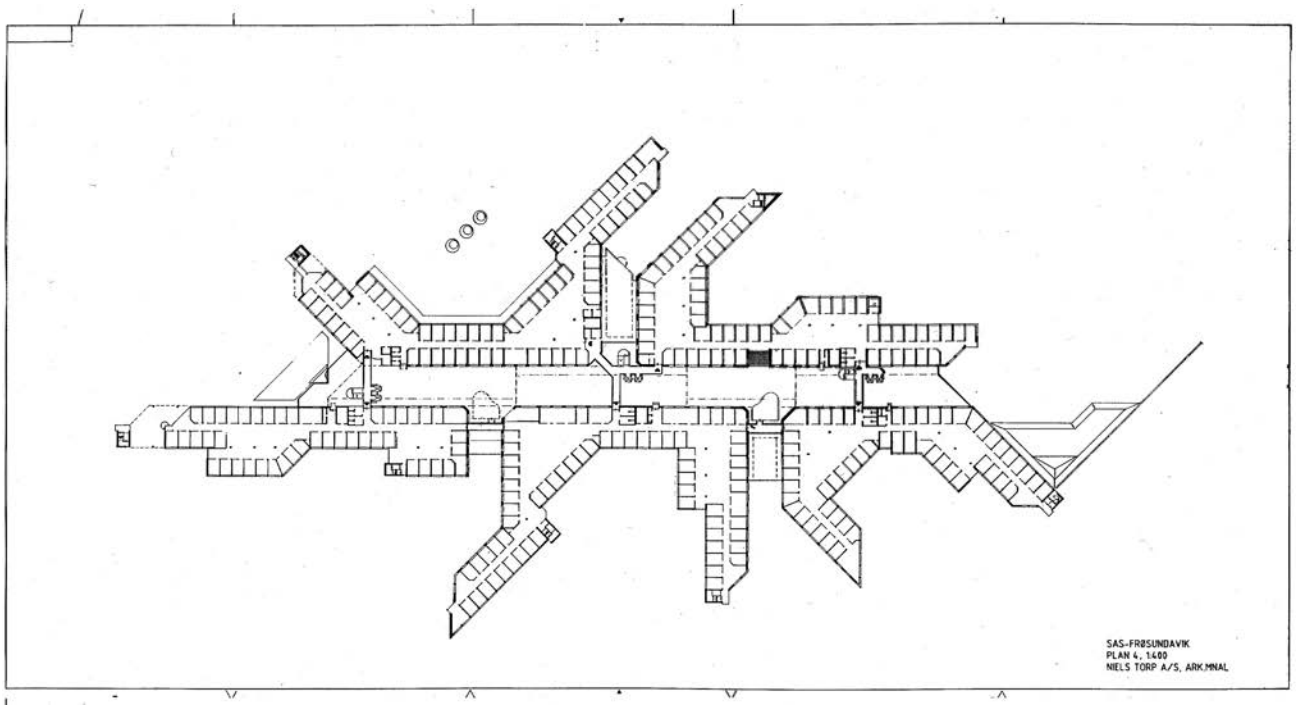
1.4 The global office

In London in the late 1970s and early 1980s, developers such as Stuart Lipton and Godfrey Bradman realised that an entirely new class of office building would be necessary to accommodate globalising organisations, particularly in the Financial Services sector. Such accommodation would allow occupiers to take maximum advantage of London's location in an intermediate time zone that permits overlapping daily communications with both Asia and North America. This led to the initial, immediate success of Canary Wharf and Broadgate and, cumulatively over the last three decades, the economy of the City of London and the capital as a whole, Figure 30.3.

Table I summarises the planning and design criteria for these different generations and locations of office buildings.

1.5 Facilities management

Facilities management (FM) is a North American concept and was an essential factor in the development of the office in the last century. FM skills may be considered as the software that enables the efficient and effective management and use of office space over time. Facilities managers tend to be undervalued, or at best taken for granted, partly because of the perceived difficulty of measuring their positive impact on business performance. However this is changing with the development of more scientifically conducted case studies.

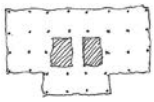
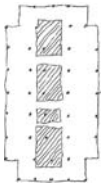
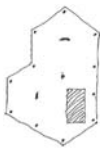
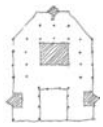


30.2 *Niels Torp's SAS headquarters in Stockholm, arranged office pavilions around an internal 'street'*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table I Planning and design criteria for different types of office building

	US corporate high-rise, 1930s	US corporate high-rise, 1950s	Office Landscaping, 1960s	UK financial services, 1980s	Scandinavian social democratic, 1980s	City as office, 21st century
						
	(Charles Center, Baltimore, US)	(525 William Penn Place, Pittsburgh, US)	(Ninoflax, Germany)	(Broadgate, London, UK)	(SAS, Stockholm, Sweden)	(Any city)
No. of storeys	25	41	5	8	5	N/A
Typical floor area (m^2)	3000	1000	2000	3000	multiples of 200	N/A
Typical office depth (m)	20	20	30m	20	10	N/A
Furthest distance from perimeter (m)	18	18	15	18	5	N/A
Efficiency: net to gross	90%	85%	95%	85%	70%	N/A
Maximum cellularisation (% of usable)	50%	50%	5%	40%	80%	N/A
Type of core	Concentrated: central	Concentrated: central	Offset	Dispersed	Dispersed (street)	Urban fabric
Type of HVAC service	100% HVAC artificial Multiple users	100% HVAC artificial Multiple users	100% HVAC artificial Single user	Floor by floor Several users	Minimal HVAC High user control	Multiple systems High user control

1.6 Information technology

By contrast, the impact of information technology on business performance is dominant and is now highly visible in practically every sector of the economy. IT mobility has revolutionised how we work, leading to a wide variety of work settings rather than just the individual desk.

2 MATCHING SUPPLY AND DEMAND

2.1 Office type variety

The idea that there should be a single, definitive model for all office buildings, let alone for office interiors, is demonstrably outdated. The current different types can be summarised as:

- High quality, architect-designed corporate office space with many amenities to attract young talent for sophisticated global hi-tech organisations such as Apple, Google and Microsoft.
- Speculative, capable of utilisation in a mix of cellular/open plan workspace.
- Alternative, individualised and often highly informal workplace cultures, for entrepreneurial, technology-led enterprises such as those at the so-called 'Silicon Roundabout' around London's Old Street. These often re-utilise existing buildings. New build developments include the White Collar Factory, Figure 30.4.
- Shared/hotelling workspaces – where space and services can be hired within a communitarian atmosphere, often by start up businesses, for the day, the week or the month. Examples include The Hub at New Zealand House in London, Figure 30.5.
- Home/mobile.

The exploratory process of creating new kinds of workplace is by no means over as increasingly powerful technologies continue to be developed and different cultural and organisational stimuli present themselves.

2.2 Supply chain

Modes of delivery and space management are also changing beyond the conventional Anglo Saxon real estate supply chain. This starts with investors' money, leads on to the developer and is passed on to real estate brokers and then lawyers before it is given over to teams of architects, engineers and cost consultants. They in turn hand the project on to project managers and the construction industry after which corporate real estate, facilities managers, IT and human resources take over. Eventually, projects are handed over to users who, in the past, have been barely consulted. At its worst, this supply chain is uni-directional, unstoppable, mono-functional and, above all characterised by minimal, even zero, feedback.

2.3 Demand and supply

Figure 30.6 shows how demand and supply should be connected operationally. What is important here is the emphasis on feedback and the reconciliation of user demands (expressed through space and furniture standards, filing and information strategies, requirements for ancillary and support as well as design guidelines) with supply side features such as space planning and structural grids, depth of space, configuration and size of floors and number of storeys.

2.4 Improving user satisfaction, health and comfort

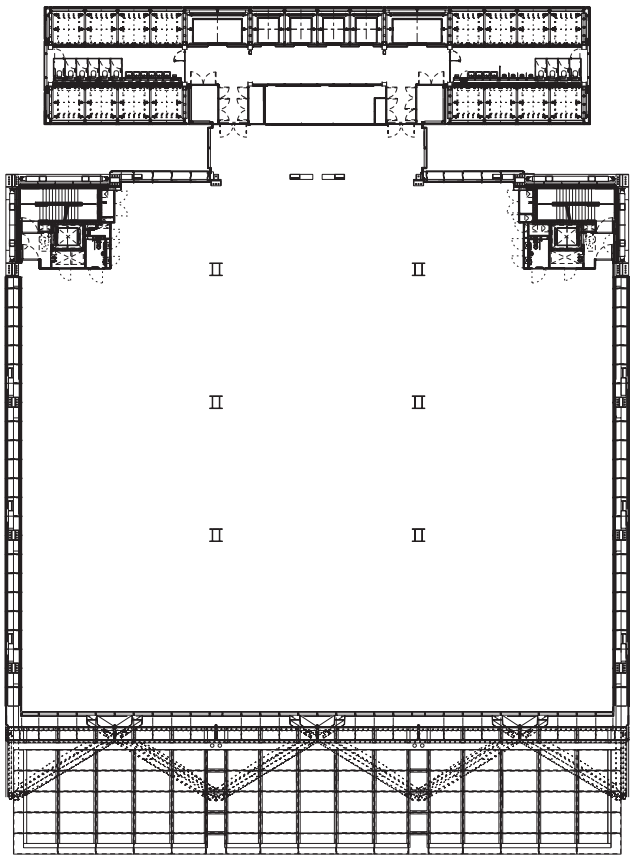
A good workplace building may be defined as one that satisfies through time both end user and organisational needs at reasonable cost, without unnecessary effort and within which, above all, occupants are happy to work. To achieve these goals three key features are required:

- *Adaptability* – to meet an open-ended range of spatial and servicing requirements. In addition to shell and core standards of provision, offices could, for the benefit of occupants, accommodate a wide range of choice in internal environmental services, such as natural ventilation and control of up-lighters.
- *Contact with the outside world* – many people like being adjacent to operable windows with clear glass. In Scandinavia and Germany this is having a major influence on office building design often resulting in office spaces arranged around a core or 'street' of common facilities.
- *Healthier and more stimulating internal environments* – many people find natural ventilation more acceptable than mechanical systems especially if they are able to control airflow and temperature, and benefit from a healthier and more stimulating environment.

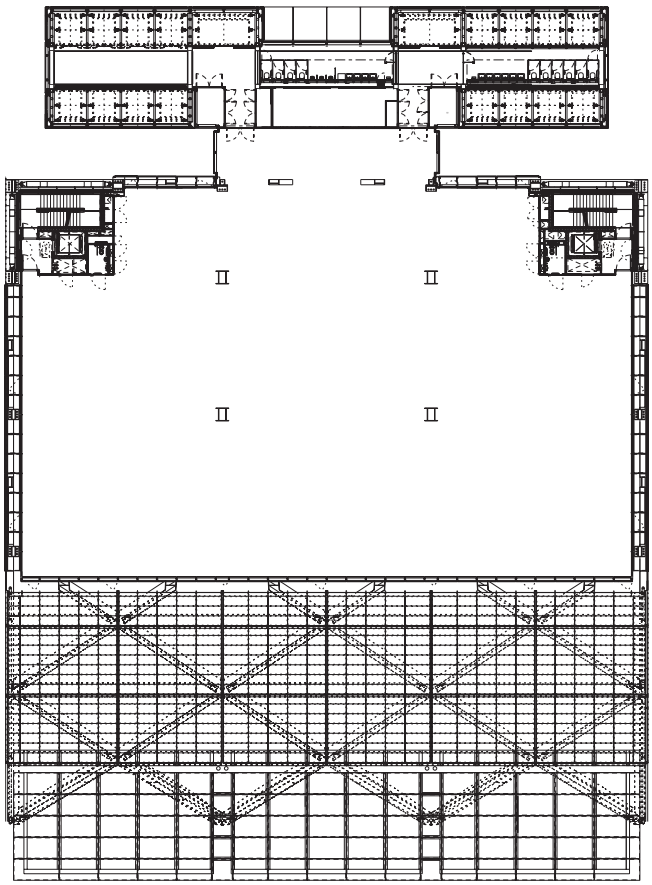
3 STANDARD METHOD OF BUILDING MEASUREMENT

3.1 Common terms

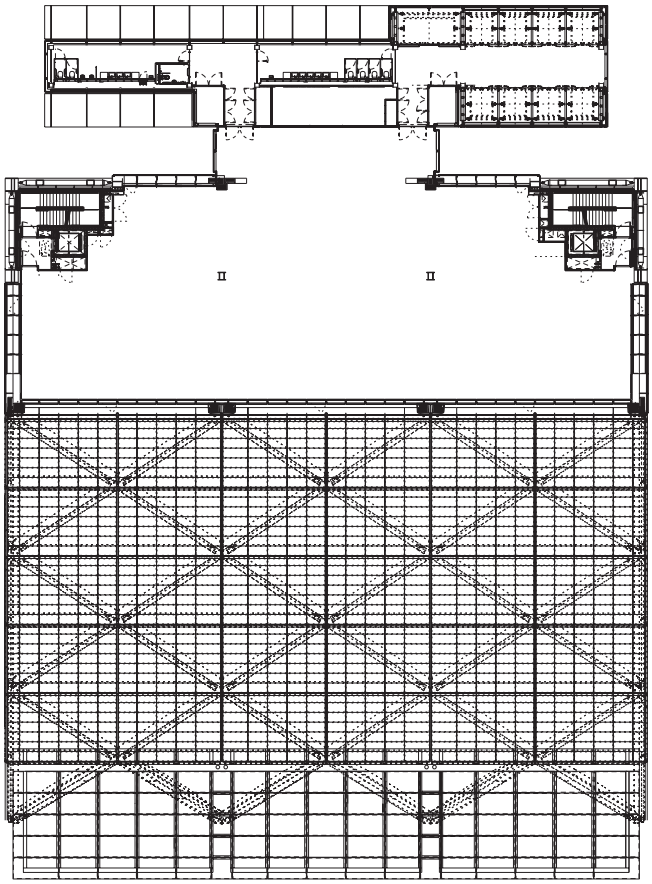
The following terms, Figure 30.7, are often used to specify floor area requirements (see BCO Guide to Specification):



30.3a



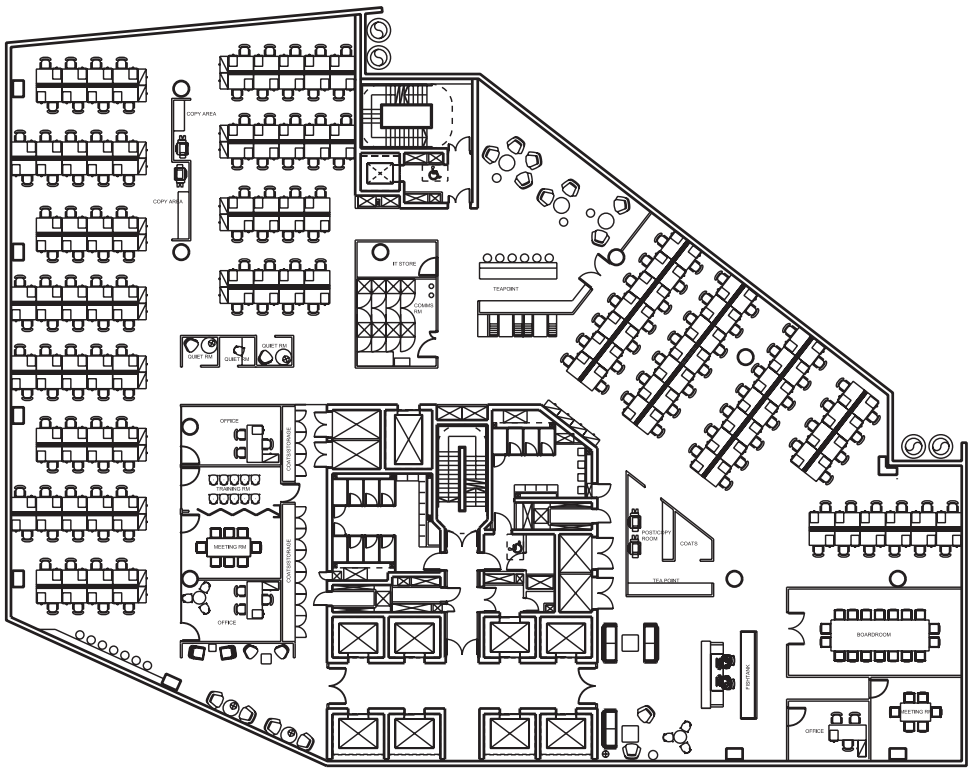
30.3b



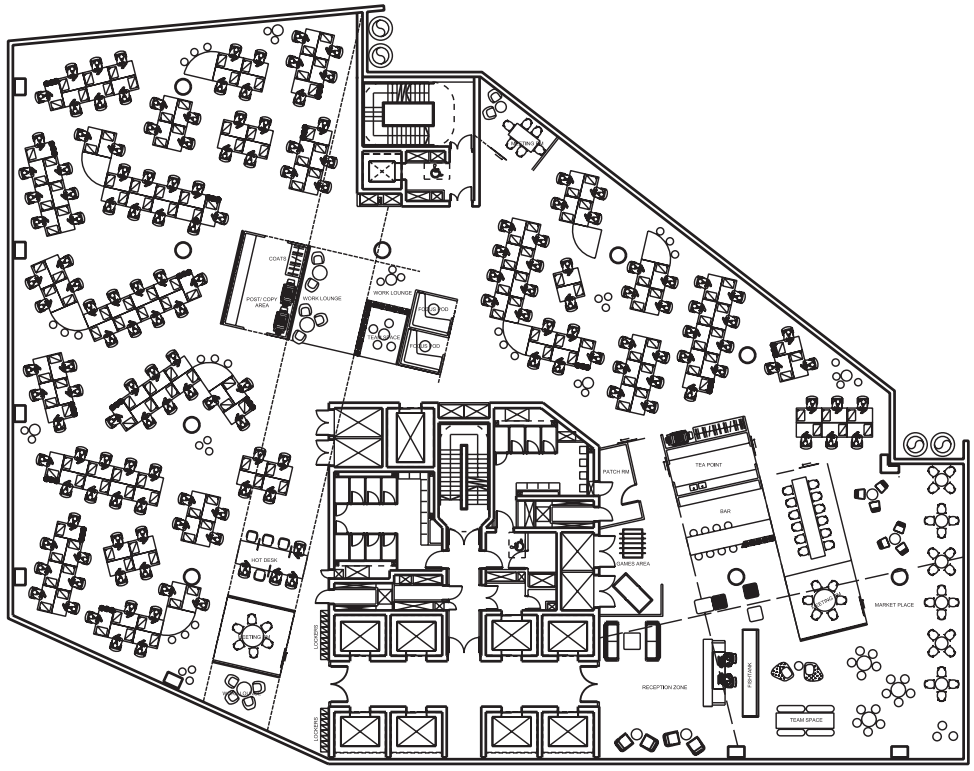
30.3c

30.3a-c *Varying floor plans at the 50-storey Leadenhall Building designed by Rogers Stirk Harbour + Partners in the City of London for British Land Company plc/Oxford Properties. Key: a Floor 6, b Floor 22, c Floor 40*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

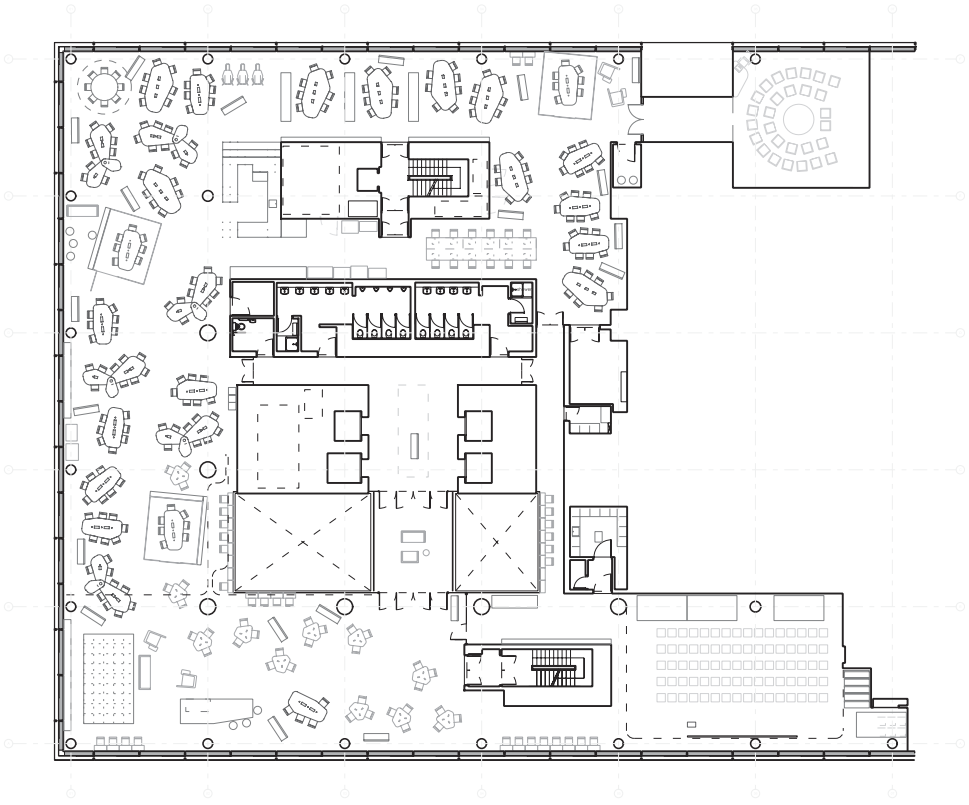


30.4a

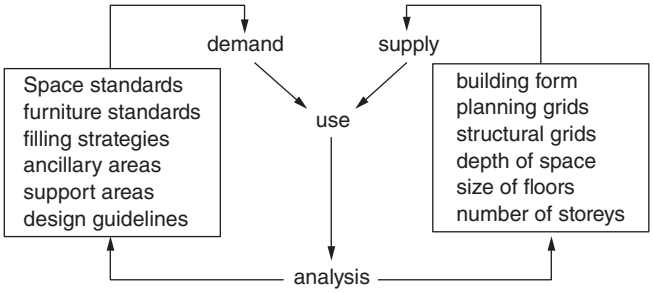


30.4b *The White Collar Factory at London's Old Street, designed by Allford Hall Monaghan Morris. a & b show alternative layout options for the eighth floor*

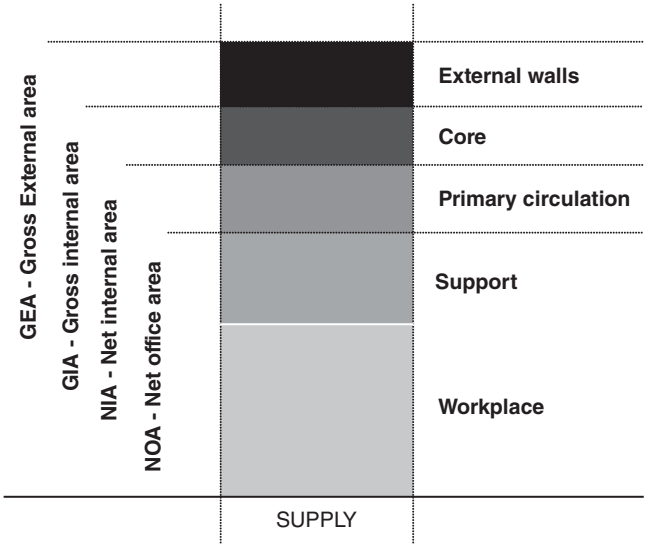
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



30.5 *The Hub, at New Zealand House in central London, is an example of a shared workspace increasingly popular with start-up companies buying a service rather than space.*



30.6 *Reconciling demand and supply*



30.7 *Standard method of measurement*

- *Gross External Area (GEA):* the floor area contained within the building measured to the external face of the external walls.
- *Gross Internal Area (GIA):* the floor area contained within the building measured to the internal face of the external walls.

In both the above gross measures, features such as atria are calculated at the filled floor level – clear voids are not included in the total area. However, enclosed plant rooms are included in all gross measures.

Net Internal Area (NIA): GIA less floor areas taken up by;

- Common lobbies and foyers.
- Enclosed plant on roofs.
- Stairs and escalators.
- Mechanical and electrical services plant areas.
- Lifts.
- Internal structure such as columns.
- Toilet areas.
- Functions within the core enclosure.
- Ducts and risers.
- Car parking is included in gross area.

An additional term sometimes encountered is *Net Office Area (NOA).* This is NIA less main corridors and other primary circulation, i.e. the routes required to maintain life safety in emergencies. Secondary circulation to provide access to workstations off main corridors is included in NOA.

GIA and GEA are incorporated into the new International Property Measurement Standard, drawn up by The Royal Institution of Chartered Surveyors (RICS) and other global organisations.

3.2 The space budget

From the user's perspective, the components of a space budget are:

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

- *Workspace:* area given over to individual and shared workstations, work settings and occupants' immediate requirements such as personal filing – although more and more of this is now accessible electronically.
- *Ancillary space:* area given over to functions that are managed by and support departments or working group, including local meeting places, project rooms, storage areas, shared equipment, refreshment and copy areas. Such shared resources are increasing as a proportion of occupied space.
- *Support space:* area given over to functions that are centrally managed and support the whole organisation or building, including mail, reprographics, network rooms, switchboard rooms, library, conference, central meeting etc. Such areas may be located on separate floors or otherwise distant from individual departments or groups.

Office buildings in use are rarely, if ever, 100 per cent efficient for two prime reasons:

- Building configuration, grids and obstructions.
- The operational imperative of maintaining departmental integrity.

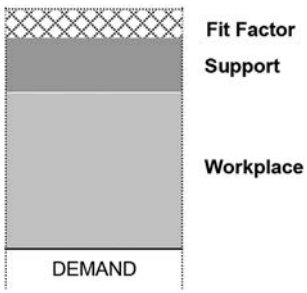
Consequently, in the calculation of space requirements a 'Fit Factor' – say 5 per cent or even 10 per cent depending on the configuration of the space to be occupied – should be added to the schedule of accommodation required, Figure 30.8.

Meanwhile more mobile ways of working and increasingly shared spatial resources are having a profound effect on such calculations of space requirements.

4 THE TIME BASED NATURE OF THE OFFICE ENVIRONMENT

4.1 Timescales

Buildings are relatively permanent entities unlike organisations within which activities and routines are continually changing. To allow for maximum flexibility, it is helpful to distinguish four different timescales, Figure 30.9, related to building briefing and design:



30.8 *The space budget represents the organisation's requirement for Net Useable Area*

- The building shell – the structure and enclosure of the building which conventionally lasts perhaps 60 years. Within the same period operational functions are certain to change many times over. The ability of a shell to accommodate change is a function of depth of space, location of cores, floor-to-floor height to provide capacity to accommodate services as well as the configuration of the floor plate.
- Building services – the heating, ventilation and cabling infrastructure of a building, which usually has a life span of 15 years – or even less as technology becomes obsolescent and equipment has to be replaced.
- Scenery – the fitting out components of a building such as ceilings, lighting, finishes, which are used to adapt a building to tenants' (or departmental) changing requirements. Typically, the life span of an office fit-out is between 5 and 7 years.
- Settings – the increasingly important day-to-day re-arrangement of furniture and equipment, to meet ever-changing needs.

These terms, which are now in common use, have been coined because they relate office design to scenography, i.e. to the time-based rearrangement of settings behind the proscenium arch during theatrical performances.

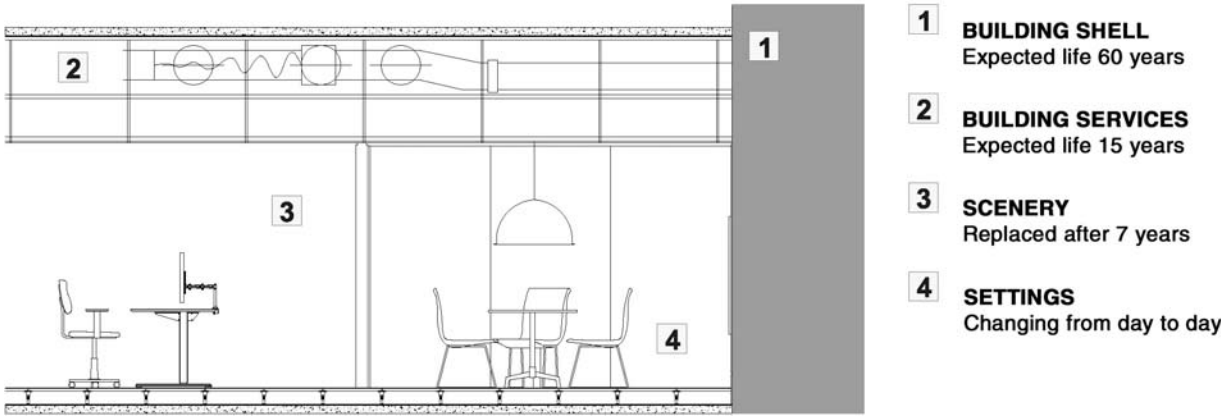
4.2 Office mobility

Paper-based office work was relatively slow moving and often static. Storage and retrieval of non-electronic documents were important as was the provision of meeting places for customers, suppliers and consultants as well as for the organisation's own staff. However, information technology has changed the pace, the timetable and the location of office work.

The most striking impact is that office workers have become much more mobile both within and away from the office. Hourly measurements of the actual occupancy of individual workstations over the working day in many different kinds of business have shown that this rarely rises above 40 per cent at peak times and, in many cases over the day as a whole, much less, Figure 30.10. Evidence of office workers being present but not at their workplace – for example, a coat left over a chair – may appear to add another 10 or 20 per cent, to occupancy levels but it is safe to say that most workplaces and offices are mostly empty for at least half of the working day. Similarly, while meeting rooms are often fully booked, even more frequently they are observed to be empty.

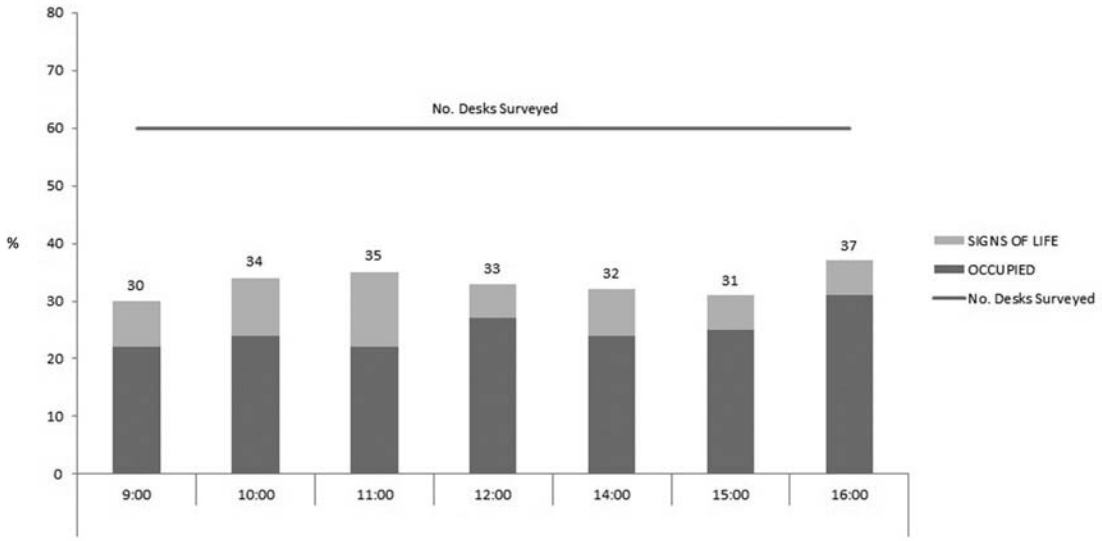
4.3 An office revolution

The space planning and urbanistic implications of such demographic findings are profound. If information technology is making it possible for an increasing proportion of staff to work at least



30.9 *Different building timescales*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



30.10 *Time utilization surveys show that actual desk occupancy is less than might be expected*

some of the time away from the office, not necessarily incidentally at home, the residual role of office accommodation is likely to be as social and communications centres within and between businesses. Such offices are likely to be occupied in very different ways over very different timescales.

These trends have important urbanistic implications. If offices are indeed half empty most of time, as seems to be already the case in many instances, the same cannot be said of cities. Like many other cities worldwide, city centres such as Manhattan or Central London have become more vibrant than ever before and over longer timescales – the opposite of what has been observed inside office buildings. Attention must be given to the programming and design of an urban fabric that would foster a business and intellectual community that operates for much of the time between, as well as within, distinct office organisations and buildings.

5 THE OFFICE SHELL

5.1 Needs

Building owners and facilities managers usually prioritise the following specification requirements:

- The ability to accommodate change and minimise operating costs.
- Freedom to address users' expectations for environmentally friendly working conditions.
- Local environmental control.
- Ease of maintenance.
- The opportunity to allow users to participate in design decisions.

5.2 Dimensions

The dimensions recommended in this section are based on those recommended by the BCO, and on what many facilities managers believe to be good practice. However, in some circumstances, such as inner city sites, different approaches may be appropriate to comply with planning restrictions or to ensure financial viability.

5.3 Floor depth

This determines the quality and dimensions of space to be provided at every level. Aspect, natural ventilation and lighting, zoning of activities and of support spaces should all be considered. Building depths are usually measured as either 'glass to core' or 'glass to glass':

- A glass to core dimension of 9–12m allows room for cellular office space or open plan plus circulation and storage.
- A glass to glass dimension of 13.5–18m allows two or three zones of office, circulation and support space.

5.4 Storey height

Related to floor depth and floor plate dimensions, storey height (floor to floor height) has a major impact on air conditioning, cable distribution, occupants' ability to have access to natural ventilation and daylight, as well as on visual comfort:

- Floor to floor heights of 4–4.5m provide more flexibility as well as visual comfort. However, a typical height of 2.75m from finished floor level to underside of ceiling is still considered good practice.

Floor depth and storey height are interrelated and, assuming glass-to-glass depths of 13.5–18m, should be thought of together. For example, narrower buildings do not require such generous storey heights because of the different servicing strategies that they use.

5.5 Floor sizes and configurations

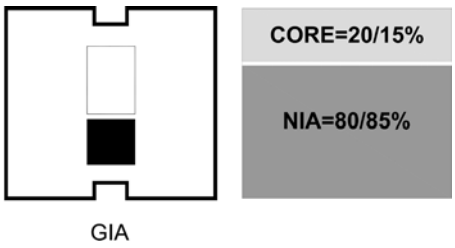
These affect circulation and internal communication. Smaller floors are less efficient in terms of the ratio between the area of cores and usable floor space. They can also lead to splitting larger departments over several floors. Very large floor plates can create extended circulation and longer distances between departments:

- Large floor plates of 2500m^2 and over tend to be favoured by larger organisations. However dealing rooms can be much bigger.
- Landlord efficiency (the ratio between Net Internal Area and Gross Internal Area) should be 84–87 per cent in mid to high rise or 90 per cent in low rise buildings.
- Tenant efficiency, expressed as the ratio between Usable Area and Net Internal Area, should be 85 per cent or above, Figure 30.11.

5.6 Floor loading

This determines the amount of equipment and storage that can be placed in the work area while preserving the overall stability of the structure. The tendency in the UK and certain other parts of Europe

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



30.11 *Tenant efficiency*

has been to over-specify floor loadings, thus adding significantly to construction costs:

- The BCO recommends 2.5 kN/m², with hardened areas for extra weight of up to 7 kN/m², but says that institutions demand ranges of 3 to 4kN/m².

5.7 Planning and partition grids

Planning grids determine the size of enclosed offices and other enclosures as well as providing an overall modular discipline for many other design decisions that help determine the ongoing efficiency of space use, even in what may have been originally intended to be completely open offices:

- A 1.35 m grid allows 2.7 m wide minimum office enclosures (relatively rare in the UK).
- A 1.5 m grid allows 3 m wide offices that are much more common and have the additional advantage of relating well to 600 mm building components. This grid is much used in office planning in the UK.
- Structural grids should relate to space planning grids as well as to wider economic, engineering and environmental factors. It is not necessarily the case that fewer columns are always better. However, decisions about structural grids should always be tested during the design process against a wide range of typical patterns of enclosure and desk layouts.

5.8 Building skin

The role of office building skins is shifting from being designed solely as barriers to the external environment to becoming an integral part of overall servicing and environmental strategies.

Natural ventilation controlled by end users has long been popular in Northern Europe (see Section 6) – and is likely to become a more common feature of British offices particularly away from city centres. The provision of cross ventilation can be a critically important determinant of office building depth.

5.9 Communications infrastructure

We live in the information age. Hence local and wide-area communications have become an increasingly important factor at every level of office design. Office building shells and services should be designed to accommodate them. Particularly significant are the provision of main entry points for external communications and ensuring that the size and location of vertical risers are adequate:

- Risers for voice data and other services should not take up less than 2 per cent of Gross Floor Area (GFA) and the capacity should be provided to knock through easily at least another 2 per cent should the need arise.
- Cores containing risers should be widely distributed to avoid cable bottlenecks.
- Cores should be accessible from common parts and primary circulation routes in order to provide options for multi-tenancy.
- Communications rooms serving the entire building or major tenants measuring 2 x 2 m for each 500 m² of GFA should be adequate and located at a distance suitable for the adopted data/communication system.
- There should be space for dual-service entries into the building.
- Provision should be made on the roof, or nearby, for satellite or microwave dishes with good sight lines.
- Provision of alternative access to power supplies and communications. Security and continuity of access is a critically important consideration given that office organisations of all kinds are now more or less totally dependent upon electronic networks communication system.

5.10 Access for goods and materials

Ease of access for the entry of goods must be at least as good as access for people to avoid conflicts and bottlenecks. A clear strategy for entry supported by appropriate signage should keep people and goods separate. Typical materials regularly delivered are:

- loading bays
- goods lifts
- refuse and recycling
- stationery and office supplies
- office equipment, machinery and furniture
- food and supplies to dining areas, vending machines etc.
- post and couriers
- building maintenance supplies and equipment.

5.11 Building shell considerations

These are summarised in Table II.

Table II Building shell considerations

Depth of building	Flexibility of layout options
Location of cores	• Amount of cellularisation • Need for mechanical ventilation/A/C • Spatial efficiency • Ease of subletting • Security • Spatial efficiency
Floor-to-floor heights	• Method of cable distribution • Type of servicing
Floor size and shape	• Spatial efficiency • Planning flexibility • Size of working groups
Perimeter detail and grids	• Flexibility of subdivision • Efficiency of space use • Solar gain, heat loss, condensation
Construction	• Base of adaptation • Space for services • Image

5.12 Sectional considerations

Following Northern European practice, internal atria, small or large, linking several floors via prominent staircases, are becoming increasingly common. The purpose of such atria is to enhance the potential for interdepartmental movement and interaction. In some cases building in the possibility of creating such three-dimensional access is provided in the design even of the structure of speculative office buildings. However, real estate efficiency has to be balanced against potential longer-term operational advantages.

6 BUILDING SERVICES

6.1 Natural ventilation or air conditioning?

There is usually a straight choice between natural ventilation and full air conditioning for both speculative and purpose-built

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

offices. In the UK many organisations choose the latter, although the consequences can be twice the building services energy costs and dearer building maintenance and management. Not all these costs are directly related to the air conditioning system but to the characteristics of the types of buildings that are air conditioned. Apart from improved comfort (not always realised), reasons for choosing air conditioning include:

- Prestige.
- Standard requirements, particularly for multinationals.
- Deeper plans, partly for alleged organisational needs and partly to maximise usable area.
- Flexibility to accommodate changing requirements – seldom achieved except at high cost.
- Higher rents giving a better rate of return.
- Poor external environments, particularly traffic noise.

6.2 New trends

Trends in office design have moved away from climate responsive forms, designed as coarse climate modifiers, towards climate rejecting, sealed designs within which the internal environment is created largely, and often entirely, artificially. This design strategy is now being questioned. Pointers for the future include:

- More powerful and reliable electronic communications systems and networks are raising questions about the long term operational value of large, deep, environmentally controlled buildings and spaces. Not least because patterns of occupancy are changing because of more mobile ways of working.
- Many occupants are expecting environments that are more natural, providing greater outside awareness, more daylight, natural ventilation and better individual control. These environments can be supported where appropriate by supplementary mechanical and electrical systems that are available on demand, including opening windows and solar controls linked to computerised building management systems. Such systems monitor the opening of windows so that heating, ventilation and air conditioning systems can be reconfigured as required.
- In difficult conditions, especially in the inner city, it may not be possible to have opening windows, but some form of solar protection should always be incorporated to minimise cooling loads.
- New materials, systems and design techniques permit closer integration of natural and mechanical systems with intelligent user-responsive controls that allow buildings which are not fully air conditioned to provide greater environmental control than ever before.
- Concern for the global environment implies greater energy efficiency through natural ventilation, light and solar heat rather than conventional mechanical and electrical systems.
- Energy consumption by desktop IT equipment is falling, reducing cooling loads in the general office though not necessarily in equipment rooms.

7 SCENERY AND SETTING OPTIONS

7.1 Layouts

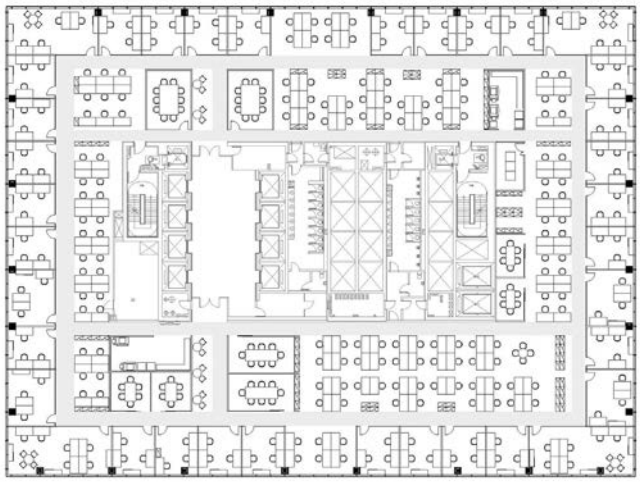
Layouts must balance the desire for cellularisation (common in Germany and Scandinavian offices) against the need to keep costs down and to add value with strongly interactive work patterns in open-plan settings. Open areas should be designed and managed to allow quiet and reflective work, and the flexible use of space at different times. Using IT to allow mobile working within the office makes possible entirely new ways of planning space.

Layouts should:

- Maximise both communication and the need for quiet and reflection.
- Accommodate team and project work and also provide space for confidential and individual work.
- Provide access to daylight, aspect, and ventilation.

7.2 Typologies

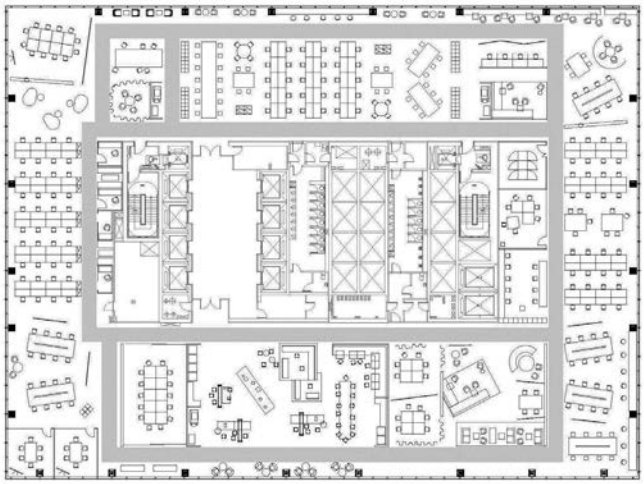
Three typical office typologies and their densities are shown here: highly cellular, Figure 30.12, 90/10 open plan/cellular, Figure 30.13, and open plan, Figure 30.14. In Figure 30.14, desk provision is at 1:1, although many organisations now provide fewer desks than headcount and operate desk-sharing strategies in order to match true levels of occupation.



30.12 *Highly cellular layout with 253 desks. NIA 9.7 m² per desk*



30.13 *90/10 open plan/cellular layout with 237 desks. NIA 10.3 m² per desk*



30.14 *Open plan layout with 233 desks + 68 other settings. NIA 10.5 m² per desk/8.1 per person*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

7.3 Meeting rooms and collaborative spaces

These are key areas in any organisation. As well as formal meeting areas, Figure 30.15, and informal meeting areas, Figure 30.16, breakout areas are increasingly important, and may include sofas, banquettes, beanbags as well as traditional seating.

7.4 Individual settings

Many offices incorporate a variety of workplace settings for staff and visitors aside from the traditional desk such as bench seating, Figure 30.17, focus rooms, Figure 30.18, and touchdown areas, Figure 30.19a & b.

7.5 Space and circulation

Figures 30.20a, b, c, show typical distances and requirements for accessing storage cabinets. Copy areas are shown in Figure 30.21a & b.

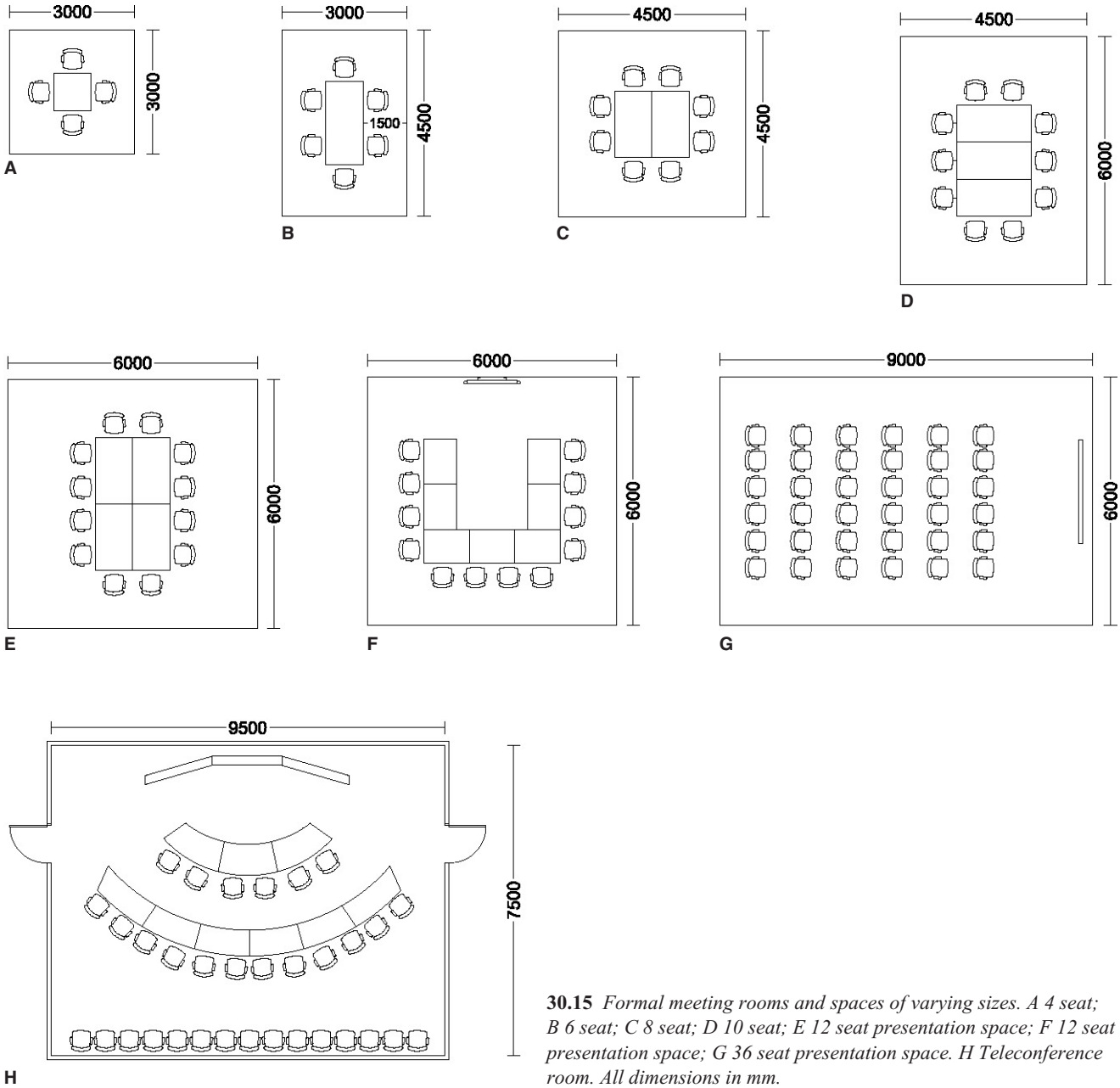
7.6 Servicing strategy

Power and communication services can be taken to each workstation and meeting place in either:

- Raised floors, Figure 30.22.
- Perimeter ducting connected to cable management systems within furniture and screens, Figure 30.23.

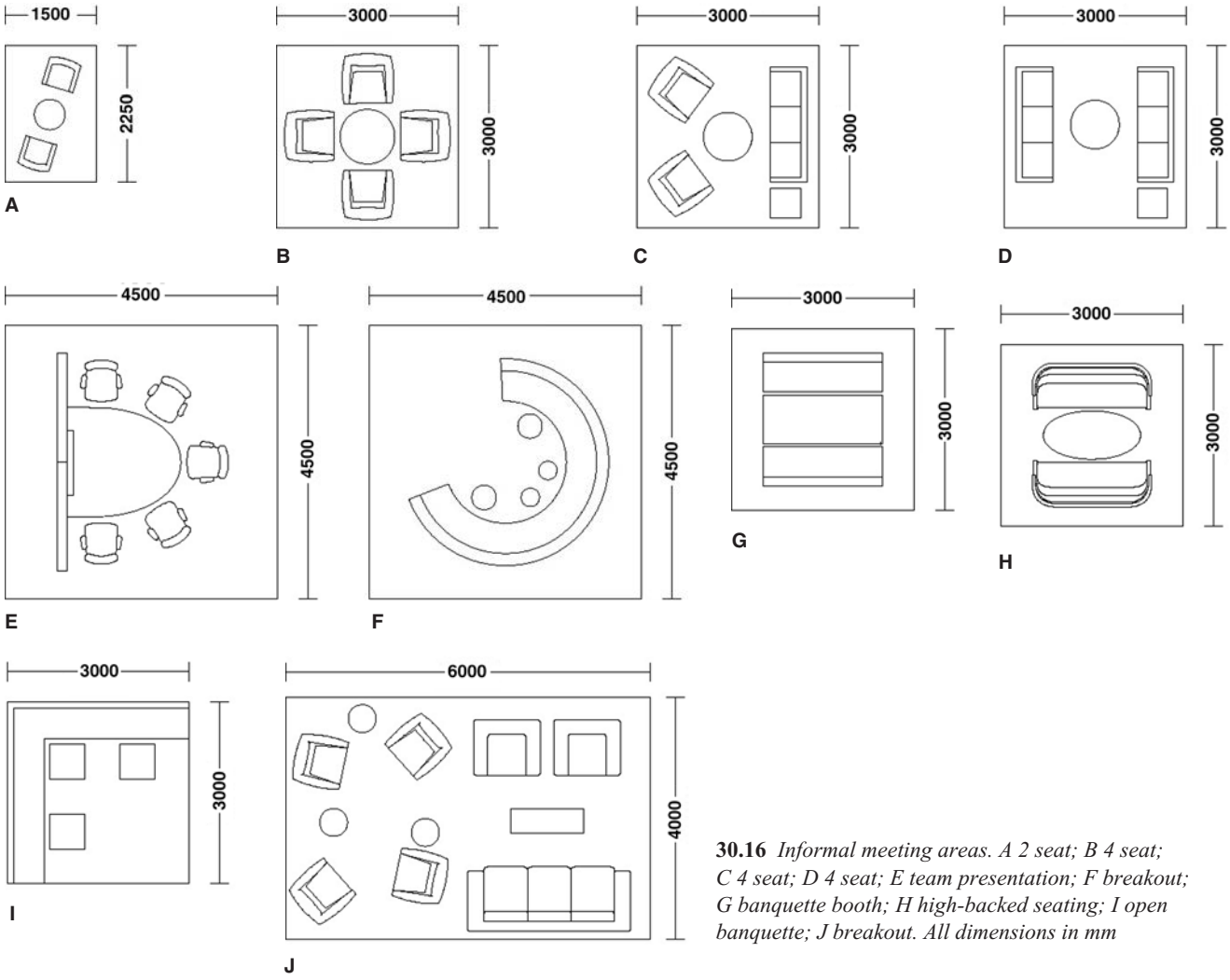
Raised floors are popular with UK developers, which is surprising as it is the most expensive method. Unless an unacceptably low ceiling is provided, it means that the floor-to-floor height is increased by the depth of the raised floor. Power and telecommunication outlets are in sunken boxes accessed through flaps with slots for the flexes. These boxes have a capacity limited by their size, and usually only have room for three power sockets and a double telephone socket. It is not that easy or cheap to provide more boxes, or to move the ones that are there, so that furniture and screen arrangements tend to be fixed in relation to them. Sometimes boxes find themselves within major traffic routes, where they can cause a hazard.

Perimeter ducting is a system particularly suitable for smaller naturally ventilated offices without suspended ceilings. However, it does make moving the furniture and screens difficult, and can inhibit easy movement between workspaces.

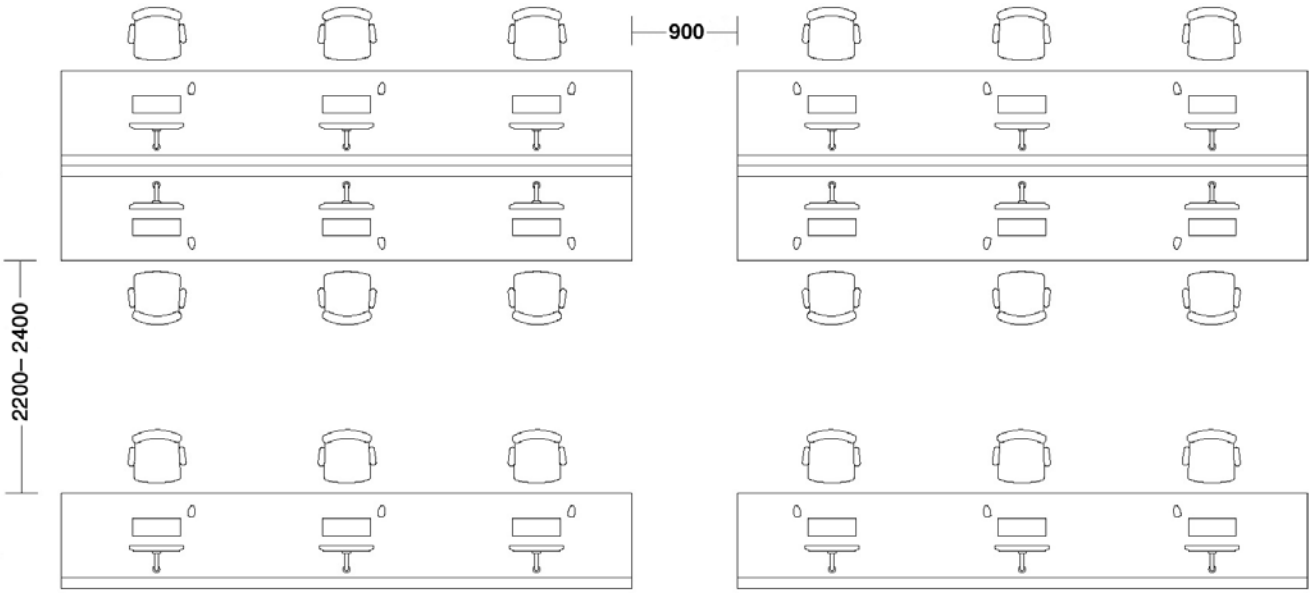


30.15 *Formal meeting rooms and spaces of varying sizes. A 4 seat; B 6 seat; C 8 seat; D 10 seat; E 12 seat presentation space; F 12 seat presentation space; G 36 seat presentation space. H Teleconference room. All dimensions in mm.*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

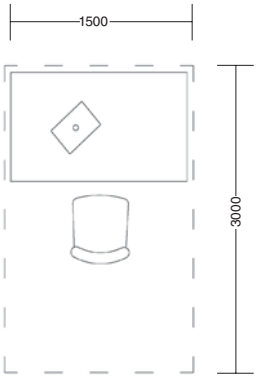


30.16 *Informal meeting areas. A 2 seat; B 4 seat; C 4 seat; D 4 seat; E team presentation; F breakout; G banquette booth; H high-backed seating; I open banquette; J breakout. All dimensions in mm*

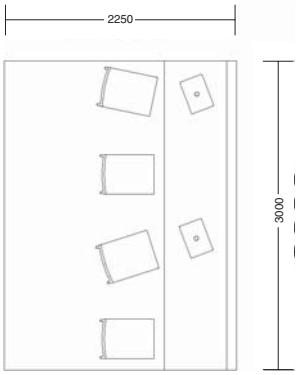


30.17 *Bench seating*

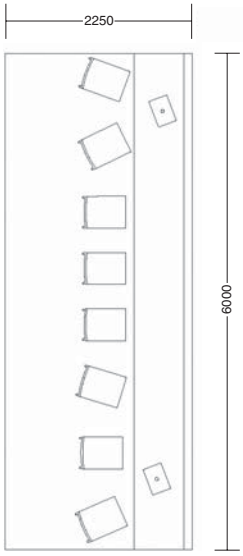
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



30.18 *Focus room*

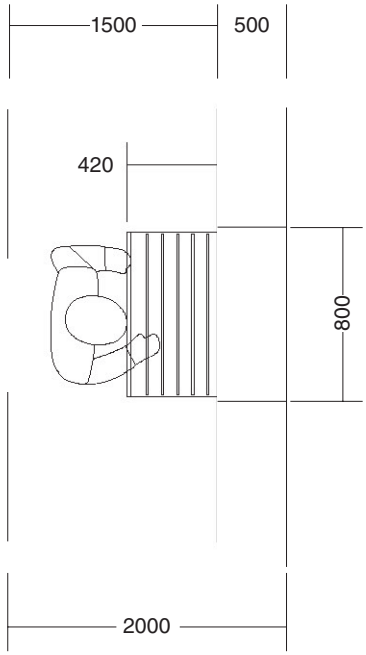


30.19a *4 seat*

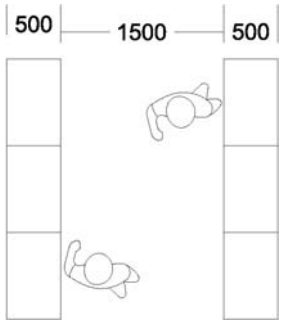


30.19b *8 seat*

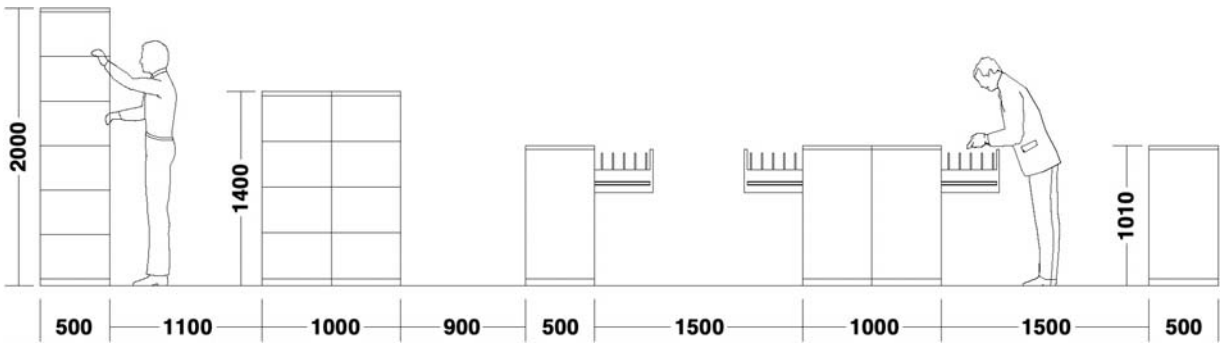
30.19 *Touchdown areas*



30.20a *Space requirement for lateral filing unit*

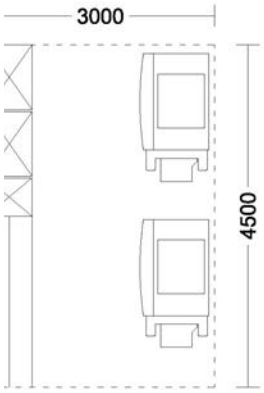


30.20b *Circulation required for lateral filing*

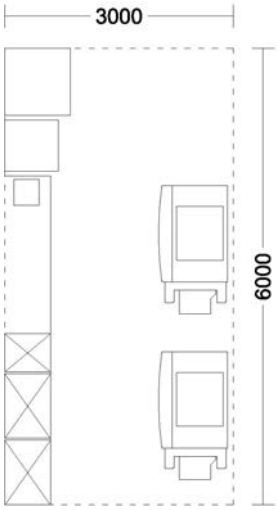


30.20c *Circulation and access to filing*

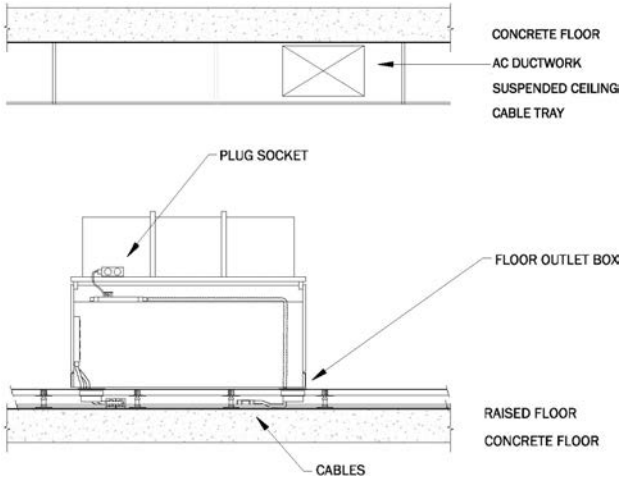
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



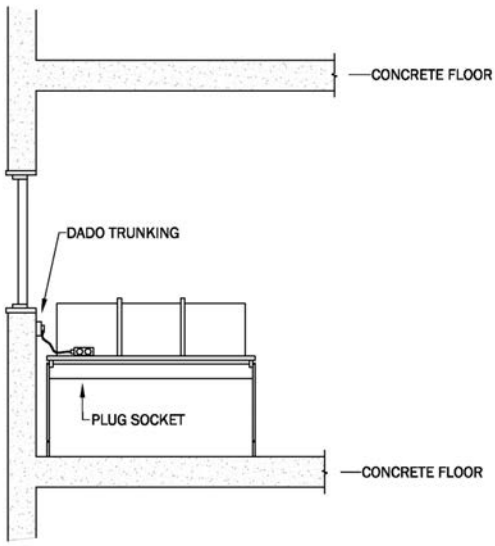
30.21a *Copy area*



30.21b *Copy and vending area*



30.22 *Raised floor services strategy*



30.23 *Perimeter ducting services strategy*

Two other methods have been used in the past, but are no longer recommended. Ducts in the thickness of the floor screed require service outlets above floor level; and these can only be adjacent to the duct positions. These totally control the placing of furniture and pedestrian routes. An even worse system is to have the cables in the suspended ceiling below the floor in question. This means that when changes have to be made, construction work has to be done on a different floor, which may be occupied by a totally different organisation.

8 TRADING FLOORS

8.1 Organisation

The model for trading floors regimented rows of desks, Figure 30.24, to condense the greatest number of traders in close proximity, primarily to promote face-to-face communication and facilitate the integration of technology.

8.2 Desk design

The desk footprint is affected by three factors:

- Ergonomics/BS standards
- Accommodating technology and equipment.
- Heat management.

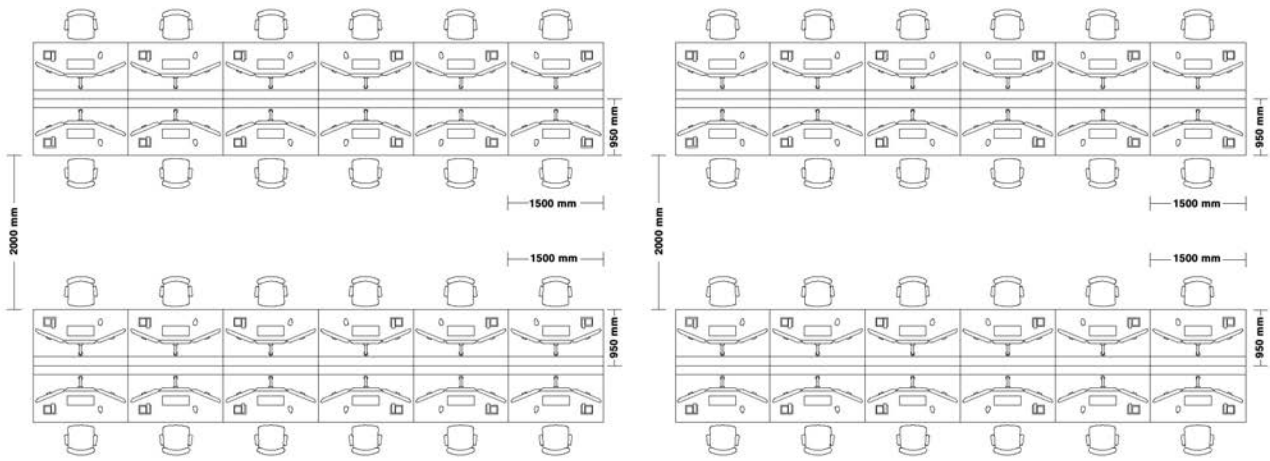
Ergonomics/BS standards

Refer to BS EN 527-1 for legroom, distance to screen and desktop space. This dictates a desktop of a minimum 800 mm deep, i.e. consistent with contemporary desk standards.

Screens and equipment

Desk design is driven by the number of screens, the preferred processing strategy (CPUs at desk or remote blade), and the requirement to incorporate a dealerboard:

- The on-floor cooling demand can be reduced by implementing remote processing which removes the primary heat source from



30.24 *Trading floor desks*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

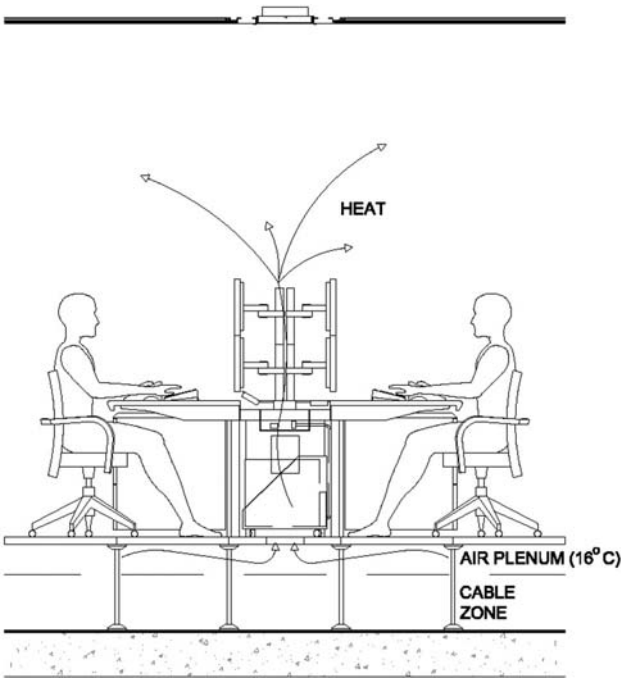
the desk to a central location where it can be more effectively managed.

- CPUs accommodated within the void beneath the desk remains the preferred processing solution, resulting in a 600 mm deep zone central to the desks to house standard PCs.
- Significantly, there has recently been a reduction in the number of screens required. There has been a shift from using multiple flat screen monitors sometimes stacked in a cockpit form to the introduction of only requiring 2 large format display screens therefore reducing the necessary width of the desk module. This has been made possible by improvements in HD providing accurate representation of on-screen market data.
- On-screen 'soft' dealer boards are now available on most trading platforms negating the requirement for a sizeable piece of kit on the desktop.
- Remote or cloud processing, particularly across wireless networks, is unlikely to have a significant impact on trading floor design due to the latency, (i.e. the fraction-of-a-second delays) experienced.

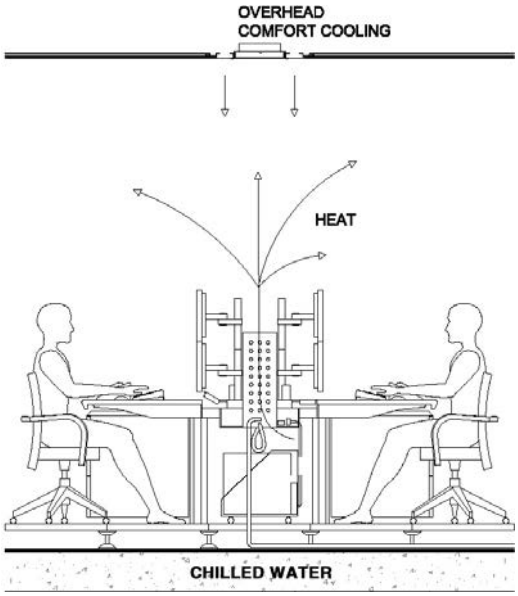
Heat management

Trading floors inherently generate a large amount of heat due to the amount of screens and processing equipment. Building services will require augmenting to manage this excess. There are primarily three solutions of conventional speculative office buildings:

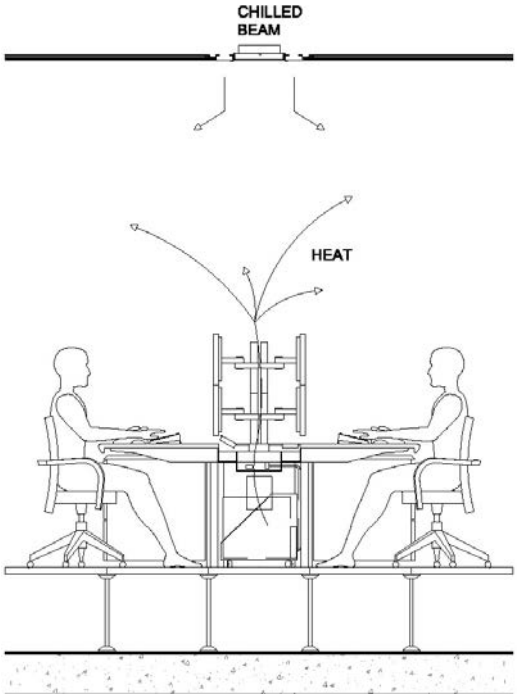
- Floor plenum – pumping cool air through the raised floor void to cool equipment within the desk void via outlets below the desks, Figure 30.25. This requires a sealed base to the desk and a minimum raised floor void of 300 mm.
- Overhead (Fan Coil Unit and/or chilled beams) – less efficient than other solutions when used in isolation, Figure 30.27. Performance can be improved by incorporating a 'chimney' to the spine of the desks to duct heated air away from the equipment housed in the desk to high level where it can mix with the cooler air.
- Cool desks Figure 30.26 – effectively housing a FCU within the central spine to the desk to circulate cool air around the CPUs/screens and deal with the heat at source. This is an efficient way to supplement existing building systems and means that standard speculative office buildings can be utilised for a trading operation since no increased floor void is required and there are reduced Category A enhancements at high level.



30.25 *Floor plenum*



30.26 *In desk cooling*



30.27 *Overhead chilled beam*

8.3 Future

Emergence of automated trading and a consequent need for technical developers to be embedded within trading teams has seen a shift from endless rows to more organic layouts, thereby promoting team organisation and interaction. Standardisation of desks, hardware and software also allows greater mobility of users, which is essential for project focused, team-based work.

Another consequence of the multi-function trading floor is the requirement for alternative, collaborative spaces around the periphery of the trading floor to support the interactive functions. This space was traditionally occupied by managers in offices, but these are increasingly likely to want to sit within their teams. There may be a requirement for a large flexible meeting room close by, or a broadcast facility, to allow the 'morning call' briefing session to be streamed live to traders' desktops.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

9 CONCLUSION – WORK AND THE CITY

Two apparently but not necessarily contradictory meta-trends need to be addressed, not just by architects, but by corporate clients as well as developers and their agents:

- The rising expectations of office workers, especially younger people, not just for higher standards of office accommodation but for more control of their use of time, workplaces and work styles, all of which are having a big impact on office design.
- Many clients and more importantly office workers are addressing the emerging reality that – with the emergence of new modes of working and new timetables made possible by ubiquitous information technology – it is no longer necessary to go to work in order to work.

Such changes raise fundamental questions not just about the nature and purpose of office buildings but about what kinds of urban development are likely to be appropriate to accommodate the knowledge economy.

As the twenty-first century progresses, conventional office developments and office buildings – mono-functional and based on strict timetables – are likely to be replaced by more permeable, responsive and mixed urban structures operating over very different timetables. What is already clear is that the city is far from obsolete – in fact very much the opposite.

10 BIBLIOGRAPHY

BCO Guide to Specification, British Council for Offices, 2014

Building Information Modelling for Commercial Office Buildings, British Council for Offices, 2013

Frank Duffy, *Work and the City (Edge Futures)*, Black Dog Publishing, 2008

Richard Hyde, *Sustainable Retrofitting of Commercial Buildings*, Routledge 2012

International Property Measuring Standard (IPMS) www.ipmsc.org

Anthony Speight, *The Architects' Legal Handbook, 9th ed*. Butterworth Architecture, 2010

Jeremy Myerson, Philip Ross *Space to Work: New Office Design*, Laurence King 2006

Nikil Saval, *Cubed: A Secret History of the Workplace*, Doubleday, 2014.

Juriaan Van Meel, Yuri Martens, Hermen Jan van Ree *Planning Office Spaces: A Practical Guide for Managers and Designers*, Laurence King, 2010

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

31 Payment and counselling offices

Richard Napier

Richard Napier is an Associate at Aedas Architects Ltd

KEY POINTS:
- *These are all facilities where security is a major consideration*

Contents
1 Introduction
2 General layout and design
3 Key components
4 Procurement

1 INTRODUCTION

1.1 General

This chapter covers retail banking premises, post offices, ticket desks and government services outlets which are generally characterised by: the need for security of staff, premises and public due to potential criminal activity where money is stored in quantity and exchanged or received over counters; where customers require privacy and discrete interaction with service providers; or where information which is exchanged is either sensitive or secure.

Due to the nature of design procurement for these types of buildings, this chapter provides a brief first point of reference for a designer who requires general guidance. It does not include details of functional space planning or fixtures and fittings, as that level of detail is now commonly provided by the individual organisations in their particular design manuals and brand templates.

1.2 Types

The building types and facilities included here are:

- banks
- building societies
- post offices
- foreign currency outlets
- ticket desks
- government services outlets
- ATMs and ATM lobbies
- interview spaces.

Common factors of all these facilities are the particular need for security for both staff and public, the requirement for surveillance and protection of the premises, and the balancing of those needs with the provision of accessible counter services and interview facilities.

1.3 Customer experience

What distinguishes these facilities today is the concept of customer-focused services, where the buildings are not designed to suit the internal operations of the organisations but to enable a more welcoming aspect and customer experience for the users. The need for additional security and application of technology have affected all these facilities; but as part of the modern high street retail offer, responses to lifestyle trends and the development of accessible government services, the open shopfronts of these buildings and the customer-friendly services and facilities they provide are key aspects in their design.

1.4 Banks

The way banks now do business and provide for customers' needs is referred to as Retail Banking, making them essentially more like shops than traditional banks. There is now less variation in the types of bank branch as they move towards providing a more uniform set of customer facilities and services. Branches now are likely to contain more ATMs than cashiers, and technological developments such as internet banking and the universal availability of ATMs in retail areas contribute to less dependency on tellers within banks for ordinary customer cash transactions.

The selling of additional products and services and the provision of more customer support services such as internet banking desks, rather than just over-the-counter money transfers, are a more dominant feature of bank branches today. Also, several main banks have merged in recent years, resulting in less competition, less variety of banks on the high street, and the development of new customer service concepts.

Because each bank organisation has its own corporate brand design manual, the figures below are indicative of the *principles* of current trends in bank branch layout.

1.5 Building societies

Building societies have become more like banks, if not actually taken over by mainstream banks. Consequently, they are following similar trends in branch design in terms of more welcoming layouts for their branches incorporating the same key components of reception desk, open-desk cashiers and open-plan customer meeting rooms. Many still retain the same requirement for secure screened cashiers, but they follow banking trends in provision of more ATMs.

1.6 Post offices

Post offices traditionally provided only counter services related to Royal Mail postal and ancillary business, but now provide a full range of financial services in order to compete with banks and insurance companies. Main city centre post offices now have a customer reception facility, automated ticket queuing operation, open counters, chip and pin cash dispensing, and premises generally provide a wider provision of stationery retail. Most main branches also provide foreign currency exchange.

There are an increasing number of sub-post offices which are operated as franchises within local shops, newsagents and supermarkets, and for security reasons those branches maintain the tradition of secure screened counters, albeit providing the same full range of postal and financial services as main city centre offices. As with banks, the detailed layout and facilities provided for the variety of post office sizes and locations will be specified within a design manual.

1.7 Foreign currency and money transfer outlets

Foreign currency outlets are now provided within a wide variety of locations and premises. These include international transport terminals (see Chapter 41), department stores and specialist retailers (see Chapter 35) as well as, of course, being a service provided within post offices. These facilities are basically secure screened cash exchange counters.

1.8 Ticket desks

Ticket desks in public facilities such as transport, sport and entertainment venues will often operate and be designed in a similar fashion to payment counters within banks. Such facilities would include:

- rail, bus and ferry terminals
- cinema, theatre and concert box offices
- events ticketing agencies
- public sports centres
- stadia and outdoor sports venues
- tourism attractions
- museums, art galleries and exhibitions.

As with banks, there will be a requirement in these buildings for ticket desk counters to provide secure ticket selling through protective screens or semi-secure open counters.

1.9 Government services outlets

The following additional types of similar facilities where interview and cash exchange are an essential function are:

- local government payment offices (Council Tax and Housing rent payment offices, etc.)
- DWP Jobcentre Plus offices
- DVLA offices
- HM Revenue and Customs offices
- regional Passport Offices
- Citizens Advice Bureau offices.

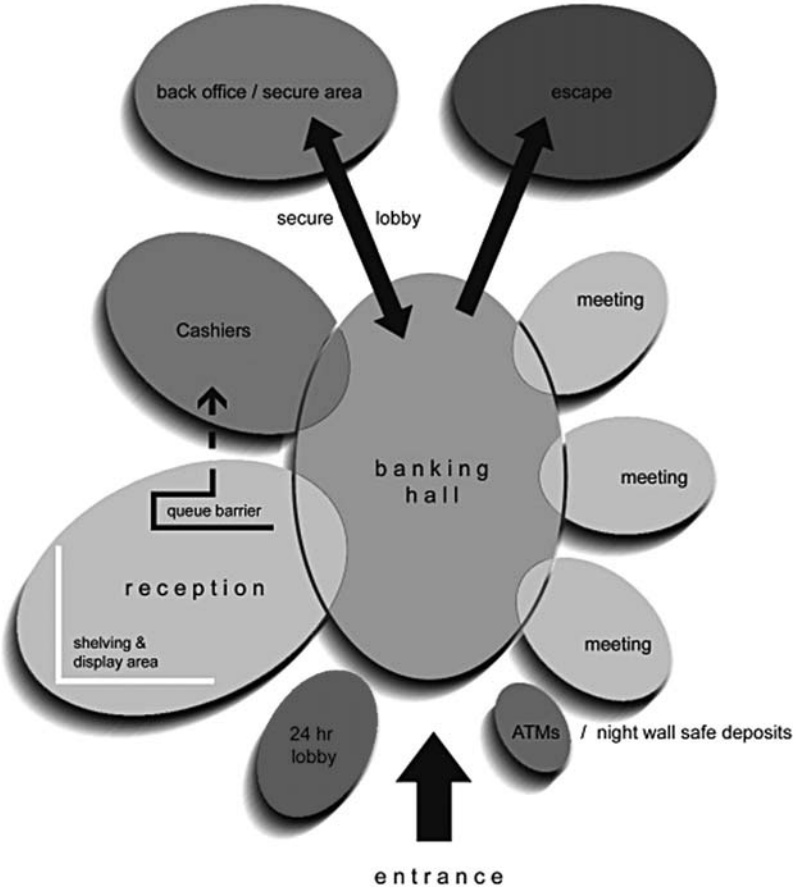
All of the above are likely to be included in many of the types of public buildings covered by Chapter 16 (Civic Buildings), but their designs are characterised by consisting of dedicated public counter services for either payment transactions, customer relations services or for the inclusion of customer interview and counselling rooms. They require similar levels of public access, security and counselling privacy as are provided in banks.

2 GENERAL LAYOUT AND DESIGN

2.1 Banks

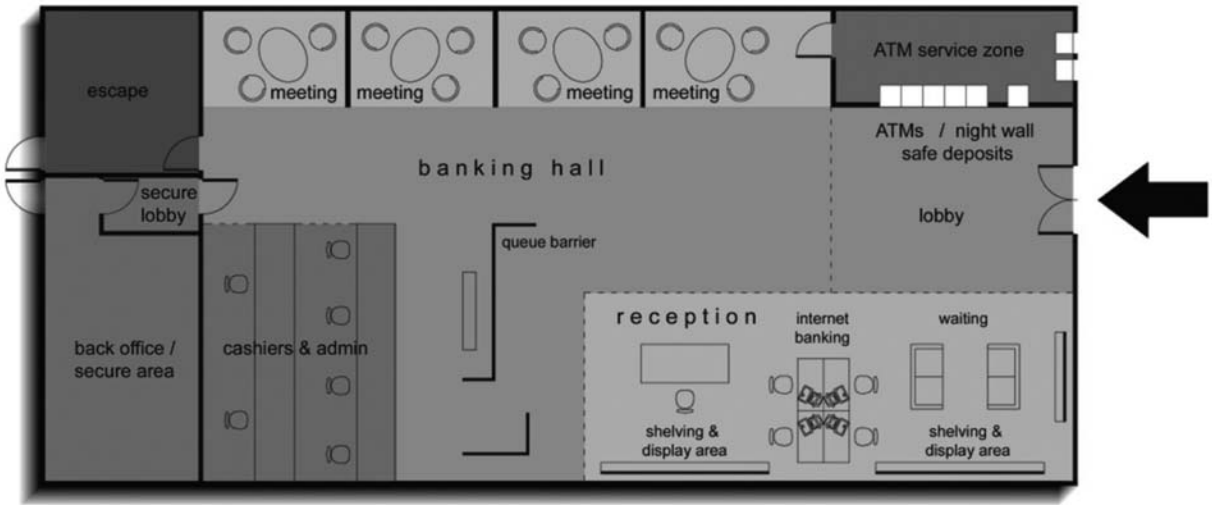
High street banks now are more like shops, following a high street retail concept. Whereas in previous decades banks principally comprised a relatively small banking hall fronting a secure line of screened tellers and vast back-of-house office areas, the trend now is for a much more spacious public area with reception desk and waiting area, open-desk cashiers dispensing limited amounts of cash, together with open-plan meeting rooms, and less need for administrative offices. Larger branches will still have secure cashier screens, particularly for business banking, but these will be arranged to one side or to the rear of the public zone.

Figure 31.1 shows the relationship and zoning for a retail bank; Figure 31.2 illustrates a typical current retail bank concept layout. Large shopfront windows aggressively sell their products and services, and spacious interiors give more floor space over to customer services and convenience. The shopfront contains a wide display of the bank's products and services, as well as a clear view of the public area, together with ATMs on the street. Some city centre banks still have a separate 24-hour lobby for ATMs; this is shown in Figure 31.10. However, the preferred arrangement in current retail banking is to combine a number of external ATMs on the street with a number of internal ATMs within the main public area. This reduces the security risks associates with late-night open lobbies.



31.1 *Relationship and zoning diagram for a retail bank*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



31.2 *Retail bank concept layout*

The main public banking area (about 70 per cent of the floor area) consists of:

- reception desk, which acts as a focal point for customers, in a prominent location in the centre of the main public area;
- waiting area with comfortable lounge seating;
- ATMs and cash/cheque deposit machine (some banks now include automatic pay-in machines accepting coins and cheques);
- internet banking terminals;
- open cashier counters and/or desks, which dispense limited amounts of cash, with space for queuing;
- customer interview/meeting spaces;
- enclosed customer meeting rooms.

Secure back-office area consisting of:

- secure screened cashiers, with space for queuing;
- ATM and deposit machine room;
- admin area with strong room for safes, for storage and handling of cash;
- staff room and toilets.

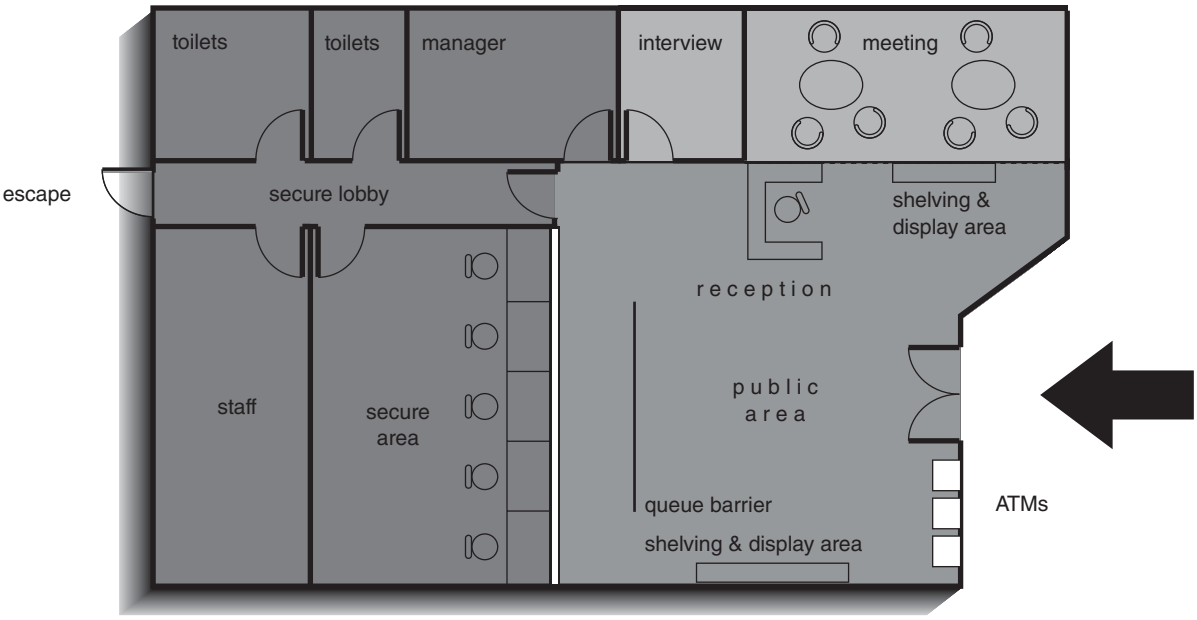
Architects and designers today are not required to provide an original design for a bank, but are expected to use their professional skills to integrate a set of standard designed components from a corporate brand manual into a site-specific project.

2.2 Building societies

The design of building societies now reflects that of mainstream banks. Smaller branches are still arranged with secure screened tellers, although the main public areas are much more customer focused in line with bank design trends, incorporating reception desk, comfortable waiting area and open-plan customer meeting spaces. Figure 31.3 illustrates a typical current building society layout.

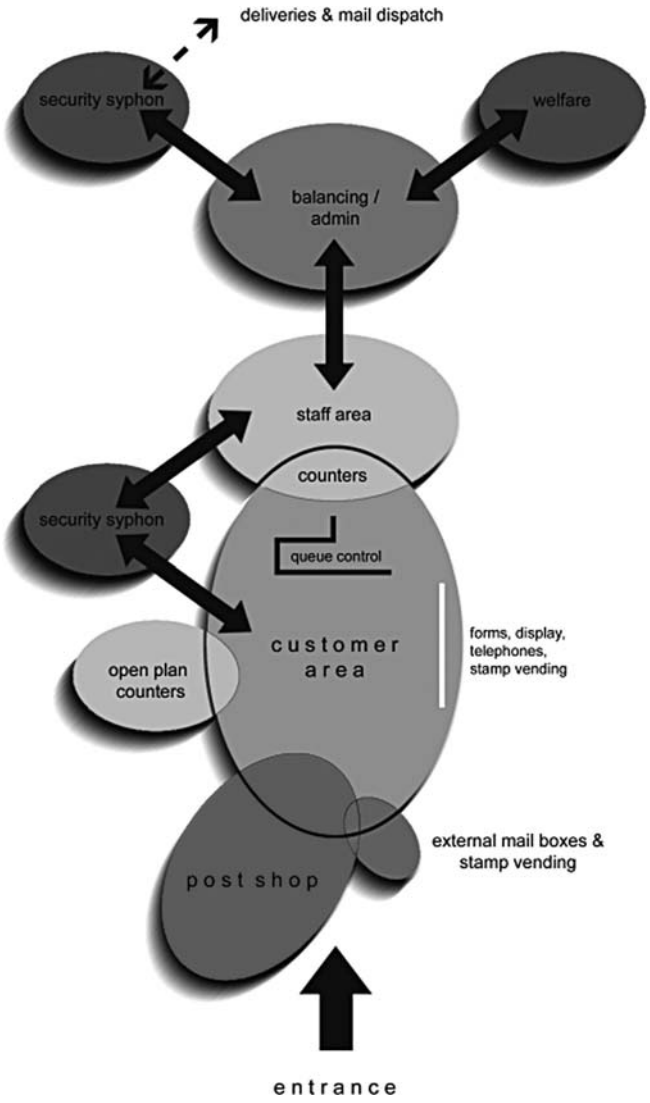
2.3 Post offices

The relationship and zoning for a typical main post office is shown in Figure 31.4. There will be a requirement for a strong room for storage and handling of cash, and for staff facilities, as with banks. Also as with banks and building societies, the post offices will be designed in detail in accordance with a corporate design manual to suit a variety of locations and sizes from a main city centre location



31.3 *Typical building society layout*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



31.4 *Relationship and zoning diagram for a post office*

to a local sub-post office operated by private enterprises as a franchise within a retail store.

Figure 31.5 shows the layout of a typical main post office which includes a sorting office and parcel-collect facility. The main public area of a city centre post office now includes a substantial stationery retail zone, and for the counter services there will be an electronic queuing system attended by a member of staff. The main counters will be open-style with chip and pin cash dispensing facilities, and a separate foreign currency outlet will be provided by means of a secure screen cashier as elsewhere. In sub-offices the counters will be behind secure screens.

2.4 Foreign currency outlets

Chapter 35 (Retail shops and stores) and Chapter 41 (Transport terminals and interchanges) make reference to individual retail components that are likely to be included with retail complexes. Payment counters within larger retail or transport facilities will include foreign exchange outlets. These are essentially secure screened cashier counters, designed in a similar way to those within banks. Figure 31.6 illustrates a typical layout.

2.5 Ticket desks

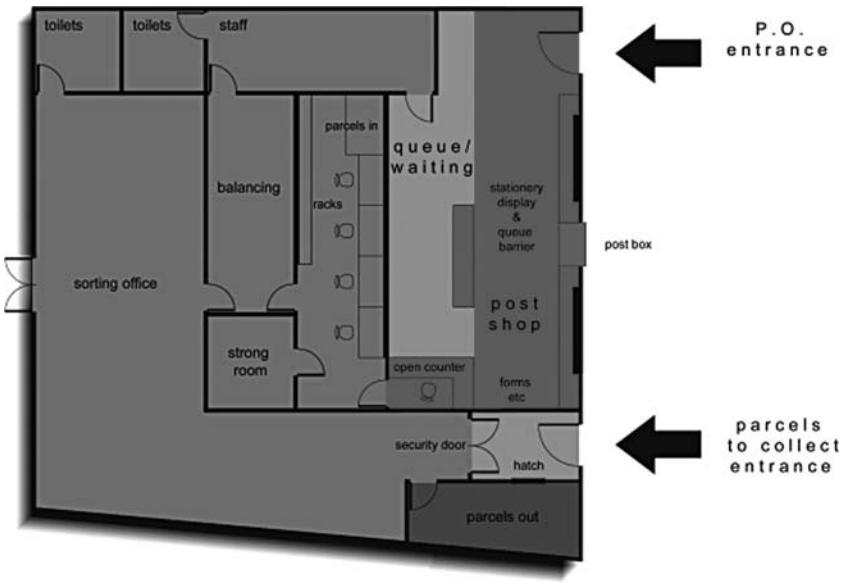
Travel centres such as rail and bus stations which provide booking services and issue tickets also require a similar kind of secure counter to those within banks. Matters concerning circulation, ticketing and retail are described in Chapter 41 (Transport terminals and interchanges), but the design of the counter component is covered in Section 3.3.

2.6 Government services outlets

Local authority council and other government or public offices which incorporate payment and counselling facilities include: Council Tax payment offices, local authority housing rent offices, DWP Jobcentre Plus offices, DVLA offices, HM Revenue & Customs offices, Regional Passport Offices and Citizens Advice Bureau offices. These buildings require a number of functions similar to those found within banks such as open-plan or enclosed customer interview rooms and payment counters. Design aspects of those elements are described in Sections 3.3 and 3.4.

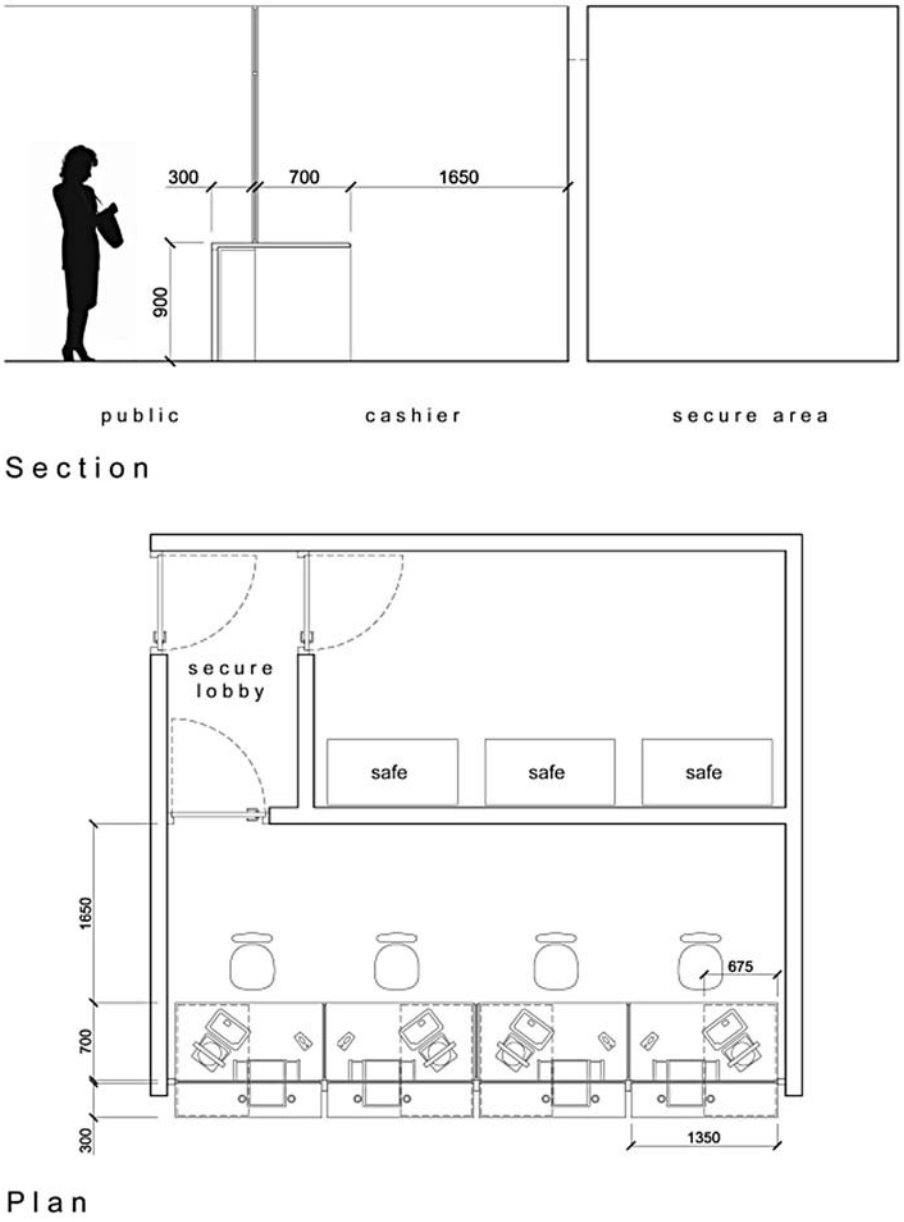
2.7 DWP Jobcentre Plus offices

As a type of government service outlet, the Jobcentre Plus, which is the Department of Work and Pensions' principal service for jobseekers, has been transformed in recent years to provide a more twenty-first-century high quality experience for users with modern, customer-focused services and facilities. Although its new system asks individuals to initially call a Jobcentre Plus call centre to register personal details, customers are then asked to attend an interview at their local Jobcentre Plus outlet. Its main function and attraction is its interactive computer system which can be accessed



31.5 *Post office layout with a sorting office and a parcel-collect facility*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



31.6 *Typical foreign currency outlet layout*

by customers using touch-screen computer terminals, together with the more customer friendly interview room facilities and services.

Figure 31.7 illustrates the zoning plan for a Jobcentre Plus office; Figure 31.8 illustrates a typical layout. In addition to accessible jobseeker terminals, the main customer reception area has a waiting area for interview services. This type of facility has a long history of having the potential for attracting aggressive customers, but with improvements in benefit distribution systems and jobseeker customer care, the Jobcentre Plus building is frequented by genuine customers making use of an essential service. However, security of staff and premises, customer privacy and discretion, and quality of service are still all key aspects of design for this building type.

3 KEY COMPONENTS

3.1 Automatic Teller Machines (ATMs)

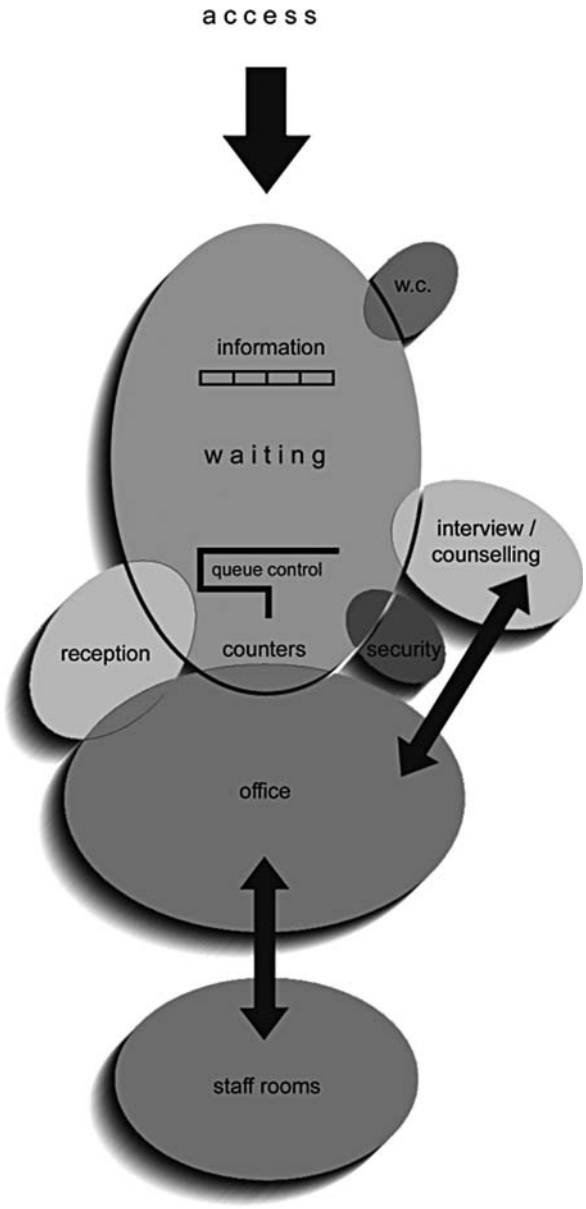
ATMs are a universal item on the high street, not only being a staple component within the exterior shopfront and interior of banks and building societies, but also being widely available within other public zones such as retail areas, entertainment complexes and transport terminals. Figure 31.9 shows the setting out requirements for an ATM. Within banks, it will be usual for several ATMs to be grouped together either on an external wall, on an internal wall in the main banking hall, or within a separate 24 hour lobby accessible from the street which has been a common element in city centre banks. The latter is described below, but the current trend in retail banking now is to omit any 24 hour lobby as this reduces the security risks and maintenance costs associated with late-night open lobbies.

ATMs require to be serviced from the rear for filling with cash or for maintenance via a secure room accessible either from within the bank's interior secure zone or from a lockable door. The latter is the case for all general ATMs located in retail or public areas. Level access is required to ATMs for people in wheelchairs, and where more than one ATM is provided at least one will be at a lower accessible level.

3.2 24 hour lobbies

A typical arrangement for 24 hour lobbies for ATMs provided by banks is shown in Figure 31.10. These will be directly accessible from the street, open during the day and accessible out of hours using a bank card. Although building societies are becoming more like banks, it is unlikely that they will follow the banking trend of recent years to provide 24 hour lobbies for ATMs due to the obvious risks.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



31.7 *Relationship and zoning diagram for a Jobcentre Plus office*

3.3 Counters

Figures 31.11 and 31.12 illustrate traditional forms of secure screened counters; Figure 31.13 shows an example of an open bank cashier desk for use in current retail banking. Payment counters which require secure screening for safety and security purposes will be fitted with bulletproof glass. Microphone and speaker systems allow for communication through enclosed glass screens, and a pass-through slot or tray is provided at counter level. For people in wheelchairs, at least one counter will be at a lower accessible level.

Where there is little fear of firearms risk, but where the possibility still exists for physical assault, i.e. in many government services outlets, counters can be designed to be higher or deeper than normal, making it difficult for the customer to reach over to the staff behind.

3.4 Interview and counselling spaces

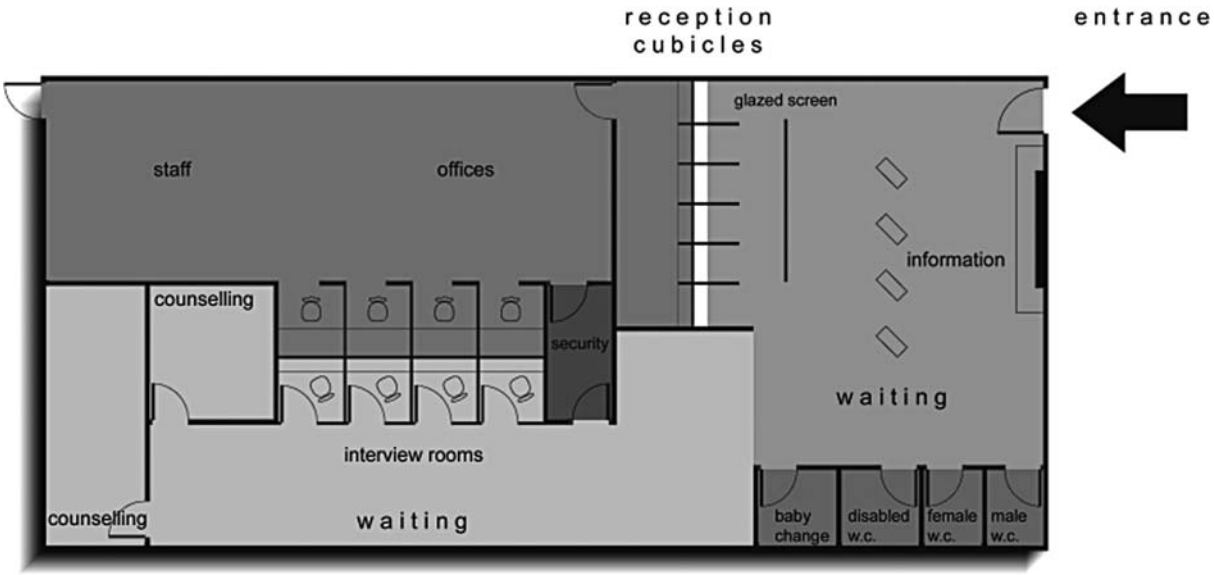
The majority of these building types provide customer interview facilities. These range from simple desks in open public areas, to open-plan interview spaces directly off a public space, to fully enclosed interview rooms. Banks and building societies tend to provide all three versions; post offices tend not to include any, apart from main city centre offices which are able to provide additional staff to advise on financial products; government services outlets usually require enclosed interview rooms, where there is commonly a need for privacy and customer sensitivity. All arrangements contain the same basic requirement of a desk or table with staff and customer seating, and these are illustrated in Figure 31.14.

3.5 Fixtures and fittings

Fittings in these buildings will be bespoke items provided by furniture manufacture specialists to corporate brand designs and specifications. Furniture design will therefore not usually be within the scope of the architect's work, and so this chapter does not cover the detailed content and functional requirements of fixtures and fittings. The organisations who procure these buildings will have their own design manuals of standard designs or proprietary specifications for fittings and equipment. However, there are key components such as counters and public accessibility issues which are required to comply with relevant legislation, and which therefore require careful dimensional location considerations.

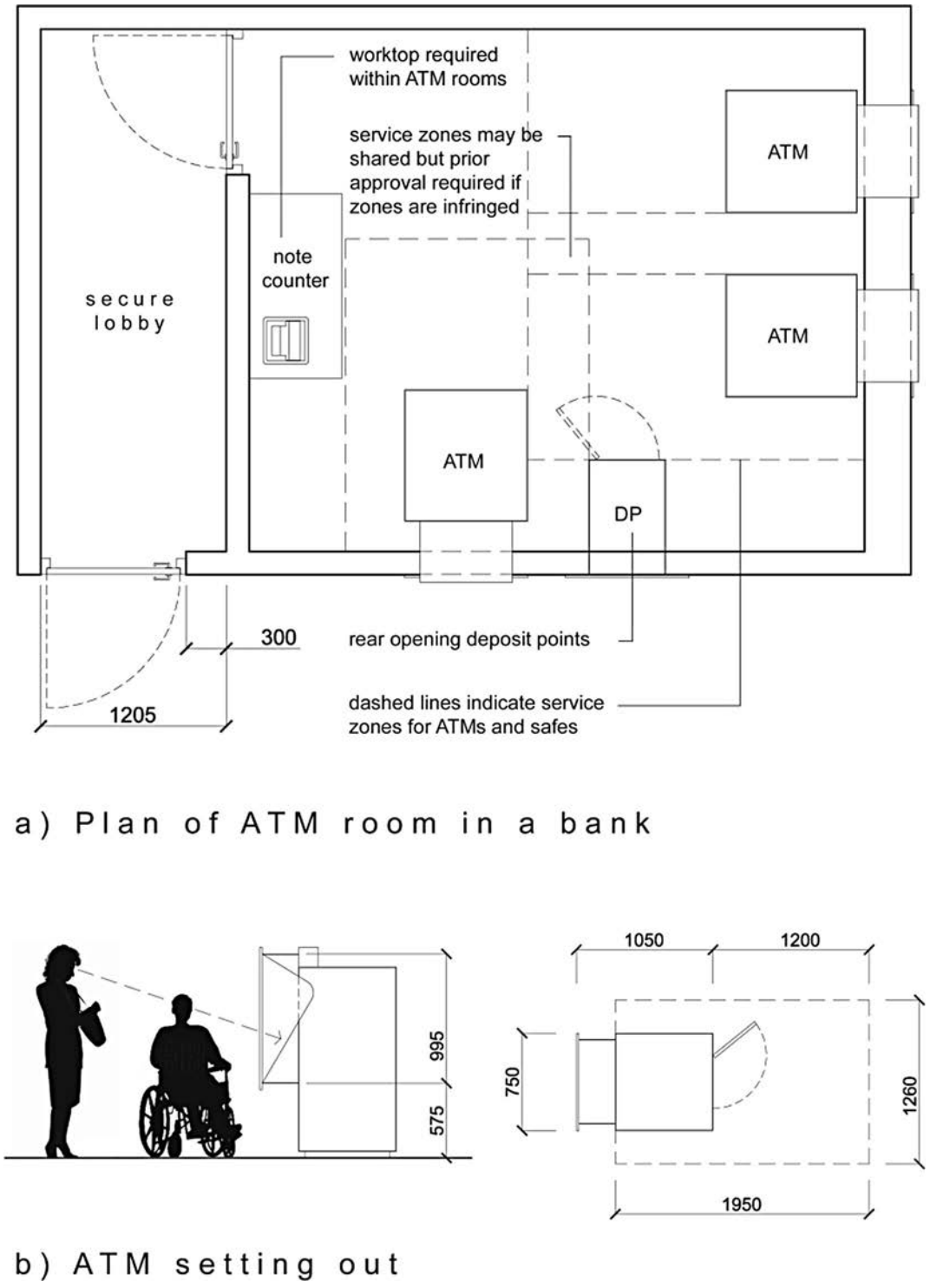
4 PROCUREMENT

Gone are the days when an architect will be commissioned by a bank to design a bank branch. Banking corporations will each have their own in-house property divisions who will have separately commissioned brand design manuals for branch concept designs and details, for use



31.8 *A Jobcentre Plus office*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



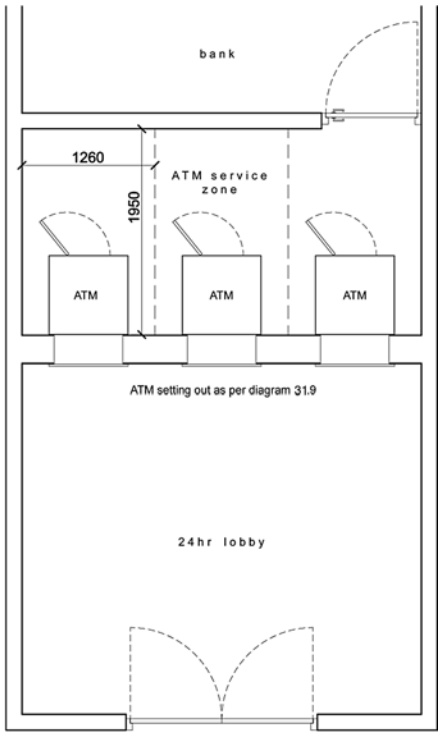
31.9 *ATM setting out*

by architects and designers to be applied to any design project involving the fitting out of an existing bank interior as a refurbishment or the fitting out of a new build retail unit. The brand concept manual will comprise standard bank branch layouts to suit differing locations, and detailed designs for all necessary interior components down to signage and items of furniture and office equipment: all designed by others as a menu of components to be applied by specific project designers.

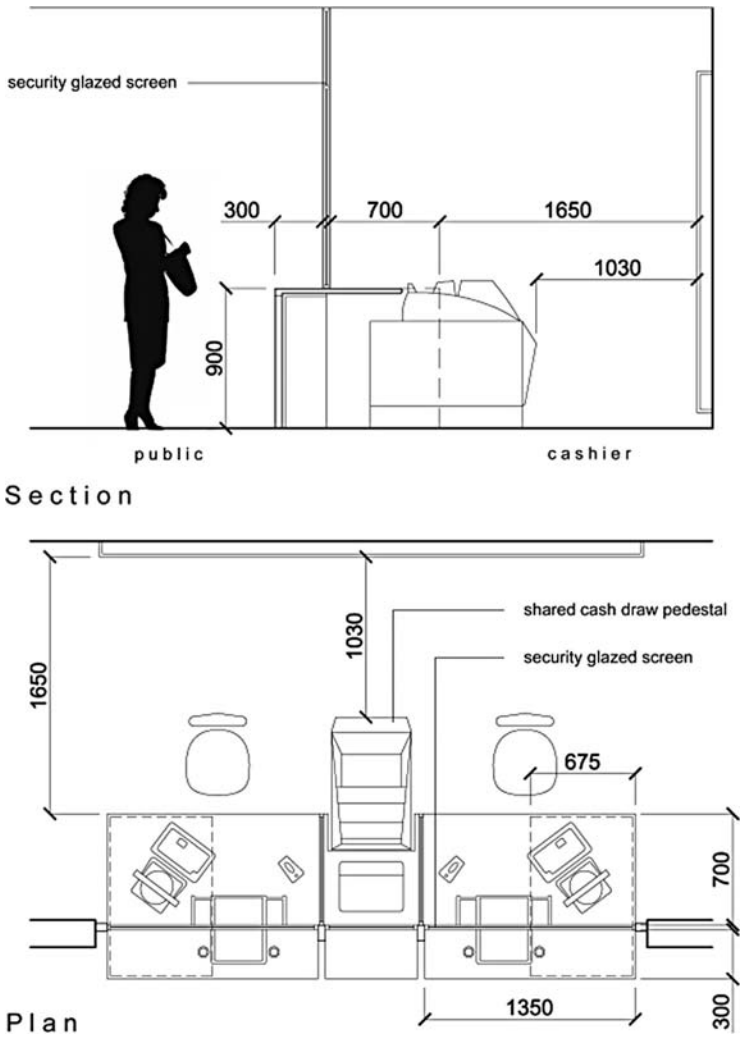
Design teams are likely to be appointed by specialist fit-out contractors who will be appointed through a design and build framework to project manage the design and construction works for the procurement of a number of projects; for that purpose a specific design manual brief will be supplied. Architects' and designers' scope of work will therefore be to apply the standard designs to a specific site and obtain the necessary statutory approvals for its execution. Similarly, building societies, post offices and specialist outlets such as foreign exchange counters will be procured to specialist fit-out contractors who will employ design consultants to apply standard designs to specific sites.

For government services outlets, design and construction projects will be procured through official government contract procurement portals such as OJEU notices and/or OGC Buying Solutions methods. Local authority and government departments will, via such public procurement methods, either appoint single consultants or contractors to individual projects, or through framework agreements appoint a number of suppliers of design and/or construction services to procure a variety of larger and wider strategic projects within any specific geographical local authority area or national project scope.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

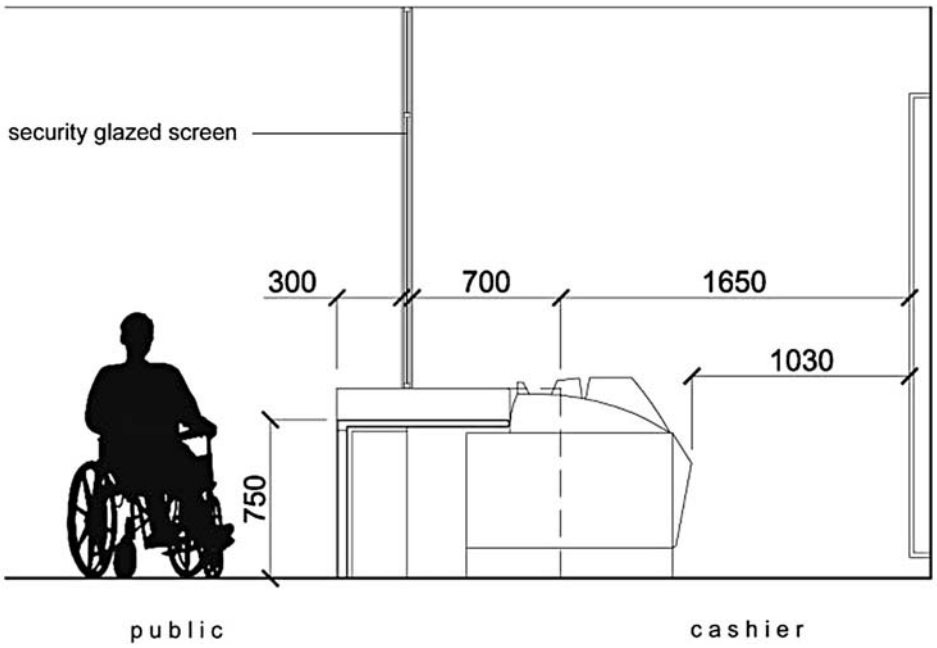


31.10 *ATM 24 hour lobby layout*

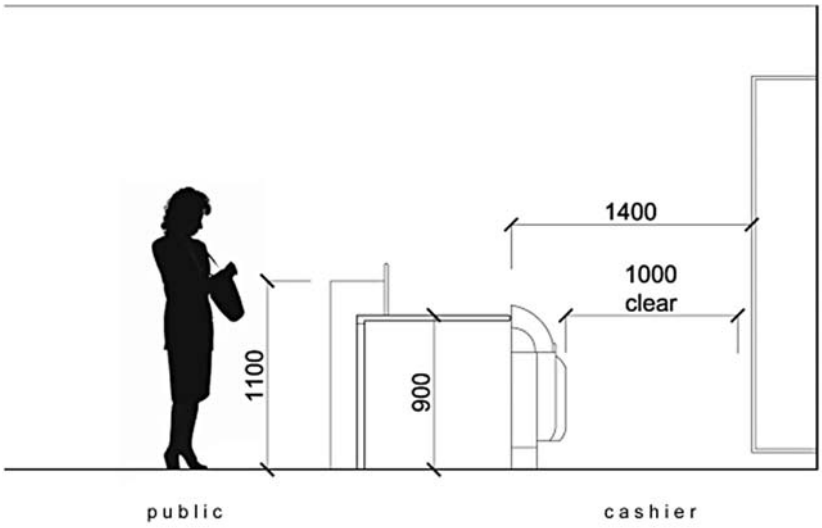


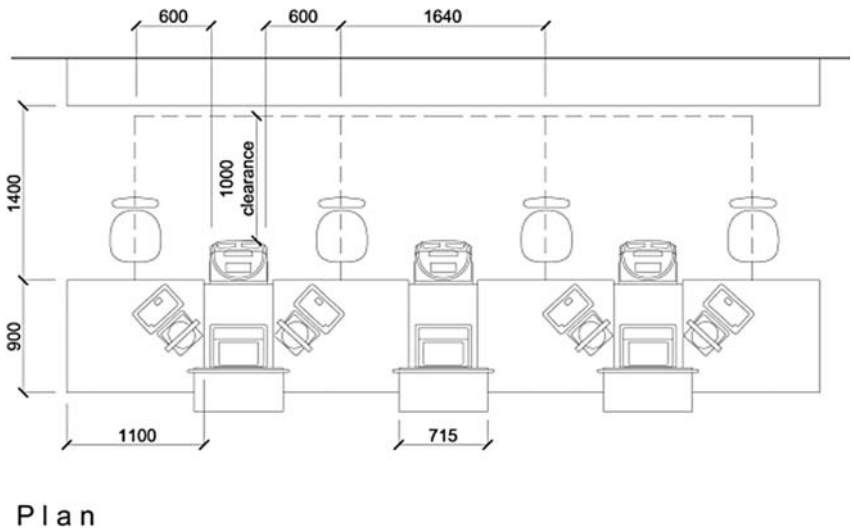
31.11 *Secure screened counter*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



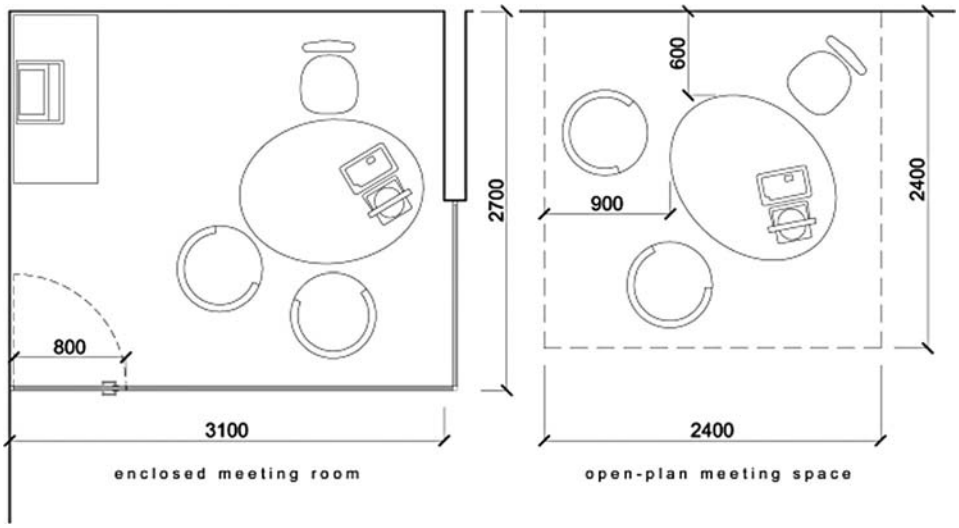
31.12 *Secure screened counter at lower accessible level*





31.13 *Open bank cashier desk*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



31.14 *Customer interview space*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

32 Places of worship

Leslie Fairweather, Ian Brewerton, Atba Al-Samarraie, David Adler and Derek Kemp

CI/Sfb: 6

The section on Church of England buildings was revised by Maurice Walton in 2011

KEY POINTS:

- *Architects engaged with religious buildings and places of worship will inevitably be concerned with tradition and ritual to a greater extent than with buildings of other types*
- *Often, within churches or other Christian buildings, new architectural interventions concern the addition of secular/community spaces which allow the parish to extend its social reach and perhaps generate funds*

Contents

1 Introduction

Part A Guide to Christian denominations

2 Church of England
3 Roman Catholic Church
4 United Reformed Church
5 The Salvation Army
6 Methodist Church
7 Baptist Church and Baptistries
8 Society of Friends
9 Pastoral centres

Part B Design data

10 Altar or communion table
11 Sanctuary furniture and pulpit
12 Font
13 Reservation of the sacrament
14 General arrangements
15 Vestries and sacristies
16 Confessional
17 Organ and choir

Part C Non-Christian places of worship

18 Synagogues
19 Mosques
20 Hindu temple
21 Sikh gurdwara

Part D Additional information

22 Crematoria
23 Bibliography

1 INTRODUCTION

1.1 Scope

This chapter will cover churches and places of worship for various Christian denominations, synagogues, mosques and Hindu temples. Places of local worship only are dealt with, not larger buildings like cathedrals or those with social spaces, which are not significantly different from social spaces in secular buildings, and for which Chapter 17 (Community centres) provides further advice.

1.2 History and tradition

In the architecture of places of worship for the more established denominations the architect is bound to be more concerned with tradition than in other fields. Users are more conscious of history (and more sensitive about it) than most other clients: they will not allow an architect to ignore established precedents and will expect a full understanding of them. However many of the new 'Community Churches' expect to see a different approach more akin to performance architecture than established precedents. These new movements have also had a major impact upon the more established denominations and have resulted in a movement away from one-man ministry to more participation by members of the congregation. Large free-span structures are required to accommodate large congregation numbers, seating capacities of 500–1000 are not uncommon for which the conversion of redundant retail warehousing and similar structures are ideal.

Exact details of the forms of worship and building procedures should be discussed with the individual clients, and the architectural implications thoroughly understood. A fairly detailed general guide to the history, procedures and forms of worship (with architectural implications) of the Church of England, the Roman Catholic Church, the Presbyterian Church, the Salvation Army, the Methodist Church and the Society of Friends, is given in Church buildings, originally published as a series in The Architects' Journal and later in book form (now out of print).

1.3 Local ecumenical projects

Some protestant churches, particularly Methodist and United Reformed Church, are now uniting to form Local Ecumenical Projects (LEPs), both as a visible expression of church unity and in recognition of declining numbers and reducing resources. In these, the uniting congregations may either continue to worship separately in shared premises, or may unite to form a single congregation recognising the practices of each of the participant denominations. The building may be either that belonging to one of the congregations or (rarely) purpose built.

1.4 Additional factors

Such projects are set up under the Sharing of Churches Act which imposes some legal requirements in addition to the particular requirements of the participants. This may be relevant to designers, as the investment of capital in buildings is one of the areas dealt with in the Act. For every LEP there will (or should) be a formal 'Sharing Agreement' which sets out its terms. Architects involved in LEPs should take considerable time and care in formulating the brief, as there are often natural tensions within such a project.

Part A Guide to Christian denominations

2 CHURCH OF ENGLAND

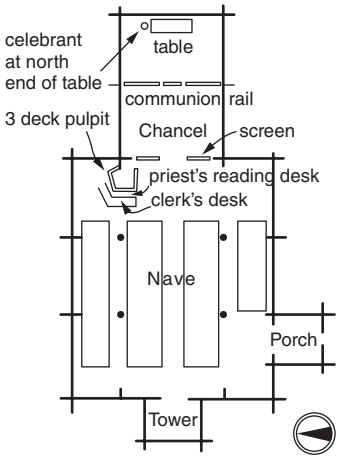
2.1 The buildings, and how they are used for worship

After the Reformation the Church of England inherited many medieval, mostly Gothic, buildings, strongly directional in their east–west orientation and with the main action remote from the congregation. The people therefore had lost the sense that they were engaged with the clergy in a common action and tended to become spectators with an individualistic rather than a corporate

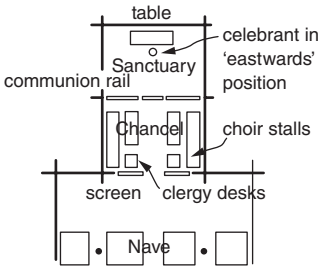
response to the liturgy. The church has now moved into a period of experiment with a fuller expression of the corporate nature of worship and the equal importance of the Word (which must be heard) and of Sacrament within a building which remains true to the Anglican sense of proportion.

2.2 Altar (or table), priest and people

The influences of the Reformation and later the Oxford Movement have produced variations to the layout of the sanctuary. The Book of Common Prayer (BCP 1662) assumes the table, or altar, to be against the east wall with the priest standing at the north end, Figure 32.1.



32.1 *Communion table is placed against east wall, priest stands at north end*



32.2 *Eastward position: priest faces altar with his back to the congregation*

In many churches this has been superseded by the priest facing east, Figure 32.2.

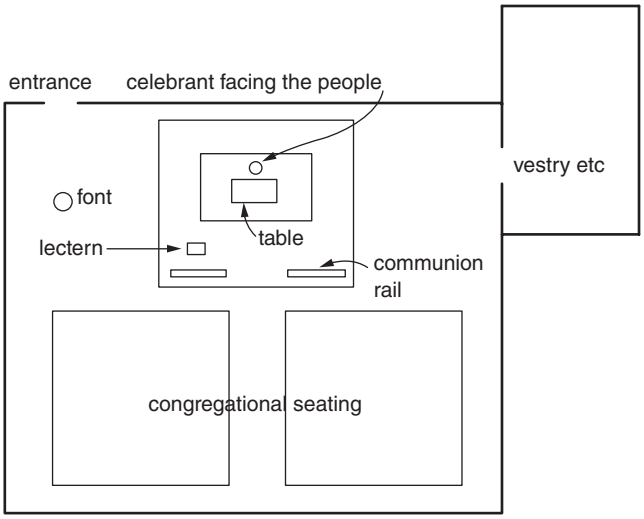
This was thought to be contrary to the spirit of the Anglican liturgy. Altars were moved west with the priest facing the people across the altar, Figure 32.3.

More recently there are churches which bring the people even closer to the celebration by positioning the altar in the centre of a square or circular building, with seating on three sides. Figure 32.4 shows the plan of the Church of St Paul at Bow Common in London (1960 Architect: Robert Maquire and Keith Murray).

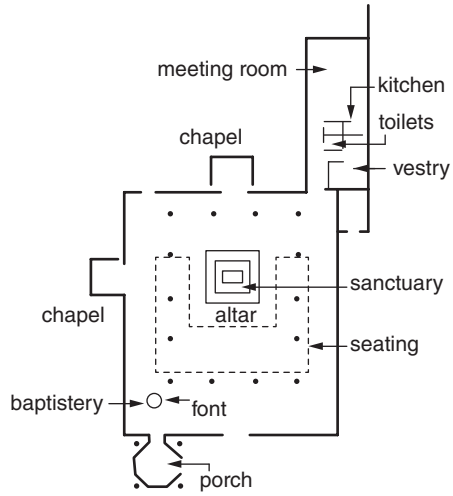
2.3 The main services

There are several types of service:

- All Age Services
- the Eucharist
- the offices of matins and evensong
- Baptism
- Confirmation
- the solemnisation of matrimony
- Burial of the dead.



32.3 *One of the many variations of plan where the priest faces the congregation across the altar. The seating may extend around three sides of the altar*



32.4 *Bow Common*

2.4 Church design

Apart from the altar, the general principles of layout and design are the same as for the Roman Catholic and Methodist Churches. These are described in Sections 3, 4 and 6. These sections also give appropriate space requirements for aisle widths, pew sizes and areas within the sanctuary.

2.5 Alterations and extensions to existing churches

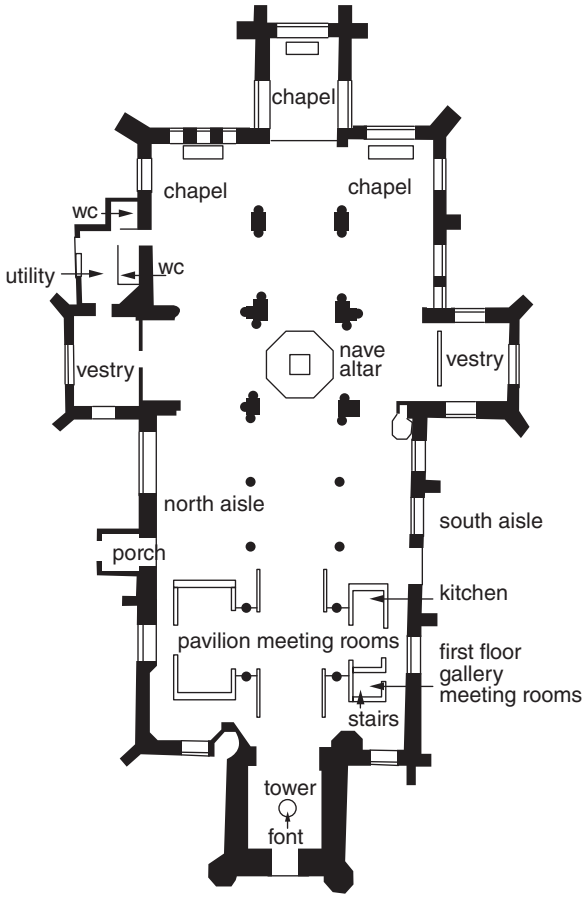
Although some new churches are being built the majority of works are for the provision of community facilities, meeting rooms, toilets and kitchens. In listed buildings any proposals are judged with great scrutiny by the DAC and English Heritage. Recent decisions suggest that proposals that are reversible and do not encroach on the existing structure are favoured. The following examples illustrate different approaches.

Church of St Andrew, Farnham (Architect Ptolemy Dean Architects Ltd., see Figure 32.5)

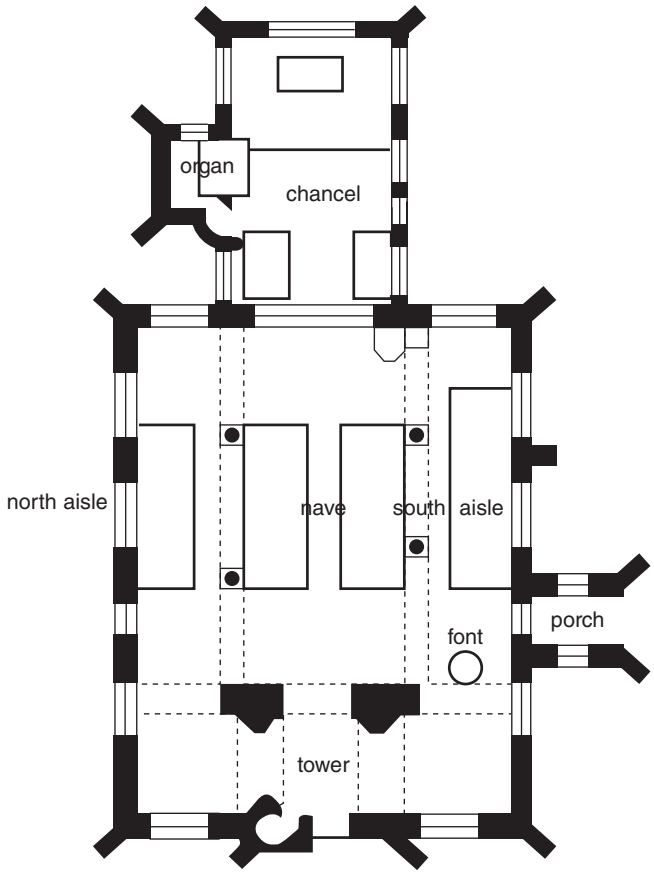
Advantage is taken of the large floor space to create a glass and timber two storey pavilion structure at the west end of the nave and the two aisles taking no support from the existing fabric. The pavilion encloses meeting rooms and a kitchen with a viewing and meeting gallery over. The altar is in a centre position with seating on all four sides.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

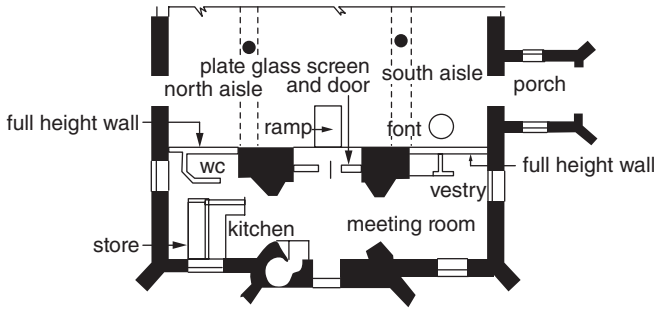


32.5 *Plan of Farnham*



32.6 *Church of All Saints Flore, original plan*

Church of All Saints Flore, (2001, Architect: Stimpson Walton Bond, see Figures 32.6 and 32.7)
A mediaeval church with a Georgian flat ceiling. Walls are plain with cornice and panelled dado. The two aisles flank the west tower. The full width of the west end is separated from the aisles by full height walls, and the mediaeval tower arch glazed creating a meeting space, toilet, kitchen and vestry.



32.7 *Church of All Saints Flore, plan after conversion*

2.6 Obtaining a faculty

There are several considerations to bear in mind when securing a faculty for church building work:

- New, extensions and repair works are subject to faculty, an approvals procedure dating back several centuries.
- It was consolidated in 1993 by the *Care of Churches and Ecclesiastical Jurisdiction Measure Code of Practice* granting exemption from Listed Building Consent for work to Grade I and II* listed church buildings.
- The Measure is administered in each Diocese by a Diocesan Advisory Committee (DAC).
- The process is often initiated by a site visit with the PCC and the Architect followed by preliminary and detailed submissions to the DAC.
- If there are no objections the DAC informs the Parish and the Chancellor of the Diocese to whom the Parish submits a formal request for a Faculty. The Chancellor is a judge or a QC.
- Exemption is only from Listed Building Consent. External alterations may be subject to Planning Approval from the local Planning Authority.
- Either the DAC or the Chancellor may refer the proposals to an appropriate conservation body such as English Heritage whose observations may or may not be accepted by the DAC or the Chancellor.
- Other major Christian denominations have their own similar exemption procedures.

3 ROMAN CATHOLIC CHURCH

3.1 Worship as a corporate act

The term 'Roman Catholic' (or to members simply 'Catholic') denotes the Christian community which has continuously accepted the authority of the Pope. The chief problem of a community which is building a Catholic church is that, though its building must suit the liturgy as it now is, community and architect must also make some estimate of what the total ultimate change in form of services is likely to be.

The corporate nature of Catholic worship is again now being stressed. Catholic churchgoing has for centuries been highly individualistic. The congregation should participate in the liturgical action and not merely watch it. Baptism is being restored as the corporate act of the local assembly: but it is still conducted as a private ceremony held at a time to suit the parents and which only they and their friends attend. The architect must make corporate baptism possible in a church, even though it may not be practised for some time.

The existence of societies within the parish is always important in its social life and the architect should find out which they are, what they do, and whether they are to be accommodated in any way.

3.2 The main services

The six main services of the Catholic church are:

- Mass
- the Easter liturgy (Holy Week ceremonies)
- Baptism
- Marriage
- Burial of the dead
- Devotions.

Other liturgical activities include: blessing, dedication, consecration, confirmation, ordination.

3.3 Church design

Apart from the altar, the general principles of layout and design are the same as for the Church of England. These are shown, with separate altar details, in Part B.

4 UNITED REFORMED CHURCH

4.1 Origins and buildings

This was established by the merger of the Presbyterian Church of England and the Congregational Church of England, followed by most of the Scottish Congregationalists. It also merged with the Churches of Christ a few years ago. A number of English Congregational Churches did not join the United Reformed Church (URC) and continue as the Congregational Union.

4.2 Presbyterian

The Presbyterian Church of Scotland (PCS) remains separate; it claims to be a continuation of the Celtic church.

During the reformation one of the leaders, John Knox, became greatly influenced by the Swiss John Calvin and it was basically his system of church government and structure, as well as much of his theology, which he brought into the church. This system of church government by courts, basically government by the members of the church congregation, is known as 'presbyterian', as opposed to 'episcopalian' which is government by an appointed hierarchy.

4.3 Ways of worship

The Reformation established the doctrine of 'the priesthood of all believers': it was not necessary for any human being to come between God and a worshipper, and the only mediator accepted was Jesus Christ. There is therefore no good theological reason for a chancel in its literal sense of a 'railed-off area' in a URC or Presbyterian church.

All take part in the full worship and sacramental act. The sanctuary or chancel area is therefore now simply where the central act takes place, but the congregation are essentially participants in that act and the nearer they are to it the better. There is now a fairly general departure from the earlier rectangular form of church in favour of a more open form where the sense of gathering the people round the Word and sacrament, as represented by the pulpit and communion table, can be expressed.

Present thinking seeks to emphasise the close links between the worship room and the rooms for secular purposes, so that there may not be a complete divorce between the weekday and Sunday activities of the congregation. The economic situation may well lead to multi-purpose buildings where only a portion is kept entirely for worship, while the rest is used for other purposes, with the use of partitions and screens.

4.4 The main services

There is a wide variety of practices within the URC (reflecting Presbyterian, Congregational and Churches of Christ practices), and local churches can adopt their own practices. The types of services normally held are:

- normal morning public worship
- evening worship, which increasingly is taking a variety of forms, or may be largely a repetition of the morning service
- as above with addition of one or other of the sacraments, holy communion or baptism
- as above, with ordination of elders or admission of new communicants
- marriages.

Funeral services are infrequent.

Following the merger with the Churches of Christ, the URC now recognises and practises both that denomination's adult baptism by immersion (for which a baptistry is required, see Section 7) and infant baptism using a font.

4.5 Minister

The ordinary conduct of worship is left almost entirely to the minister who may choose to remain in the pulpit for the whole service or may take part of the service from a prayer desk or a lectern, or from behind the table, using the pulpit only for preaching. The minister may move from the pulpit to the communion table to receive the offering, and will certainly do so to administer the sacrament. The font will of course be used for administering baptism, and the front of the sanctuary steps for admission of new communicants or for ordination of elders.

4.6 Church design

The elders in the URC (and the members of the Kirk Session in the PCS) normally sit among the congregation. While there is great variety in the way services are conducted, most of the speaking is normally done by the minister. The congregation sit for prayers and do not kneel in the pews. The pews are seen as an extension of the communion table, so the congregation is, in effect, sitting around the table. Worshippers remain in their seats throughout the services, the elements of communion being passed around by the elders.

Baptism must take place in the face of the congregation and the font or baptistry should therefore be visible to all. The font should be in advance of, and probably to one side of, the communion table and at a slightly lower level. It can be movable but should have a permanent site in the sanctuary. It need *not* be at the entrance to the church. There are no special design requirements for Christmas or Easter services.

A central aisle is desirable for marriage ceremonies.

The choir should be visible to the congregation but should not be in the sanctuary.

There is little social activity connected with worship but ancillary accommodation for social and educational purposes may be needed outside the hours of service.

Many aspects of design are similar to those for the Church of England. The main differences are listed below:

- The communion table is a table and not an altar. It is usually rectangular but other shapes are not precluded. Basic sizes are given in Section 10.
- A large lectern is not essential but where provided should be to the sizes shown in Section 11. Sometimes pulpit and lectern are designed in one piece with upper and lower levels.
- Pulpit may be centrally in front or to one side of the table or, more rarely, behind the table. It should not be more elevated than is required for the congregation to see the preacher. General design is as shown in Section 11.
- A chair for the minister is provided centrally behind the communion table with often at least one additional chair on each side for elders. Alternatively seats for elders may be provided against the back wall of the sanctuary.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

- A meeting room should be provided in addition to a vestry. This is where the elders (or the Kirk Session in the PCS) meet before services and where communion is prepared.

5 THE SALVATION ARMY

5.1 Origins

The Salvation Army arose from evangelical meetings conducted in east London during 1865 by the Reverend William Booth, a minister of the Methodist New Connection. Booth decided to take the church to the people. His services were held in the open air, in tents and in theatres: later he built barracks and citadels in which his converts could hold their meetings. His services were sensational: he used brass bands playing secular tunes to accompany hymns; converts (soldiers) wore uniform. He became a 'general' and directed the organisation in quasi-military style. Men and women had equal rights in office. Booth regarded social work, care of the poor and rehabilitation of the outcast as an essential part of his Christian mission.

The Christian mission, as it was first called, grew beyond all expectations and in 1878 became known as the Salvation Army. In its belief, it is orthodox, evangelical and prophetic. The corps assembles for worship in a hall – a multi-purpose building sometimes called a citadel, temple or barracks. Sometimes within the complex there are two halls, for senior and junior soldiers respectively. Religious services and social activities may be conducted in either or both halls.

5.2 Ceremonies

Ceremonies may be divided into two types:

- Ordinary services held on Sunday – morning, afternoon, and evening
- Ceremonies applicable to marriages, funerals, memorial services, covenants, swearing-in of soldiers and presentation of colours (these may be embodied within one of the ordinary meetings).

The architectural implications are shown in Figures 32.8 to 32.13.

5.3 Design of the assembly hall

There will be no communion service and visually there will be no elevation or placing of the sacred elements in a part of the building. The font, lectern, pulpit, communion table and altar are not essential to the Salvation Army form of worship. In every Salvation Army hall there is a place for the mercy seat, Figure 32.14. This is a simple wooden form, usually placed at the front of the platform in front of the congregation, and is a place where Christian and non-Christian penitents may kneel at any time.

Platform

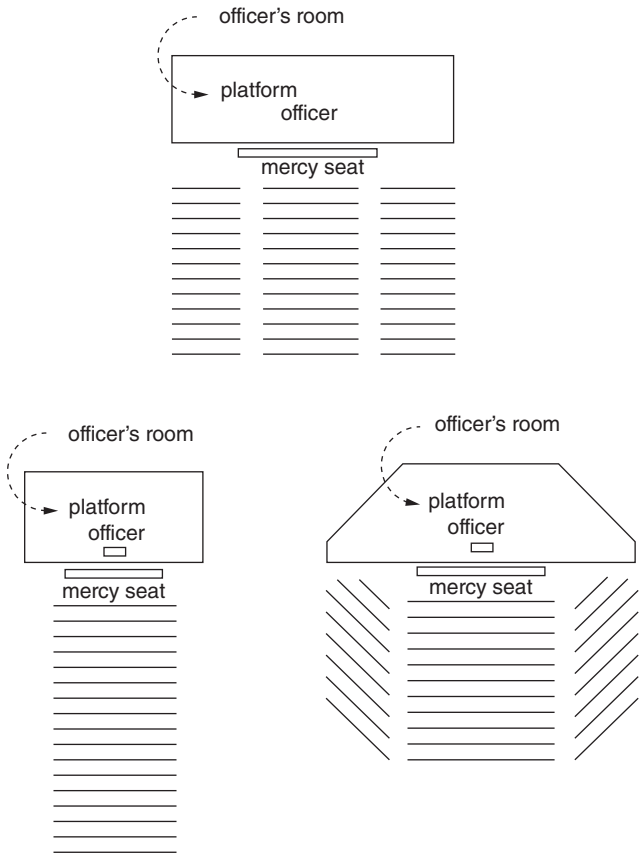
The platform will be required to accommodate, at various times, officers taking a leading part in the services; the band (possibly a visiting one which may be larger than that designed for); the songster brigade or a visiting choir.

The size of the platform will depend on local conditions and requirements but approximately 0.5 to 0.6 m^2 per person (seated in rows) should be allowed. The platform should not be less than about 4–5 m depth, but will normally be more. Its height above the hall floor should not normally be less than 760 mm or more than 1100 mm but sight-lines must be considered in relation to a level floor both on the platform and in the hall.

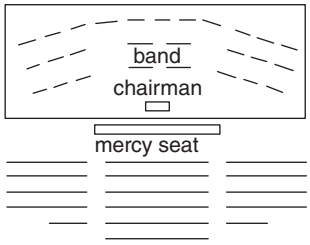
If there is a gallery there must be a view of the mercy seat from every seat. Movable seats, not fixed pews, are always used both on the platform and in the hall: flexibility is important.

Hall

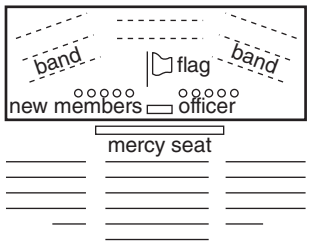
As a first estimate for the overall area of the hall, allow 0.56 m^2 for each person to be accommodated. Aisles should not be less than 1.35 m wide. The space between the front edge of the mercy seat and the front face of the congregational seating should not be less



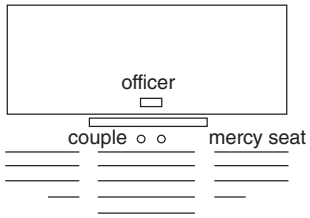
32.8 *Salvation Army: possible basic arrangements. Note that access from officers' room to platform may be on either a side or rear wall*



32.9 *Praise meeting or festival*

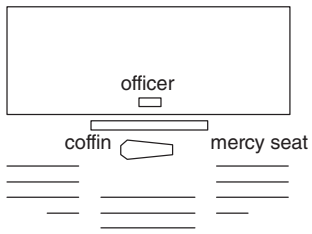


32.10 *Swearing-in ceremony*

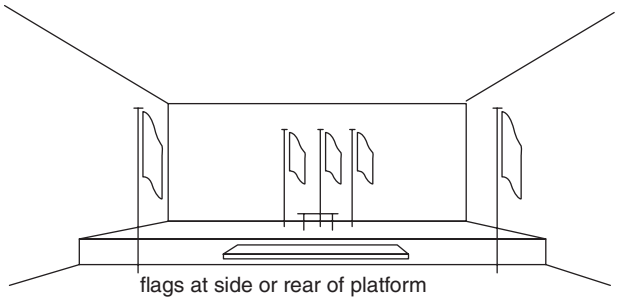


32.11 *Wedding*

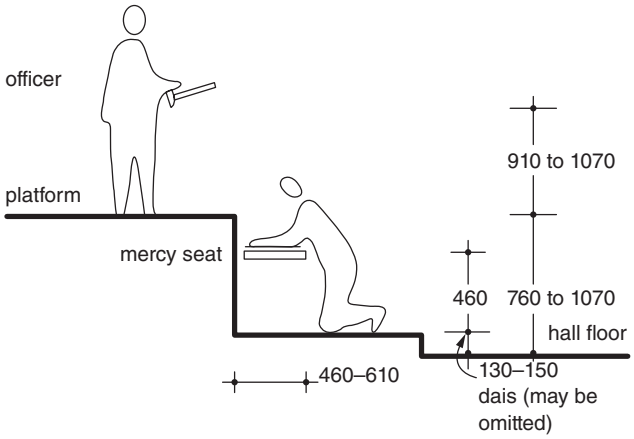
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



32.12 *Funeral*



32.13 *Presentation of colours*



32.14 *Mercy seat*

than 1.5 m. A wide rectangle, polygon or square will be a more satisfactory shape than a long narrow rectangle.

The requirements will be for a reasonable standard of acoustics for speech, choral singing and brass band playing. There should be a reasonable level of natural lighting and a reasonable standard of artificial illumination, both on the platform and in the body of the hall. The ventilation in most cases should be natural.

Officers' room

The officers' room (vestry) is used as a meeting-place by leaders or chairmen of meetings and officers of the Census Board who will assemble in the room before taking their place on the platform. The room should accommodate between two and ten persons. Corps records will be kept in this room. Lavatory accommodation will be required, normally one unit for each sex.

Cloakrooms

Lavatory accommodation should be provided for both sexes near or adjacent to the entrance vestibules of the senior or junior halls. This will be required for women in the songster room and for men in the band room.

Storage

Storage will be required in a band room for brass band instruments, music stands and music. The room will also be used for assembly, briefing and cloakroom. Minimum area shown will usually be 23–28 m^2. Instruments are stored in individual lockers to suit sizes of instruments with a small store for reserve instruments and cupboard with shelves for music.

Storage will be required in a songster room for a wind-type portable organ or electric portable organ with amplifier, and music. The room will also be used for assembly, briefing and cloakroom for the women members who would number about 20 to 30 in an average-sized brigade: 18.5 m^2 would be a minimum area.

Where there are junior and senior corps activities, there may be a junior band and singing company (junior choir). Storage will be required for brass band instruments for this junior band and for music for the singing company.

Where there is a separate junior hall, storage compartments will be contained in that hall. Other social and club activities may also require storage.

6 METHODIST CHURCH

6.1 Origins

The Methodist Church grew out of the Church of England during the eighteenth century and was founded by John and Charles Wesley. A distinct feature of the new movement was the introduction of lay preachers or, as they came to be known, local preachers. The strong emphasis on evangelical preaching is rooted in the Methodist tradition: 'Methodism is nothing if it is not evangelical.'

The church or chapel is normally reserved for worship alone, although meetings, lectures and musical recitals of a specifically religious character may also take place there. A multi-purpose hall, with a sanctuary that can be screened or curtained off, may also be used for public worship during the early stages of the development of a local congregation. There may be other units within the complex such as classrooms, club rooms and assembly halls, both for religious and secular purposes.

6.2 Ceremonies and buildings

The kind of church required today will seat between 100 and 300 people. The influence of the liturgical movement is shown in certain specific ways, and particularly in a new emphasis on the place of the sacraments in the life of the church, and in the increasing use of set prayers and liturgical forms of service. The altar, therefore, is seen again as the Lord's table, used for the family. The font is no longer viewed as making possible a semi-magical act. It is the place at which and the means by which the person baptised, whether child or adult, is sacramentally incorporated into the body of Christ. This rediscovery of the laity, the Lord's table and the font has to be considered in designing a church, for in the end it is the function of the church which is of supreme importance.

These theological rediscoveries will affect the building of a Methodist church:

- in relation to the shape of the church
- in the arrangement of the sanctuary
- in the siting of the choir.

There are normally two services on Sunday, one in the morning and one in the evening. These are conducted by a minister or local preacher from the pulpit, though the earlier part of the service may be conducted from a lectern, the pulpit being used only for the sermon.

Holy Communion is normally celebrated once a month. In order to emphasise the theological statement that the ministry of the Word is of equal importance to the ministry of the Sacrament, pulpit and communion table may be placed close to each other. The minister dispenses the bread and the wine (the latter in small individual glasses) to each of those who have come forward from the congregation to kneel at the communion rail. A small trough or perforated shelf should be fitted to the inside of the communion rail, about 50 mm or 65 mm deep and slightly lower than the top

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

of the rail, where communicants may place the empty wine glasses. See also Section 9, for dimensions of communion rails.

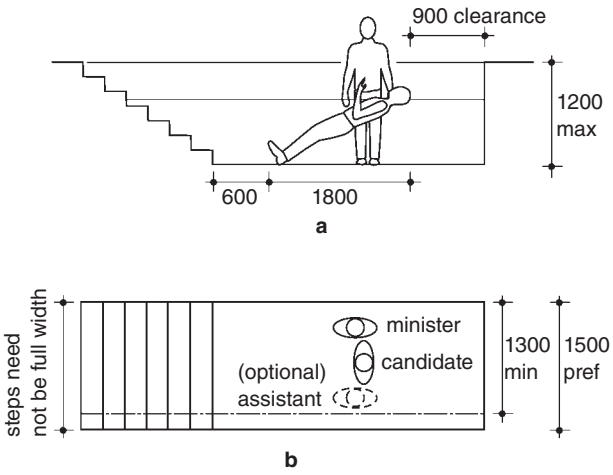
All other main services are similar to Church of England practice and the architectural requirements are the same, although a credence table is not required near the communion table. Specific guidance is contained in *The Methodist Church builders' decalogue* (from the Methodist Property Division, Central Buildings, Oldham Street, Manchester MI IJQ).

7 BAPTIST CHURCH AND BAPTISTRIES

7.1 Introduction

The chief difference in this denomination is the practice of deferring baptism to the age at which the person is able to make his or her own choices, normally 13 or older. This practice (often referred to as 'Believer's Baptism') is shared by other churches such as some of the URC and many independent churches.

The adult, known as 'candidate', is baptised through total immersion in public ceremony in the context of a service of worship. This requires the church to have a baptistry appropriate for such use, Figure 32.15.



32.15 *Baptistry pool for adult baptism as used in Baptist, some URC churches and a number of others: a section, b plan*

7.2 Baptism ceremony

The minister will enter the baptistry first, followed by the candidate. If more than one candidate is to be baptised they will be dealt with one at a time. The minister may speak briefly, and the candidate may also make a personal statement (or may have done so earlier in the service). It follows that that minister and candidate should be visible while standing in the baptistry, ideally from the shoulders up. If only the head is visible the effect can become somewhat incongruous. The candidate turns to face the steps (unless there are steps at both ends of the baptistry) for the practical reason that they will be unable to see clearly when leaving the baptistry, due to water in their eyes. The minister faces the congregation.

The minister then supports the candidate by the shoulders, pronounces a blessing, lowers the candidate backwards into the water, submerging them completely, and immediately raises them again. The candidate leaves the baptistry, usually supported or guided by the minister and/or other assistants, to ensure they do not trip or slip.

On occasions, and particularly if either minister is small in stature (and ministers in the denominations practising adult baptism include women) or the candidate is large in stature, the minister may be assisted by another member of the congregation. Exceptionally, if the candidate is infirm, they may kneel.

7.3 Key dimensions

Width, absolute minimum 1300 mm, but this is known from experience to be inadequate when an assistant is present, and 1500 mm to 1600 mm is better. The steps need not be the full width of the baptistry;

Length, about 3300 mm, determined by the tallest likely candidate (95th percentile) plus space to move and clearance at the 'head' end of the baptistry;

Depth (surrounding floor level to floor of baptistry), 1200 mm or a little less, determined by the shoulder height of minister and candidates (5th percentile);

Steps, suggested rise going and step profile to Part 'M' of the Building Regulations;

Figure 32.15 shows a rectangular plan, but other arrangements meeting the functional requirements are acceptable. The views of the local congregation should be sought.

7.4 Other functional requirements

The baptistry may be located either on a dais or in the body of the church; it is normally covered by a removable floor when not in use. In either case sightlines should be considered. If in the body of the church, consideration should be given to temporary edge protection when open to avoid accidents.

The removable floor sections should be as light and manoeuvrable as practicable. These will normally have to be moved by one or two of the congregation who may well be elderly or un-athletic, and the design of the floor sections should allow for this.

Floor surfaces. The baptistry base and the steps should have a non-slip finish. Adjacent floor surfaces may need protection.

Water supply needs to be available to fill the baptistry in a reasonable time (less than one hour), and drainage is needed to empty it in about half an hour. The floor of the baptistry should fall gently towards the outlet.

The drainage system should not be embedded or inaccessible. With infrequent use, water traps on the drainage line will tend to dry out. Any leak in the drainage system or the baptistry will be discovered at the most inconvenient moment. Suppliers should be asked to confirm that their specifications allow for long-term dry conditions with occasional use filled. The design life of the complete baptistry installation should equal the design life of the building without any significant maintenance.

Water heating. It is normal to temper the water temperature; the water need not be warm, but should not make the candidates gasp on entry! It is probably inefficient to design the main heating and hot water system to supply such a large volume of slightly warmed water. Portable electric immersion heaters have been used, but all fittings will need to be to an appropriate IP rating.

Changing spaces are required for candidates and minister, separate for opposite sexes, and possibly for the minister. They should be close to the room containing the baptistry, and normally in multi-purpose rooms, but consideration should be given to privacy.

8 SOCIETY OF FRIENDS

8.1 Origins

The Society of Friends (Quakers) originated through the experiences and preaching of George Fox (1624–1691). Early Quakers reacted strongly against the current religious practices and liturgy of the established church. All through their history, Quakers have been concerned with a sense of duty to the community.

Because Friends believe that God can communicate with man direct, they do not partake of the outward sacraments. They have no separated priesthood, they do not require their members to subscribe to a creed, and their worship does not make use of a liturgy. They are, however, in broad agreement with the main emphases of Christian belief, and would claim to be both orthodox and evangelical.

8.2 Ceremonies and buildings

In a meeting for worship, Friends gather in silence as a congregation of seeking souls, and 'wait upon the Spirit'. No one directs the worship. Out of the 'gathered' silence of united worship, one or

another may be led to engage in vocal ministry or in prayer or to read from the scriptures. There is no music or hymn singing.

The building must be designed to help the quiet worship and the vocal ministry of the participants. There is no observance of the Lord's supper or orthodox communion service; no baptism or initiation ceremonies involving ritual. There will therefore be no need for font, lectern, pulpit or altar.

Sizes of meeting halls vary, but they will mostly be designed to accommodate fifty Friends or fewer. A square, rectangular or polygonal room may meet the requirements. It is likely that seating will be required in a square or a circle. Meetings may prefer fixed or movable, tiered or level seating.

There is no need for a table in the meeting room, though there normally is one to act as a focal point. The position is not usually literally at the centre of the room; the seating will be arranged in the way felt by the group concerned to be most conducive to a good meeting for worship, and the table, if placed anywhere, will be fitted in with the general arrangement of the room. Its main use is for business meetings.

Society of Friends meeting halls when not required for worship are often used by other denominations, or for secular purposes of an appropriate nature. Other accommodation might include a multi-purpose hall, library, small kitchen foyer and cloakrooms and a caretaker's flat.

9 PASTORAL CENTRES

9.1 Form and function

Pastoral centres are alternatives to conventional church buildings and are increasingly being considered where there is to be a large new population with non-existent or inadequate ministry and buildings.

A pastoral centre could take many forms – basically it would be a small building or suite of rooms with facilities for consultation, meetings, refreshments and occasional worship. It could be a modified house, a transportable structure or a specifically designed community building: it could even be a converted shop or a caravan. Its purposes would be to shelter a Christian 'presence', comparable to a doctor's surgery or a citizen's advice bureau: ministers would be present for counselling and office work at advertised hours. Small meetings could be held and modest hospitality offered. It could be used for acts of worship though it would be linked to a major worship centre elsewhere. It should be sited in the local centre and could be integrated into a complex of amenity buildings or a shopping centre. If resources were available, and if the population distribution were suitable, two pastoral centres might be provided in a neighbourhood of 6000 to 10,000 people.

Part B Design Data

10 ALTAR OR COMMUNION TABLE

10.1 Symbolism

The altar symbolises three things:

- the body of Christ
- the altar of sacrifice
- the table of the last supper.

10.2 Canon law

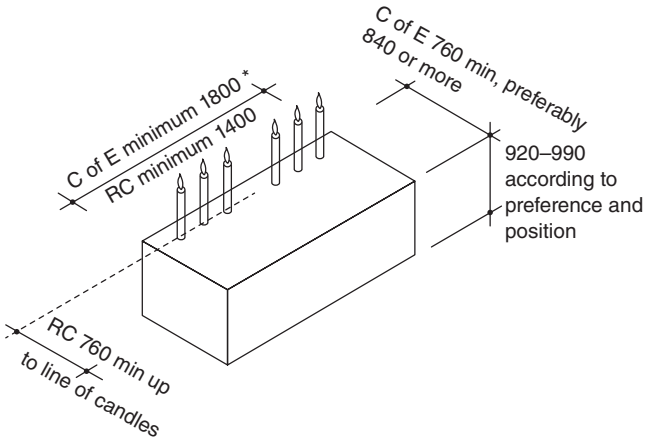
A Church of England altar may be of wood, stone or other suitable material and may be movable. It should be covered with silk or other 'decent stuff' during divine services and with a fair white linen cloth at holy communion. A Roman Catholic altar must be of natural (not reconstructed) stone with the top member (the mensa) in one piece and containing the relics of two canonised martyrs or saints. However, this requirement may be fulfilled by a small portable altar which is in effect an altar stone often about 300 mm square (or less) and 50 mm deep containing a sealed cavity (the sepulchre) for the relics. The altar may be fixed (stone cemented to the structure) or unfixed (timber with inset portable stone altar as described above). Only a fixed altar may be consecrated. Alternatively, relics may be sunk into floor below altar.

10.3 Position

The altar must be related to congregational seating in such a way that what is done at it is, and is seen to be, a corporate action of the whole assembly. Altars are being brought further forward in the sanctuary and with congregations grouped around, there is less need for the altar to stand so high as in the past, especially when the priest faces the congregation across the altar.

10.4 Size

For liturgical reasons, altars can be less long but possibly slightly deeper than in the past. Average sizes are shown in Figure 32.16 and anthropometric data in Figure 32.17.



32.16 *Average size of altars. The exact proportions will depend on its position, and whether the priest is facing the congregation or has his back to them. Note that the tabernacle containing the reserved sacrament is not now normally placed on the altar (see section 13)*

10.5 Supports and coverings

Methods of supporting the mensa are shown in Figure 32.18. With the altar now normally nearer the congregation, the question of clothing the altar may need to be rethought. A traditional Church of England altar covering is shown in Figure 32.19.

10.6 Footspace

The platform or base on which the altar rests must be large enough for the number of priests expected to stand around while celebrating the Eucharist. It may be raised one or two steps above the level of the congregation, but in general the altar should be kept as low as possible to avoid any sense of separation between it and the people. Possible dimensions are shown in Figure 32.20.

10.7 Cross and candles

The exact requirements must be discussed with the priest. Candles and cross should not form a barrier between priest and people. Some possibilities for the cross are shown in Figures 32.21 and 32.22; and for the candles in Figure 32.23.

10.8 Communion table

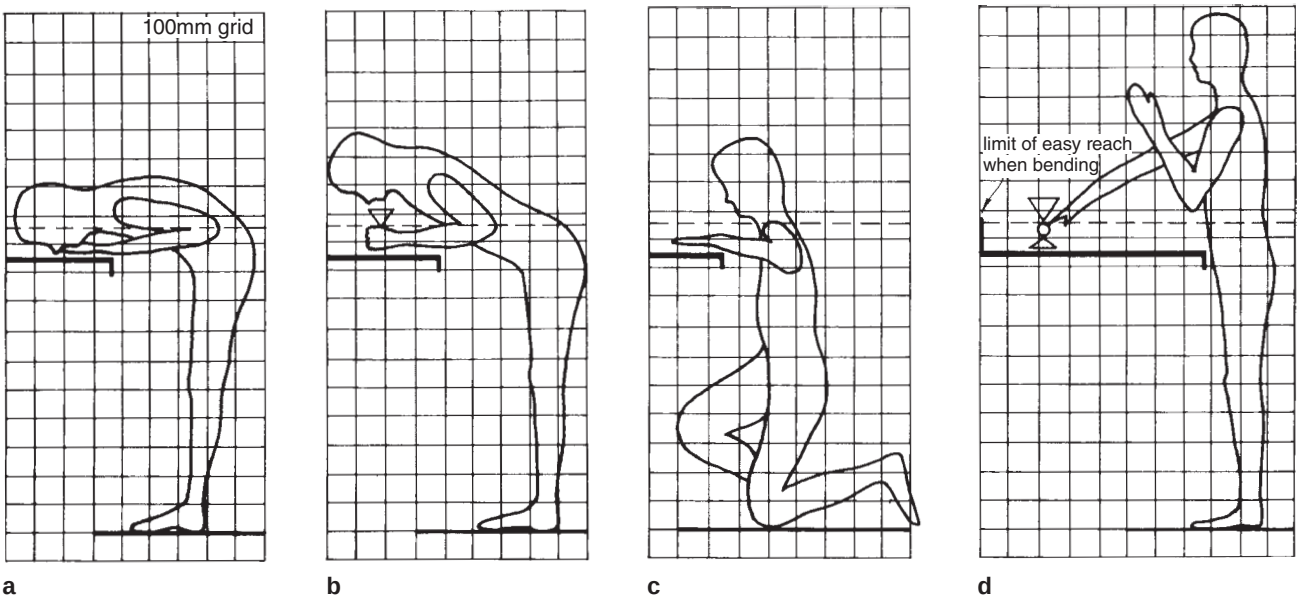
A communion table with table lectern as used in Presbyterian churches is shown in Figure 32.24.

11 SANCTUARY FURNITURE AND PULPIT

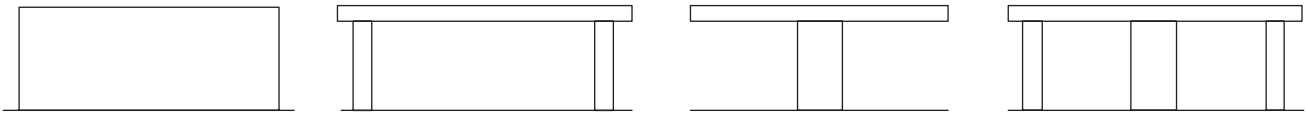
11.1 Lectern

This should be in or near the sanctuary but sufficiently apart from the altar to constitute a separate focus, and conveniently sited to be accessible to the congregation to read from, Figure 32.25. Occasionally two lecterns may be asked for, one each side. The lectern must be in

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

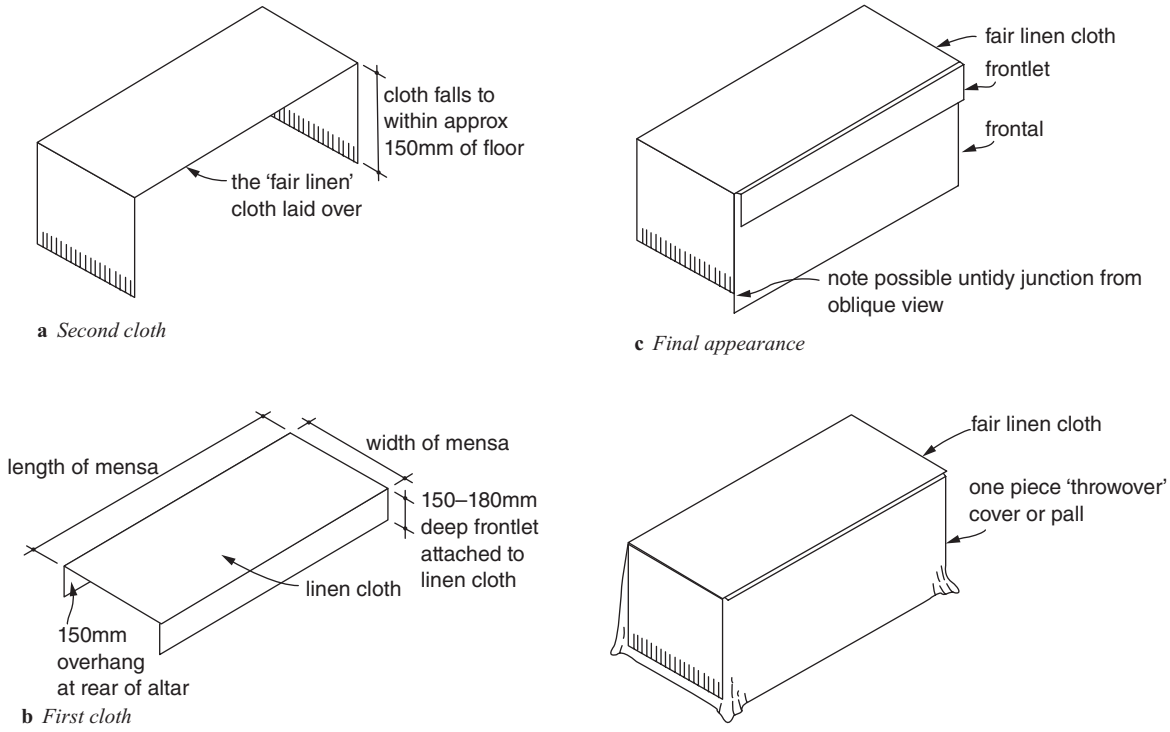


32.17 *Critical actions of priest when standing at the altar. The horizontal dotted lines represents the eye level of the average adult member of the congregation when kneeling. This should preferably not be less than 75 mm above the top of the altar, emphasising the importance of keeping that low. This represents some sacrifice to the priest, since actions a and b are easier if the top is at the traditional height of just over 1 m. a Kissing the surface of the altar. b Saying the words of consecration. c Genuflecting. This position emphasises the value of recessing the altar supports at least on the priest's side, to prevent him bumping his knee. d Reaching forward when standing upright, illustrating the extent of reach*



a *Monolith* **b** *Support at four corners* **c** *Centre support* **d** *Centre support plus short end walls*

32.18 *Supporting the mensa (altar top). Note that RC altars should not oversail their supports by more than 150 mm, so that the bishop can pass his thumb over the joints at the Consecration*



a *Second cloth*

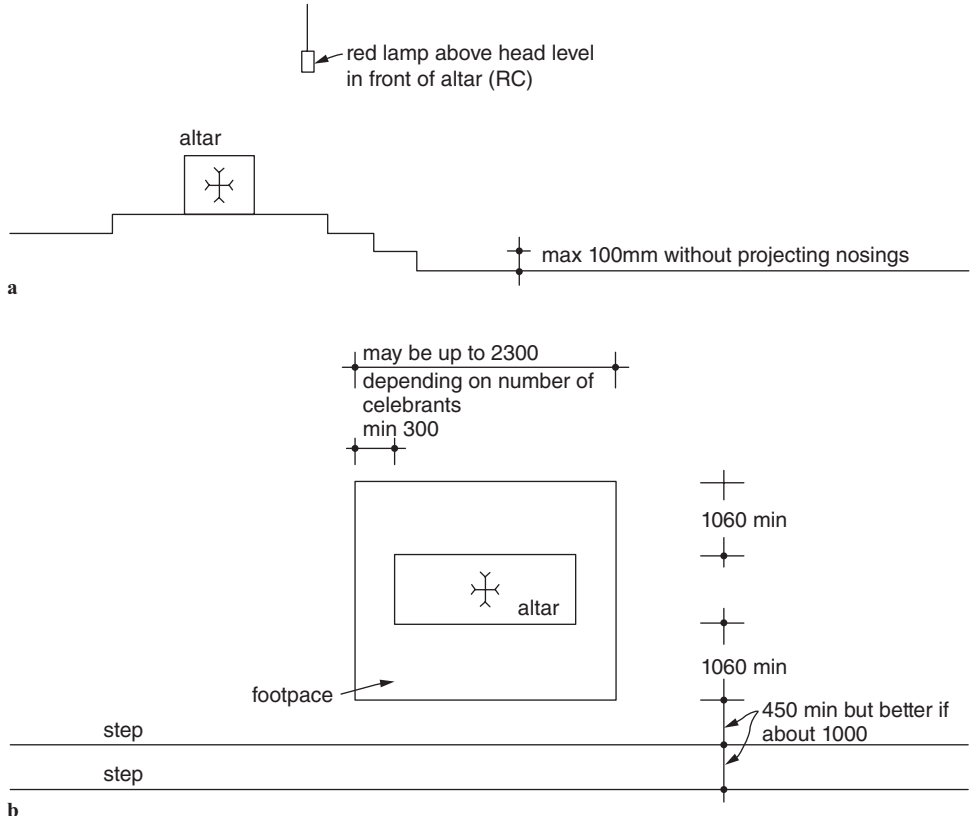
c *Final appearance*

b *First cloth*

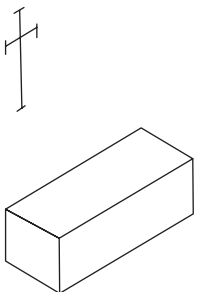
d *One-piece throwover altar cover. This may have loose draped corners as shown, or tight-fitted corners*

32.19 *Clothing the altar*

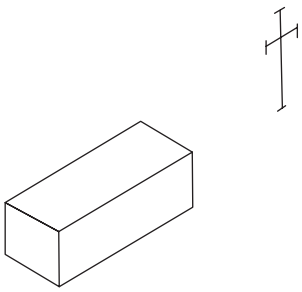
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



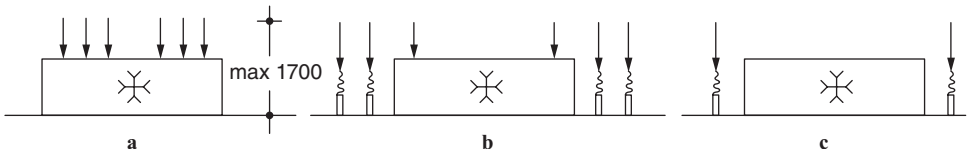
32.20 *Space around the altar. Keep altar as low as possible, usual maximum three steps. Position of the altar can also be defined by use of a canopy, structure, lighting, floor pattterns, etc. a Section. b Plan*



32.21 *The cross behind the altar at a height where it will not be obscured by the priest. Crosses are not usually placed on the altar in 'facing the people' churches*



32.22 *The cross forward of the altar to one side or suspended above*



32.23 *Arrangement of candles. a, b Six candles. c Two candles only. Candles may also be placed on a step lower than the altar to reduce height and obstruction to view*

a position where everybody can see the reader's face including those within the sanctuary. It may be fixed or movable, and it may also serve as a pulpit. Dimensions are shown in Figure 32.26.

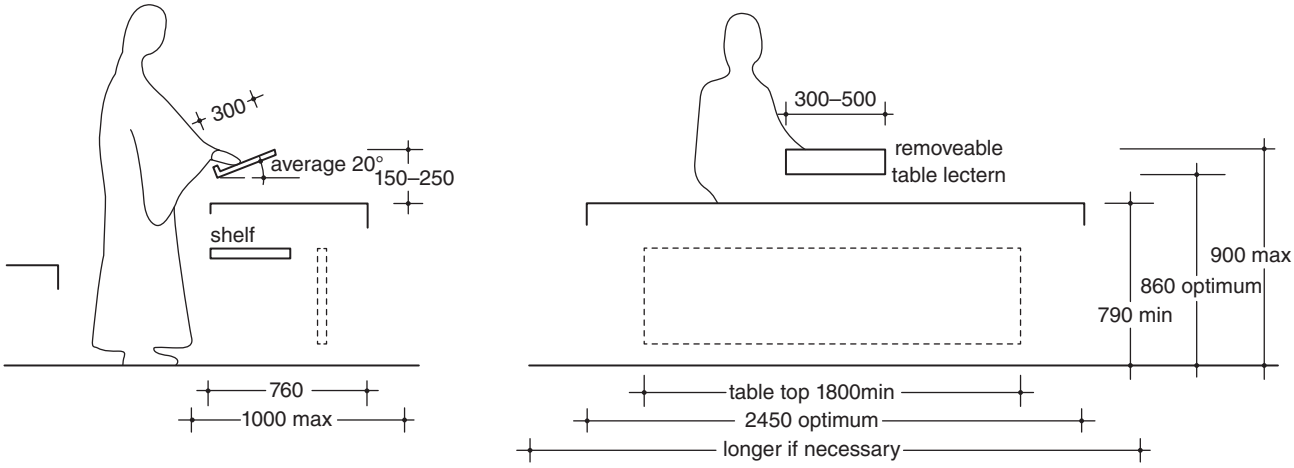
11.2 Altar rail

A rail may be dispensed with in some churches, but most will still provide lengths of rail for kneeling to receive communion. It need not be continuous, but must be rigid and firm. Minimum dimensions are given in Figures 32.27 and 32.28.

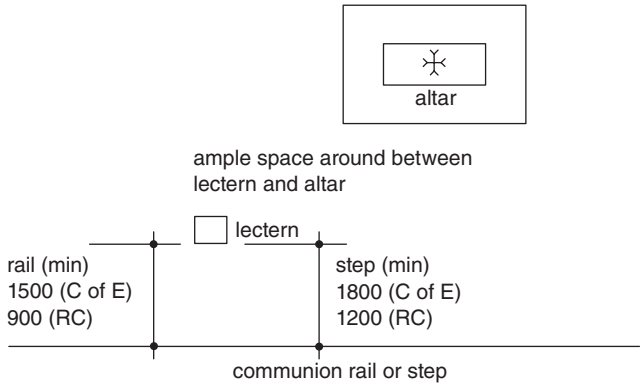
11.3 Credence table

This serves as a sort of sideboard for water and wine, but check if anything else is to be placed on it (e.g. offertory money, service books, etc.) in which case a shelf below the table may be needed. It should be to the right of the celebrant within the sanctuary but not where it might cause a visual obstruction. It could be a shelf instead of a freestanding table. Dimensions will vary from about 610 × 760 mm to 1200 × 460 mm, with a minimum height of 820 mm.

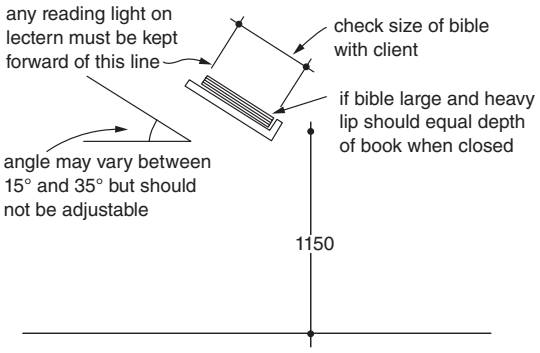
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



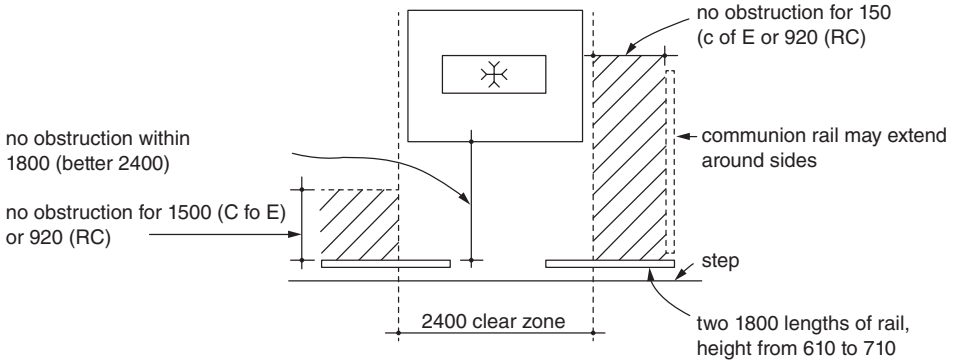
32.24 *Communion table with table lectern for use in Presbyterian churches instead of the altars described above*



32.25 *Minimum dimensions around lectern depending on whether communion rail or only a communion step is provided*



32.26 *Minimum requirements for lectern*



32.27 *Clear space requirements around communion rail*

11.4 Seating for officiants

These will vary considerably and requirements must be established with the local community. Ceremonial seats for priests. In Roman Catholic churches the 'president's seat' will be on the centre line behind the altar, raised up on one or two steps, Figure 32.29. The seat, which is used by the priest, must not look like a bishop's throne and will usually not have a back to it. The bishop's throne is portable, and placed in front of the altar whenever he visits the church. In Church of England churches it is often better to have the ceremonial seat (which is used by the bishop) at the side of the sanctuary facing the altar.

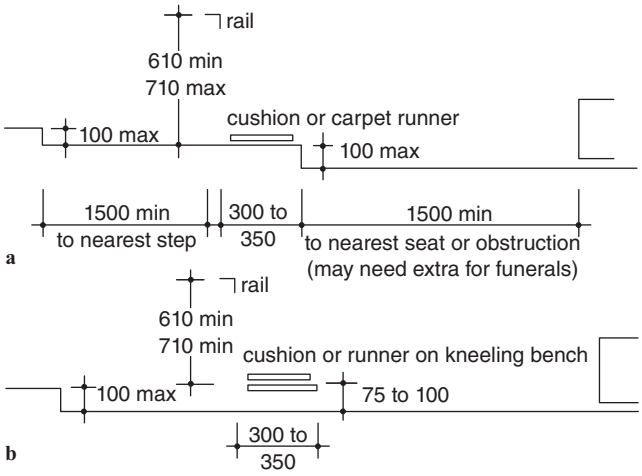
Incidental seating should be kept to a minimum. It will be needed for additional priests, servers, and lay people on special occasions. It will usually be in the form of benches at the side of the sanctuary.

Stalls will be needed (especially in Church of England churches) for priests at matins and evensong at the side of the sanctuary. Dimensions are similar to those for congregational seating (see Section 14) except that as priests are vested they will need more room to move in and out. Surface for resting a book should be deeper (say, 300 mm) and almost horizontal – not sloping – with a shelf below.

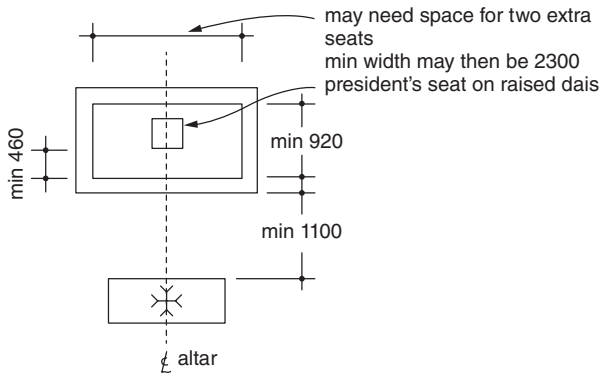
11.5 Pulpit

This should be sited outside but close to the sanctuary. No particular location is now insisted on apart from functional reasons of good sight and sound. Minimum internal area is about 1–2 m^2. Access should desirably be from the side (if from back, fit a door).

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



32.28 *Dimensions for altar rail (i.e. outside central zone of sanctuary). In a new Roman Catholic church there is unlikely to be a second step in the sanctuary, and the minimum unobstructed distance on the sanctuary side of the rail is 920mm. It is also normal for the whole of the sanctuary to be one step above the nave, but too many steps should be avoided. a With stepped floor. b With flat floor*



32.29 *Dimensions around the President's seat*

Other details are shown in Figure 32.30. A Presbyterian pulpit may be behind the altar or at either side.

12 FONT

12.1 Description

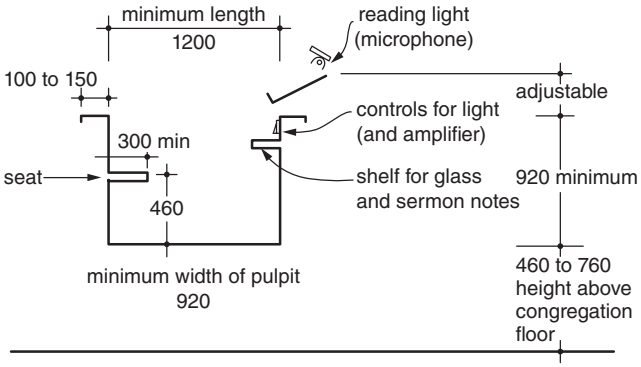
In Roman Catholic churches movable fonts are not permitted and they are not generally approved of in the Anglican communion. They can be used in Presbyterian and Methodist churches. In Church of England churches fresh water is used for each baptism drained to a separate soakaway. In Roman Catholic churches water is blessed once a year and the baptismal water is stored in the font which has two compartments.

12.2 Dimensions and shape

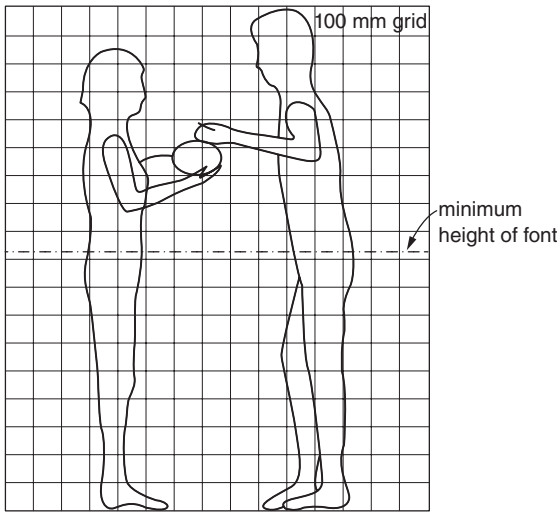
Anthropometric requirements are shown in Figure 32.31. Shape is governed by the needs of the priest (space for service book and other small objects); the comfort of the priest in holding the baby; and the safety of the baby (the priest should not have to lean too far over).

12.3 Position of font

Various alternative positions are shown in Figure 32.32. The font must be approached from the church (congregation) side but be divided from it in some way (e.g. by difference in floor or ceiling levels). It must be in a prominent position and be



32.30 *Pulpit dimensions*



32.31 *Anthropometric diagram showing the critical action at the font*

seen by the congregation when seated, or space provided for most of the congregation to stand around. It should be a separate focus from the altar and therefore possibly not in the sanctuary.

13 RESERVATION OF THE SACRAMENT

13.1 Siting

The reserved sacrament in Roman Catholic churches (the consecrated bread of the Eucharist) is not now normally kept in a tabernacle on the altar. It is normally kept:

- in a separate chapel outside the sanctuary
- in a position which is architecturally important
- where its location will be easily recognised by the congregation.

The requirements are complex and the practice of the local church community must be established and agreed with the Diocesan Advisory Committee. Figures 32.33 and 32.34 show height limitations.

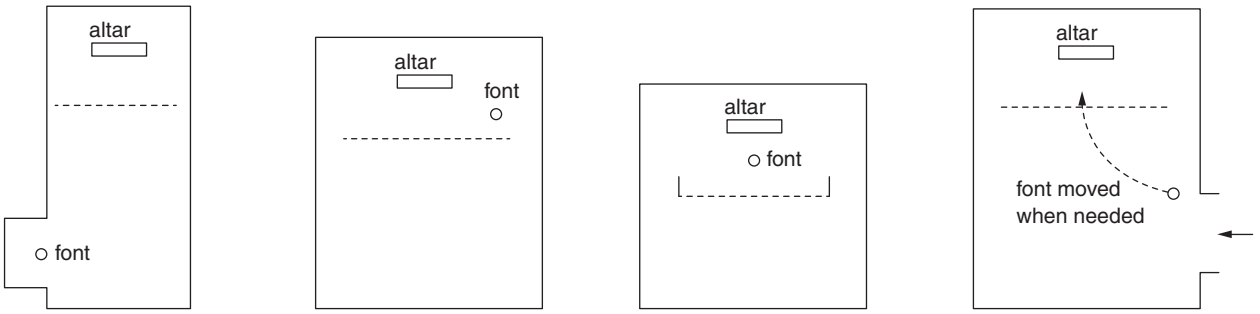
The reserved sacrament is occasionally found also in the Church of England, but is more rare and many methods of reservation are practised. For more explanation see the AJ information sheet 1529 contained in Church buildings.

14 GENERAL ARRANGEMENTS

14.1 Entrance requirements

There are several considerations for designing entrances:

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

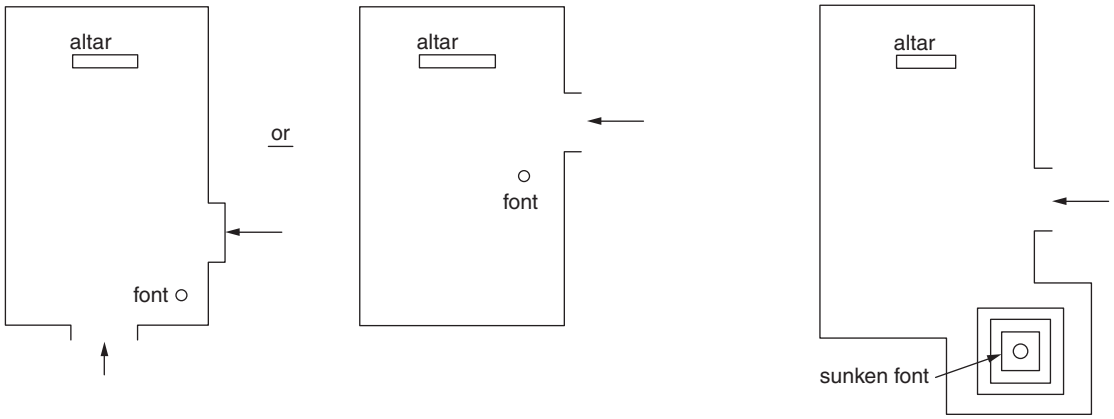


a *In separate baptistery. Acceptable if only baptism proper is performed here with the rest of the service is in the main body of the church*

b *Font in sanctuary. It may compete with altar, or be made insignificant by it. But in a Presbyterian church, the font is often in this position although lower than the table and possibly on a side extension of the lowest sanctuary step*

c *As for b, but the font is also an obstruction to sight*

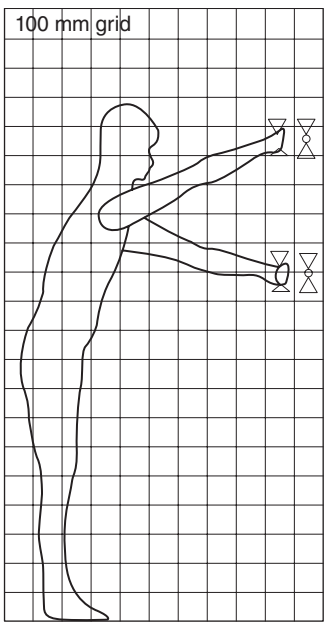
d *Care is needed with a moveable font to retain the dignity of one of the church's great sacraments*



e *and* **f** *When font is placed near the entrance it is important to have the entrance near the font and not the font near the entrance! This may mean that the main entrance is in front of the people's seats and not behind*

g *The font is sunk into a 'dry pool' with a 'drowning' symbolism*

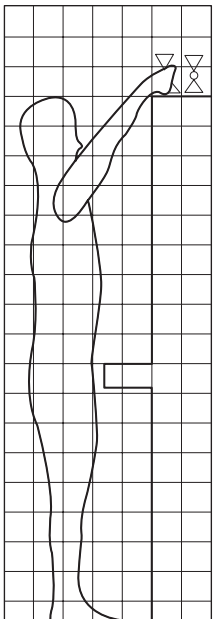
32.32 *Variations on font positioning*



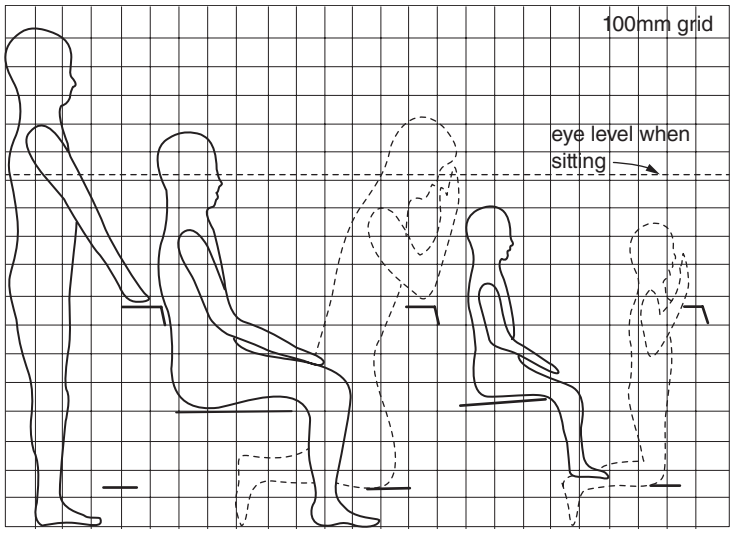
32.33 *Removing ciborium from tabernacle and putting on lower shelf*

- Provide wind lobbies outside entrance doors.
- Minimum clear door width (for processions and funerals) should be 1.7 m (1.1 m in a small church); minimum clear height (for processional cross) 2.3 m, otherwise 2.05 m is sufficient.
- Provide proper access for disabled people (see Designing for the disabled).
- Provide secondary exit door, especially for weddings.
- Provide gathering spaces inside and outside the church as part of the normal exit route where people can naturally gather to talk.
- Where needed (especially in RC churches) place a holy water stoup on the entrance side of each doorway leading into the church. Rims should be 710 to 760 mm above the floor.
- Provide considerable space for notices of all types in a conspicuous position.
- Allow space, where required, for one or two small credence tables just inside the entrance.
- Provide facilities for selling of publications, etc.
- Where possible provide access from the entrance area to the WC and to the sacristy or vestry.
- As a general rule try to keep the purely *secular* activities more in view when the congregation is *leaving* than when entering for a service.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



32.34 *Maximum height to give view of back of tabernacle*



32.35 *Critical dimensions for seating. Black lines indicate one particular solution found very satisfactory in practice. The dotted line indicates 'eye' level when sitting, and concerns the relationship with the altar top*

14.2 Arrangement of seating

The congregation should be continuous with the minister with no strong dividing line between them. Equally, the congregation must be united with one another and all must have good access to circulation and to the sanctuary. Seats facing each other around an altar should not be closer than about 6 m, and nobody should look sideways on to anybody else closer than 1.5 to 3.0 m.

14.3 Spacing and dimensioning of seats

Anthropometric details are given in Figure 32.35. Note also:

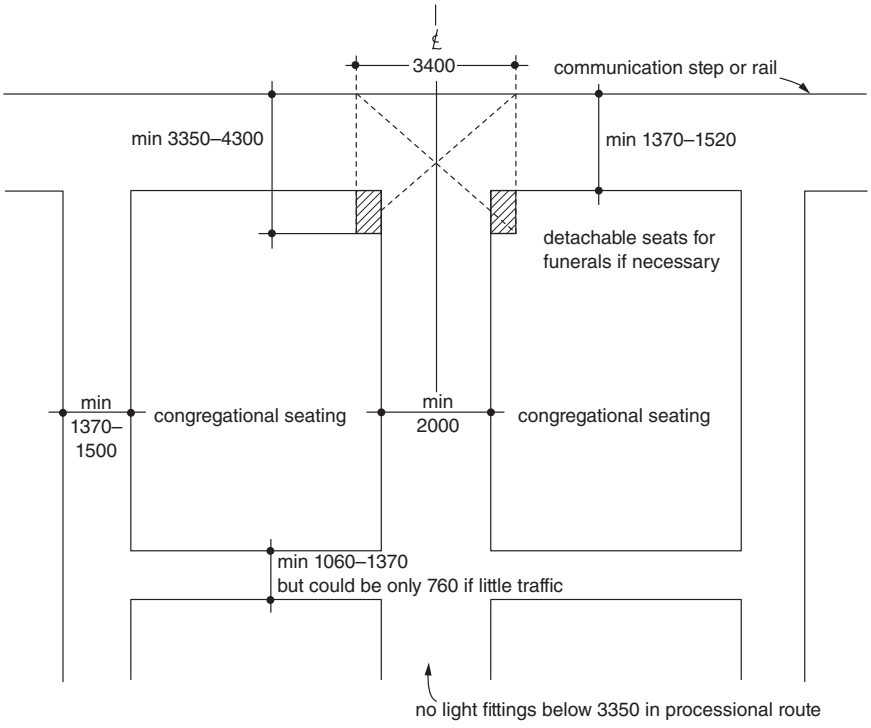
- Minimum dimension of seat plus kneeling space front and back is 920 mm. Where congregations do not kneel (e.g. Methodists, Presbyterians), the dimension can be reduced to 760 mm.
- Leave a space of about 280 mm between front edge of seat and back edge of kneeler.
- Allow minimum width of 510 mm per person.
- Maximum length of row is 10 persons (5.1 m) with access from both ends, or 6 persons (3.06 m) with access from one end.
- The ledge for hymn books should be about 150 mm wide (300 mm for the choir).

14.4 Circulation

Basic dimensions are shown in Figure 32.36. Space must be allowed for invalid chairs during the service where the occupant can participate but not block circulation.

14.5 Sound reinforcement

Many churches now use systems of sound amplification of speech, singing and instrumental music. This is particularly important in connection with 'loop' systems for people who are hard of hearing. This is not of course confined to Christian buildings; it applies equally to other religious buildings (e.g. see Section 18.3).



32.36 *Aisle widths. Size and pattern will depend on overall plan and liturgical considerations. Seating may be fan shaped or in blocks around the sanctuary*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Further, the increasing use of miniature and lapel microphones with radio transmitter/receivers linked to such a system enables the person leading the worship to move around when speaking. He or she is no longer tied to the pulpit and lectern. These traditional locations were determined largely by audibility and visibility requirements and the changed circumstances are now affecting their design and location; indeed there is some question whether they are needed at all. This can greatly increase the flexibility available, particularly where the worship function shares in a multi-use space.

15 VESTRIES AND SACRISTIES

15.1 Accommodation

Accommodation requirements will vary considerably. The most lavish could include:

- Priest's sacristy (sometimes called priest's vestry)
- Server's vestry
- Choir vestry and practice/committee room
- Women's choir vestry
- Churchwardens'/interview room
- Cleaners' room } sometimes placed together
- Flower arrangers' room } and called working sacristy
- Priest's WC
- Men's and women's WCs
- General storage
- Small kitchen.

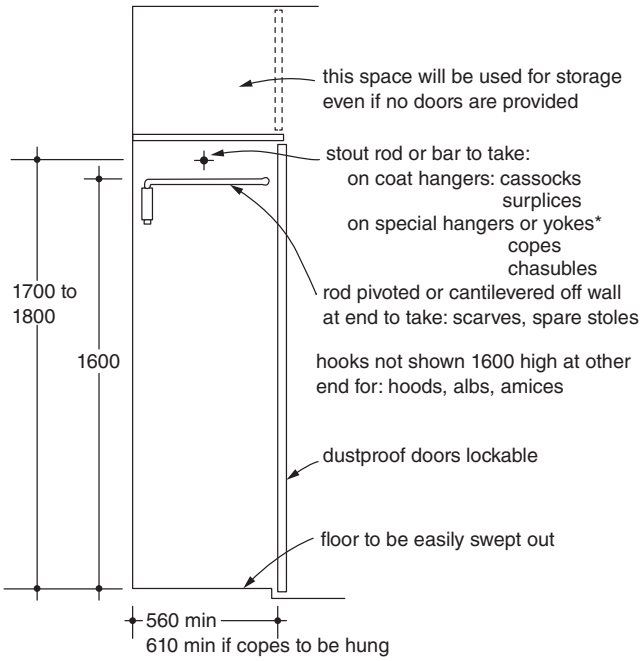
15.2 Planning relationships

The tradition of the vestry/sacristy complex opening directly onto the sanctuary has disadvantages: it emphasises the separation of priest from the congregation and makes sharing of toilet facilities difficult. The vestry could be near the entrance (but ensure security) so that priest and procession go through the congregation to their place in the sanctuary. Since children often participate in adult worship for only part of its duration, movement between the main worship space and ancillary rooms should be considered.

There should be a lobby with double doors between the choir vestry and the worship room, and a space out of sight of the congregation for processions to form up. A door direct to the outside is essential as priests and choir should not have to go through the worship room to reach their vestries.

15.3 Detailed design

There is a very wide range of objects and vestments to be stored and the precise requirements must be ascertained. A vestment storage cupboard is shown in Figure 32.37. Doorways should be 1700 mm wide × 2300 mm high.



32.37 *Section through vestment cupboard*

Notes:

*These to be fitted with 'trouser bar' under to take stole and maniple of each set of vestments

†Choir vestry: part of bar at 1320 if there are children in the choir

16 CONFESSIONAL

16.1 Design requirements

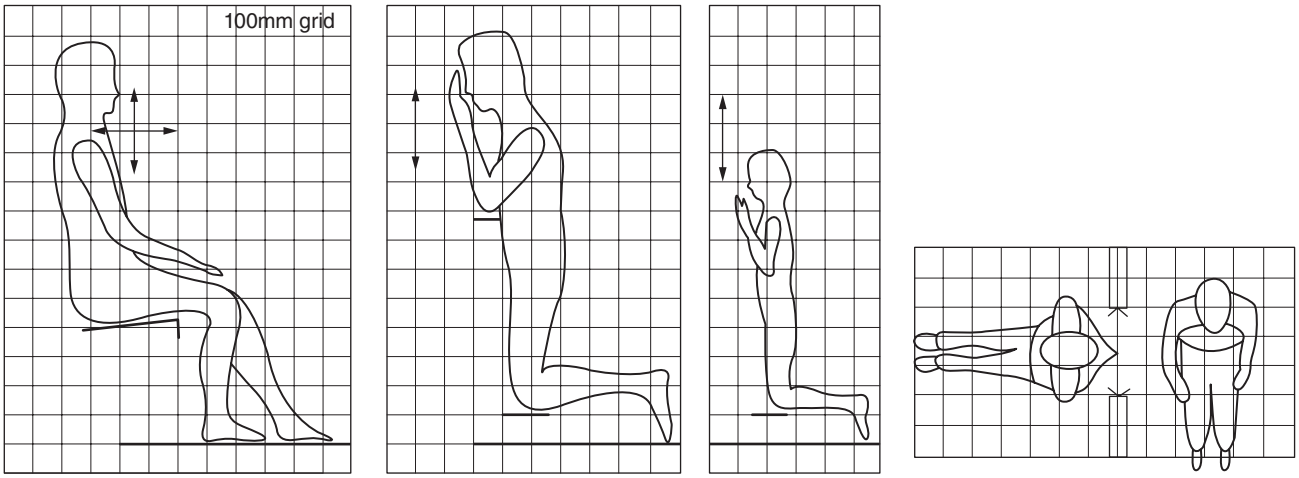
Priest and penitent must be able to hear what each other has to say without being overheard by others. The bishop's requirements must be established, and the psychological expectations of the parish.

Either priest and penitent may be enclosed in an acoustically isolated box or, more desirably, they may be visible but placed far enough away from other people to make a physical acoustic barrier unnecessary. Basic dimensions are shown in Figure 32.38.

17 ORGAN AND CHOIR

17.1 Music in church

Use of music in worship can be a highly emotive subject with the type of organ and the placing of the choir two of the most difficult problems. For new churches organs based on the 'werk prinzip' (sometimes called 'neo-classic') should be considered rather than the more traditional Victorian organs with high wind pressures and powerful but muffled tone. The organ builder should be brought in at an early stage of the discussions.



a *Relationship of grille to seated priest*

b *and* **c** *Kneeling penitents showing positioning of grille where it will serve both adult and child*

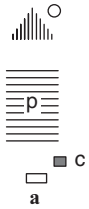
d *Plan view of priest and penitent*

32.38 *Anthropometric study of confessional*

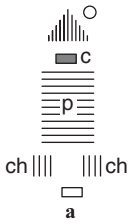
17.2 Relationship of musical elements

A few basic principles must be observed:

- The player must be with his or her instrument (i.e. the organ console must be near the pipes), Figure 32.39.
- The choir should be as near as possible to the organ, Figure 32.40.
- Ministers should not be separated from either people or organ, Figure 32.41.
- People should not be placed between the choir and ranks of pipes, Figures 32.40 and 32.41.
- The organ must be in the main volume of the building and raised above the floor so that the pipes are above the heads of the listeners.



32.39 *Bad organ arrangement. Key: o organ, c organ console, p people, ch choir, m minister, a altar*



32.40 *Bad position of choir and people, key as for Figure 32.35*



32.41 *Bad position of choir, minister and people, key as for Figure 32.35*

Different possible locations of choir, organ and congregation are shown in Figure 32.42.

Part C Non-Christian places of worship

18 SYNAGOGUES

18.1 History

The original churches evolved from the synagogues set up to supplement and eventually to supplant the Holy Temple in Jerusalem. It is therefore not surprising that they have many elements in common.

There are two main strands of Judaism: orthodox and progressive. As far as the design of the synagogue is concerned the only difference between them is that in the orthodox tradition men and women are rigidly segregated, and women take no direct part in the service.

18.2 The sanctuary

Holy Ark

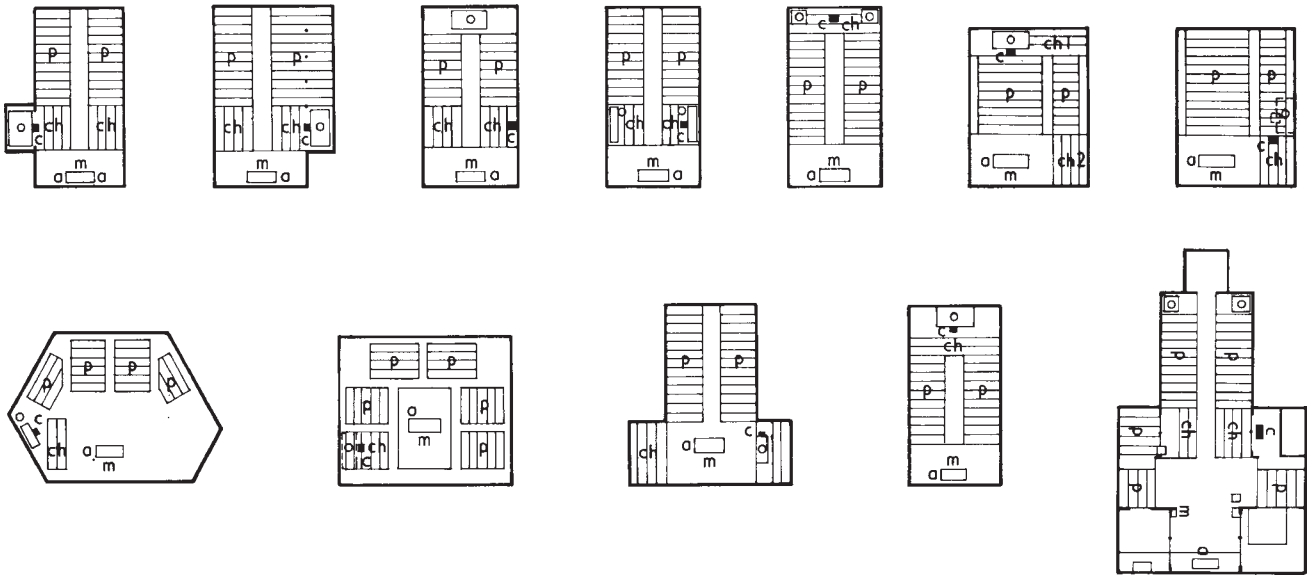
The principal architectural feature of the synagogue is the *Aron Kodesh* or Holy Ark, Figure 32.43 which contains the Scrolls of the Law. These scrolls, Figure 32.44, are hand written on a very long strip of parchment, and are the first five books of the Old Testament, called the *Torah*. Each end of the parchment is fixed to a stave, and the parchment is rolled around the staves. Because the portion to be read is not immediately accessible, as in a conventional book, it is usual to have several scrolls in the Ark, so that the correct place is not having to be found during the service.

Scrolls, when not being read from, are bound, covered with a mantle and usually adorned with a silver shield, a pointer and *rimonim*. The latter are detachable silver finials, often decorated with small bells, for the top ends of the staves on which the parchment is rolled. The Ark itself is raised and approached up steps from the floor of the synagogue. It should preferably, but not necessarily, be on the eastern wall of the synagogue. It has both doors and a curtain. It should be able to accommodate at least four scrolls, and may well be large enough for many more. It needs internal lighting, *not* operated by a door switch.

Traditionally the Ark is decorated with particular Hebrew texts, by representations of the Tablets of the Ten Commandments, and often by heraldic beasts.

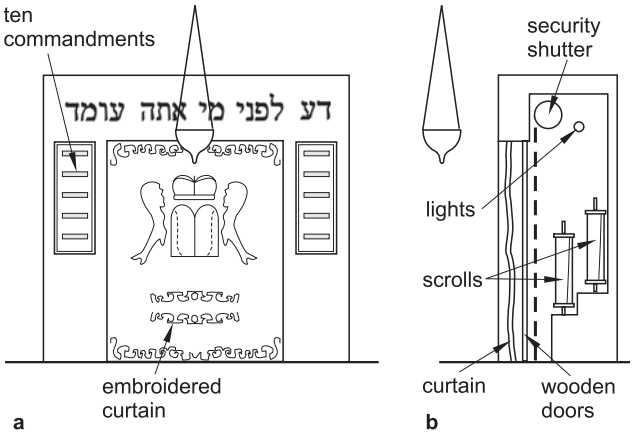
Bima

The service is conducted from a reading desk raised above the floor of the synagogue. Traditionally this should be in the centre of the space, as in the plan of a synagogue in Figure 32.45; but some

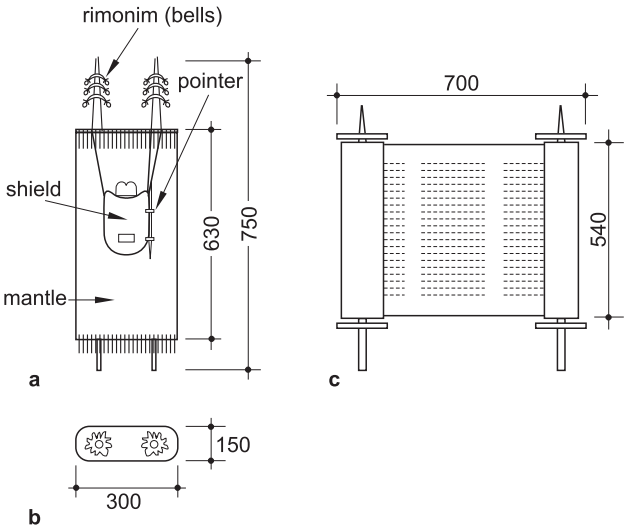


32.42 *Good relationships of organ, choir, congregation and minister/priest. Key as for Figure 32.35*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



32.43 *Holy Ark. a Elevation, inscription means 'Know before whom you stand', b Section*



32.44 *Torah scroll, a Elevation, b Plan. c Scroll when open, on reading desk or when elevated*

synagogues have been designed with the Bima integrated with the Holy Ark, Figure 32.46. There is a custom that the Bima should be three steps above the floor.

The Bima contains a reading desk large enough to hold an open Scroll, with at least five people around three sides of it. The Bima should also be able to accommodate two people holding unused scrolls, with sufficient space for dressing them (separately). Facilities are provided for scroll vestments to be kept while that scroll is being read, including pairs of 'spikes' for the rimonim.

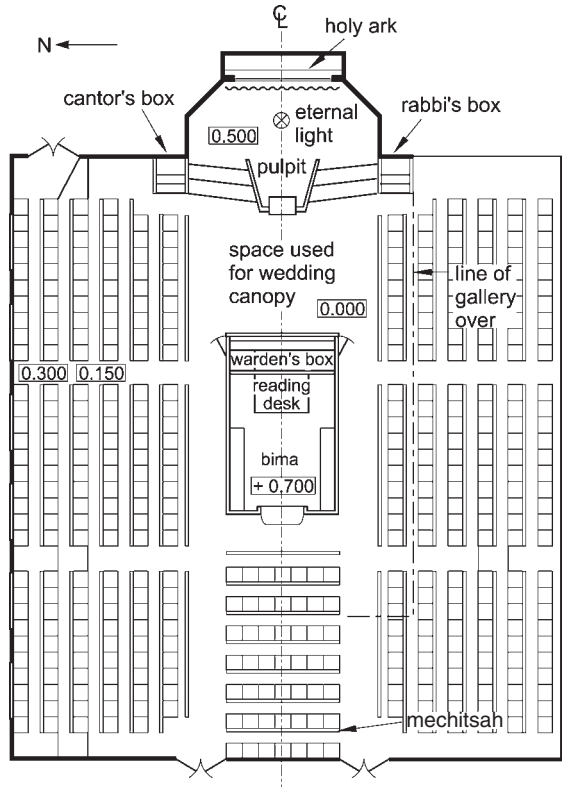
Pulpit

A pulpit is provided for the minister or rabbi from which to deliver a sermon. It is usually placed on the longitudinal axis of the synagogue immediately in front of the Holy Ark, and is not raised above the Ark's level. It does not have a door.

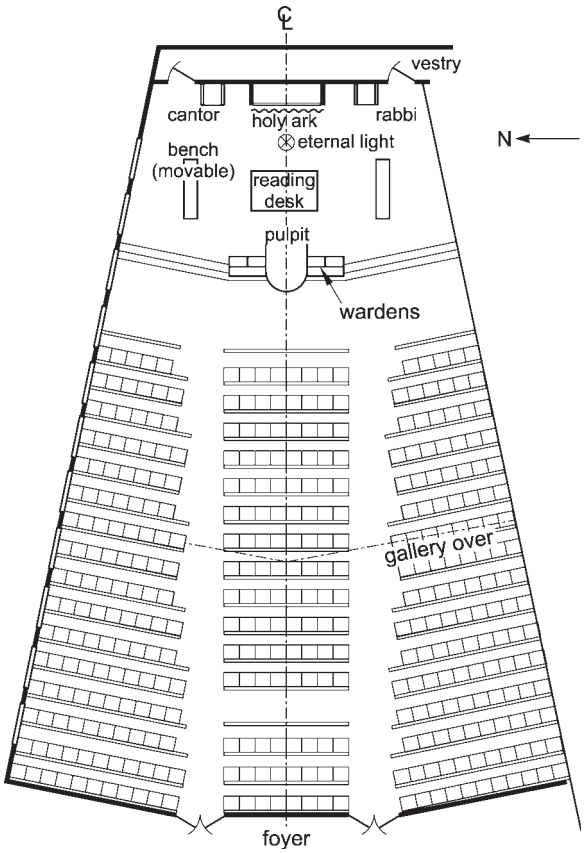
Congregational seating

The congregational seating surrounds the Bima. Since services can be very long (on *Yom Kippur* they take the whole day), the seats have to be comfortable. It is common for them to have lockable boxes beneath, as on the Sabbath orthodox people do not carry their prayer books, prayer shawls, etc. In larger synagogues the seating is banked to enable a good view for all.

The reading of the scroll is followed by the congregation from Hebrew bibles which are quite large. Each seat, therefore, needs a bookrest, Figure 32.47. However, some prayers have to be said

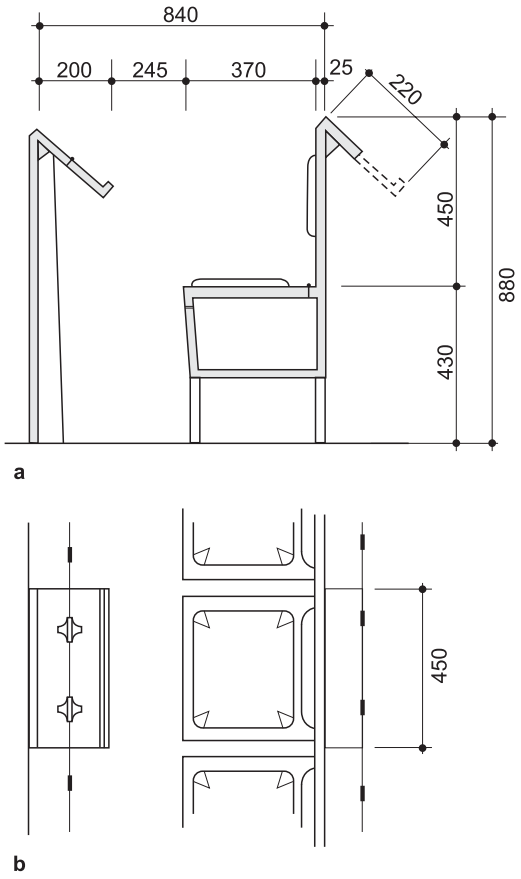


32.45 *Plan of synagogue with central Bima. This would seat 396 men downstairs, 7 women downstairs and 275 women in the gallery*



32.46 *Plan of synagogue with Bima before the Holy Ark, seating 376 downstairs and 234 upstairs. For weddings the reading desk and benches are moved aside to accommodate the canopy on the Bima*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



32.47 *Seat and bookrest. a Section. The bookrest folds up to make more clearance. The seat lifts to reveal a locker for prayer book, bible and prayer shawl. b Plan*

facing the Holy Ark; this means turning sideways in many seats. It is normal for the bookrests to be hinged to increase the clearance. Prayers are said either standing or sitting. Congregants *never* kneel in a synagogue.

Most larger synagogues have galleries and in orthodox synagogues the women sit here. Since the use of a lift is forbidden on the Sabbath and Holydays, they are not usually provided in orthodox synagogues. Women unable to climb stairs are accommodated in a section of the downstairs behind a curtain (*mechitsah*).

Processions

These are a feature of synagogue services. At services where readings are given from the Torah, the scroll or scrolls are taken from the Holy Ark and processed to the Bima before the reading, and processed back afterwards. On the Feast of Tabernacles most of the men will process behind the scrolls carrying palm branches and citrons. On the Rejoicing of the Law, all the scrolls that the congregation owns will be processed around the synagogue many times. The aisles must be wide enough for these processions.

Other features

- A *Ner Tamid*, eternal light, hangs before the Holy Ark.
- The rabbi or minister has a 'box' normally placed to one side of the Ark, with a seat facing the congregation.
- The chazan, or cantor, has a matching box on the other side of the Ark.
- The wardens have a box usually placed just forward of the Bima facing the Ark. It should have room for four wardens.
- Where there is a choir it may be accommodated in a normal seating area, or in a special place such as above the Holy Ark.
- Storage near the entrance should be provided for prayer books, bibles and prayer shawls.
- A display board similar to a hymn board is provided for service details.
- Progressive congregations need an organ. Some orthodox synagogues have a limited musical facility for weddings.
- For weddings, a *chupah* (canopy) is erected on the Bima if there is room, or forward of it on the floor of the synagogue. The couple and the rabbi are accommodated under the chupah, with as many others of the family and witnesses as there is room for.
- Funerals only take place in synagogues on rare, very special occasions. A special prayer hall, Figure 32.48, is provided at Jewish cemeteries. This is a covered open space with a few benches around the walls for infirm people. The floor is at ground level: the coffin is not carried by bearers but pushed on a wheeled cart. There are doors at both ends to signify the progress of man from birth to death. A small detached building on one side with open windows is provided for *cohanim* who are not permitted to enter any building containing a corpse.
- Purification using water, analogous to Christian baptism, takes place by total immersion not in a synagogue but in a separate facility called a *mikvah*. The design of this can be similar to a hydrotherapy pool. Such purification is not for infants, but is used by the orthodox at adult conversions, on certain occasions by women and by some men on a weekly basis.

18.3 Building services

Lighting

Lighting levels should be high as many services take place after dark. It is traditional for all available sources to be used even in daylight. Some may be symbolic, such as a *menorah* near the Holy Ark.

Heating

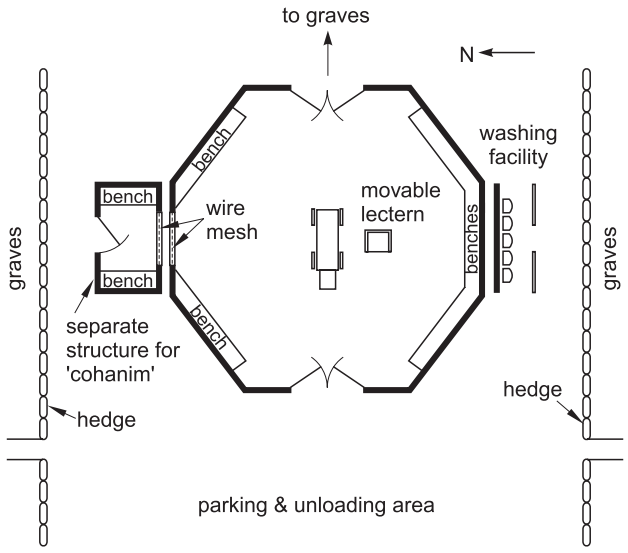
As services can be long, an efficient heating system is essential. Commonly this comprises hot water radiators; radiant sources such as used in churches are not popular.

Ventilation

This must be efficient as on occasion the synagogue will be packed. Control should preferably be automatic. It should not produce draughts or noise.

Speech reinforcement

This may be required in progressive synagogues, but is not permitted by the orthodox on Sabbaths and Holydays. However, nearly all synagogues are now allowed to use 'loop' systems for deaf people,



32.48 *Plan of cemetery prayer hall*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

and this will require microphones to be placed very discreetly on the Bima, pulpit and the Holy Ark controlled automatically.

Large Orthodox synagogues need to be carefully designed for excellent acoustics in view of the lack of any reinforcement system. Even so, this implies a maximum capacity of about 1500.

18.4 Outside the sanctuary

Since services are long, synagogues need adequate cloakroom and lavatory accommodation. A vestry for the rabbi and chazan is often provided at the Ark end of the building with a direct entrance into the sanctuary close to the rabbi's box.

There is a foyer between the street entrance and the sanctuary and there are stairs from this to the ladies' gallery. The foyer should have notice boards to publicise the many activities in conjunction with the congregation. There may also be one or more built-in charity boxes (used only on weekdays). Immediately outside there will be a board giving the times of services, etc.

Most synagogues have additional halls, classrooms for religion school, kitchens, etc. Orthodox synagogues provide no car parking, as driving on the Sabbath and Holydays is forbidden. However, a very few parking spaces may be provided where land is available for the minister and for weekday use.

18.5 Holydays

The High Holydays occur around September and congregations are much larger than on a normal Sabbath. Some buildings are designed to open up hall and classroom areas to the main sanctuary at this time; alternatively, one or more additional services are provided in detached halls. As Orthodox synagogues use no electrical speech reinforcement, additional services are separately conducted. This usually involves using a mobile Holy Ark with the reading desk on the floors of the hall used; thus special provision in the building design for these occasions need not be made.

19 MOSQUES

19.1 Elements

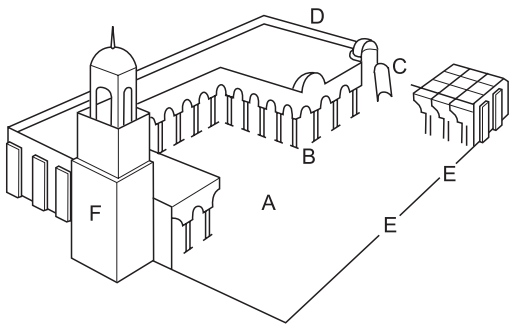
Muslims actually need no special place to pray – praying can and does take place in the street. Where a purpose-built mosque is provided, it should comprise and conform to particular rules.

Every mosque has four basic elements, Figure 32.49. These are the *Mihrab, Bab Al-Sadir*, dome and minaret. Both the dome and minaret have a symbolic rather than a utilitarian function in contemporary mosque design. (Terms in *italics* are listed in the Glossary section 19.10.)

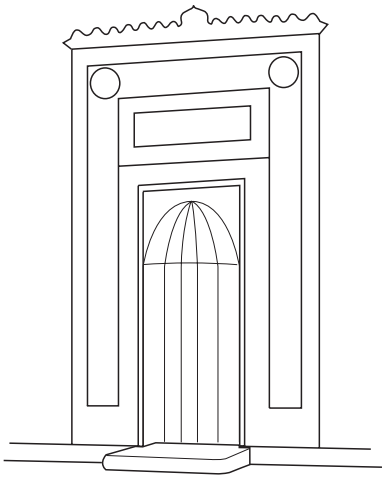
19.2 The Mihrab

The Mihrab, Figure 32.50, is indispensable, as it indicates the direction to the *Kaaba* in Mecca, Saudi Arabia. The direction to Kaaba is also known as *Qibla*. In symbolic terms, it is the most important element of the modern mosque.

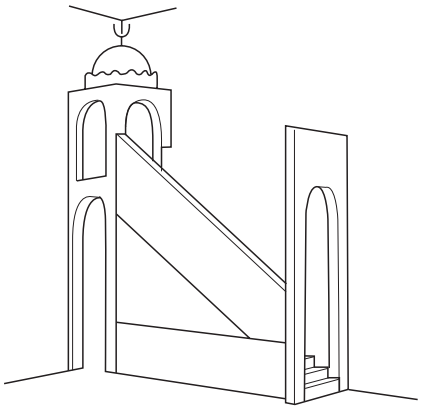
It is essential that this direction is accurately established. The Ordnance Survey office on application can give the precise bearing and distance to Mecca, Saudi Arabia from anywhere in the UK. Generally it is in a south-easterly direction with a bearing of approximately 118° from the north.



32.49 *Main features of a mosque. Key: A Fountain, B Worship hall, C Mihrab, D Qibla wall, E Entrances, F Minaret*



32.50 *Mihrab*



32.51 *Minbar*

The Mihrab is where the Imam leads the congregation for prayer and also houses the *Minbar*, Figure 32.51, a pulpit from which the *Imam* will address the congregation, particularly on Friday. The Minbar might be a low platform, or be at the head of a flight of stairs.

19.3 Bab Al-Sadir

Bab Al-Sadir is the grand entrance. In Arabic, 'Bab' means a gate or door and Al-Sadir means the frontal. Traditionally it symbolises the importance of the mosque in the life of the community:

19.4 The dome

The dome is generally centrally located over the main prayer hall and there may be more than one dome to a mosque. It is first and foremost a landmark, indicating the importance of the mosque to the life of the community. In addition, it has two practical functions; one is to echo the words of the Imam inside the mosque and the other is to cool the hot air when it rises upwards and draws in cooler air from outside. Modern technology compensates for the two functions above.

19.5 The minaret

The minaret is used to call the faithful to prayer. It is usually in the form of a circular, octagonal or square tower which projects above the mosque with at least one balcony along its length. It is possible to provide more than one minaret in a mosque and more than one balcony for each minaret.

Traditionally the minaret has an internal staircase leading up to the uppermost balcony, but these days it usually only carries a speaker system so that the Muezzin stays at ground level (sometimes a recording is used).

19.6 Prayers

Prayers are said standing, kneeling and prostrate. There are therefore no seats, but the prayer hall is carpeted and the carpet is marked with imprinted prayer mats pointing to Qibla. Allow at least 0.75 m^2 per person for praying.

No shoes are allowed past the main entrance, and there are places to leave them, usually in racks, to one or both sides of the entrance.

19.7 Other essentials

Other essentials to be provided are the *Wuzu, Wudu* or ablution area, the *Janaza* or morgue, and *Kutub Khana* or library.

19.8 Ablution area

The ablution area, Figure 32.52, is where the faithful wash their hands, elbows, faces, behind the ears and their feet in preparation for praying. This is performed under running water. The ablution area also houses the toilets and showers. The number of ablution seats, toilets and showers is governed by the size of the prayer hall.

19.9 Design

Mosque design must conform to particular detail rules, some of which are:

- Male and female entrance/exit, prayer hall and ablution areas must be separate.
- Toilets should be in compartments not cubicles: i.e. must be of solid wall construction not thin partitions or gaps at floor level.
- Their orientation is of paramount importance. Compartments must not face or back in the direction of Mecca.
- No other habitable enclosure or space should be behind the Mihrab within the confines of the site.
- Toilets may not be situated under or over the prayer hall, and no drainage pipes whatsoever should pass under or over it.

It is important for the fulfilling of the client brief that the designer combine the four elements in proportion to each other. Figure 32.53 shows plans of the two levels of a typical mosque.

19.10 Glossary

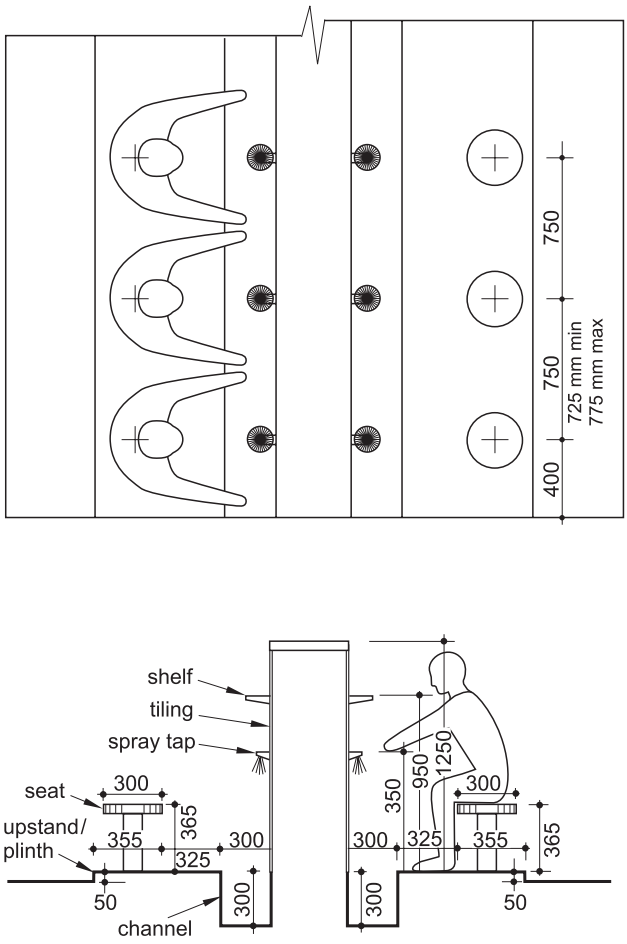
Bab Al-Sadir	main or grand entrance/gate
Imam	the holy man/preacher/leader of the prayer
Jami or Jame	Friday or congregational mosque
Janaza	Morgue
Kaaba	the holy shrine in Mecca
Kutub Khana	Library
Madrasa	School
Masjid	Mosque
Mihrab	a niche in the Qibla wall indicating the direction to Kaaba
Minor or Minara	Minaret
Minbar	pulpit or seat used by the Imam for Friday speech
Muezzin	person calling faithful for prayer
Qibla or Kibla	the direction of prayer oriented towards Kaaba in Mecca
Wuzu or Wudu	ablution

20 HINDU TEMPLE

20.1 Design

There are three main sections to a Hindu temple, Figure 32.54:

- The *garbagriha* or shrine room
- The *mandapa* or pillared hall
- The *ardhamandapa* or porch.



32.52 *Plan and section of ablution area*

20.2 The garbagriha

This contains the object representing the deity, usually a statue. It may be covered by a canopy, or the roof of the garbagriha itself may be in the form of a pyramid. There should be an ambulatory called the *pradakshina* between the statue and the outer wall.

20.3 The mandapa

This is the central hall where the worshippers assemble. They approach the garbagriha through the *antarala* which steps up. Prayers are said here, seated upon the floor. A portable fire altar is brought into the room at the time of worship. Some of the worshippers play musical instruments, others assist the priest.

20.4 The ardhamandapa

This is traditionally orientated towards the rising sun, and also is raised above the ground by steps.

21 SIKH GURDWARA

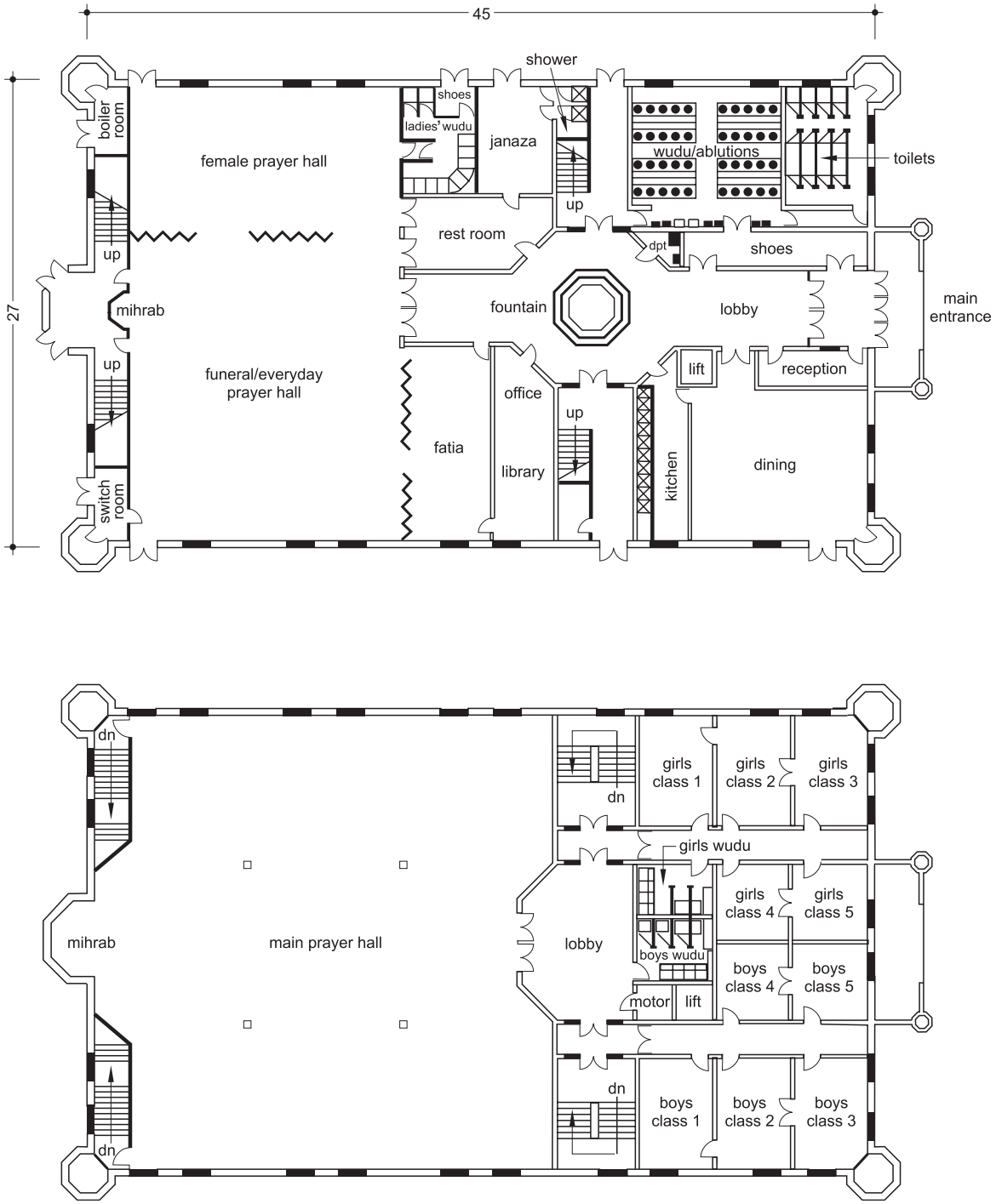
21.1 Design

The gurdwara, Figure 32.55, consists of a single large room with the takht platform at the end furthest from the entrance. There are no special requirements for orientation. On the takht stands the *palki*, a canopy over the *Guru Granth Sahib* which is the focal point of the gurdwara. The Guru Granth Sahib is the Sikh scripture, and is kept on the *Manji Sahib*, a low reading desk. The palki is free of the wall behind to permit circumambulation.

21.2 Services

Worshippers enter the gurdwara at random times, go directly to the takht and prostrate themselves before the Guru Granth Sahib. They leave offerings of money or of kind on the takht in front of it. They then sit on the floor, men on one side and women on the other, leaving the

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



32.53 *Plan of a mosque, ground and first floor*

central aisle for later comers. During the service, verses are read from the Guru Granth Sahib; hymns are sung, music is played by the *ragis*, musicians seated on the takht. The distinguishing feature of a gurdwara externally is the Sikh flag. A tall flagpole is therefore necessary.

Part D Additional Information

22 CREMATORIA

22.1 Introduction

More people are cremated than buried now due mainly to the scarcity of land for cemeteries and the consequent high cost of grave space. However, some religions such as strict Catholicism and orthodox Judaism do not permit cremation.

In most cases of cremation a ceremony precedes the disposal. This may be religious or it may be a purely secular occasion. After the body has been cremated (which may not be immediately after the ceremony) the ashes may be:

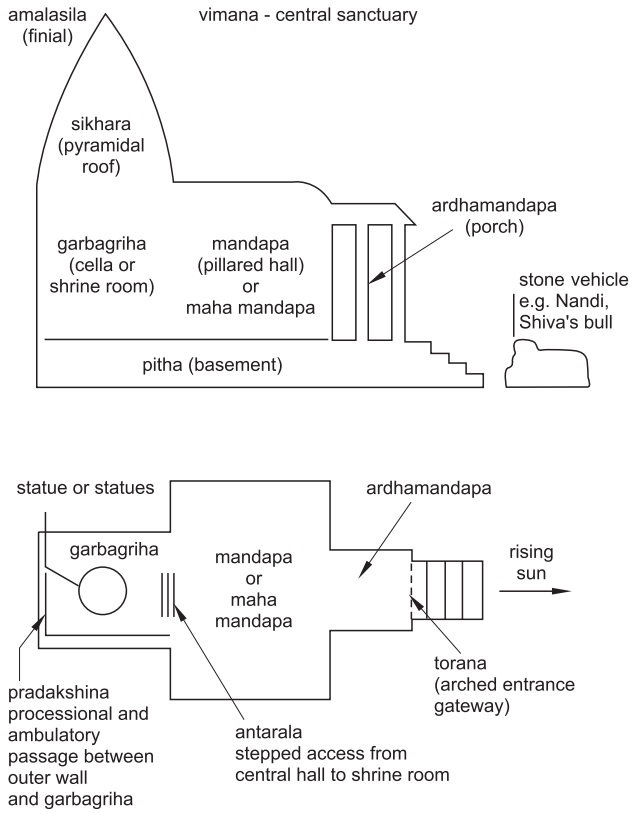
- deposited in a columbarium associated with the crematorium;
- scattered in a Garden of Remembrance also at the crematorium;
- taken away for deposition or disposal elsewhere.

Crematoria may be municipal or commercial. In the former case they are usually situated in or next to a municipal cemetery. Columbaria and Gardens of Remembrance can be provided on the cemetery land. Private crematoria will also provide these facilities, as they can be financially rewarding. The designer must establish a clear brief from a client in these respects.

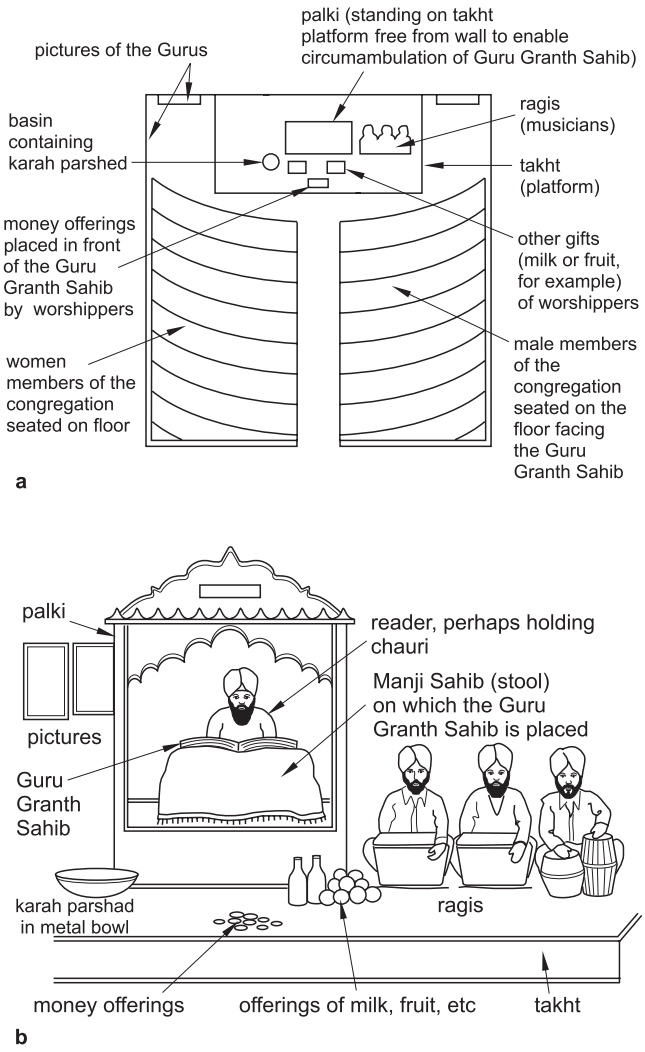
22.2 Siting

The crematory (i.e. where the furnaces are housed) should not be sited near existing buildings because the effluent from the flue can be unpleasant under certain climatic conditions. The statutory situation requires that crematoria may not be sited closer than 183 m (92 m in inner London) to domestic property. Ideally, crematoria

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



32.54 *Hindu temple, longitudinal section and plan*



32.55 *Sikh Gurdwara. a Plan. There is no standard shape but the Guru Granth Sahib must be the focus of attention always visible from all points of the room. The aisle is left free for worshippers to pay their respects to the Guru Granth Sahib before sitting in the congregation. Sometimes separate entrances are required for men and women. b Elevation of the Takht*

should be located in quiet surroundings, with as much natural landscape as possible.

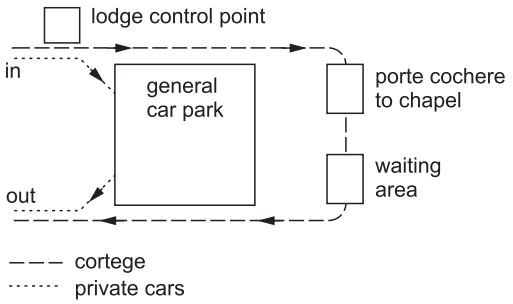
A minimum site of 1 hectare is required for the crematorium buildings themselves. Further space requirements will depend on whether a Garden of Remembrance is required, when a further hectare at least will be necessary, and more if commercial aspects are to be developed to the full. These areas include the space needed for traffic circulation, parking, a modest amount of room around the building, and the crematorium itself.

Vehicular access to the site should be simple and dignified and free from traffic hazards. The entrance should preferably not be immediately off a principal traffic route. If this is unavoidable, then it should be off a roundabout or where there is space in the central reservation of a dual carriageway for the hearse and mourners' cars to wait in a dignified manner.

22.3 On-site circulation

Clear routes should be provided within the site for vehicular and pedestrian traffic, Figure 32.56. Only the hearse, principal mourners' and disabled people's vehicles should be allowed beyond the car parking area. These vehicles should arrive at the building under a porte-cochère. The coffin will be transferred to the chapel and then the hearse and other vehicles routed to a waiting area, ready to pick up the principal mourners after the service. One or two parking bays should be provided close to the chapel for disabled people. All other mourners should park their cars in a car park away from the main building.

The entrances to and exits from the building should be located as far as possible from the furnace room so that mourners are not aware of the mechanics of disposal. The pedestrian traffic flow should follow that of the coffin into the chapel. Mourners arriving at the chapel should not meet mourners leaving the previous service. After the service, the people walk from the chapel to a covered way, where floral tributes are displayed, through to the chapel of remembrance (if provided) and then back to the car park via the garden.



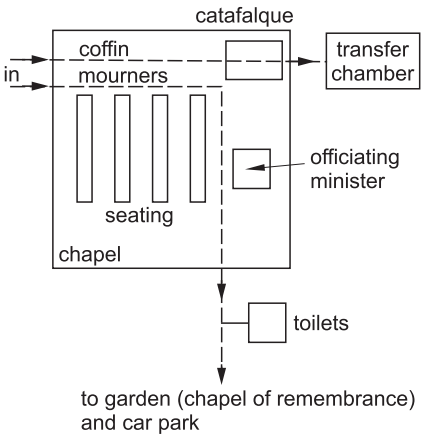
32.56 *Crematorium vehicular flow diagram*

22.4 Chapels

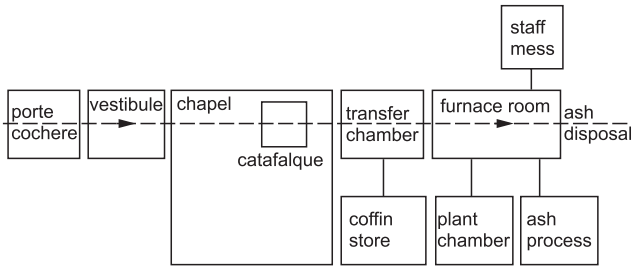
Chapels should take into account Christian, non-Christian and secular usage – perhaps separate chapels for Christian and other users; or if the same space is used for all, a system of easily changed symbols installed. Where more than one chapel is provided, one may be small (20 seats) and the other larger (110 seats). Organs are rarely used, but good facilities for playing recorded music are essential.

The chapel should be designed to reduce emotional disturbance caused by the proceedings, Figure 32.57. The event can be 'softened' in a number of ways. For example, windows can be provided at a number of levels to enable the mourners to look through the

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



32.57 *Chapel arrangement*



32.58 *Coffin circulation pattern*

chapel into a restful and attractive external landscape; the designer should avoid a totally introspective environment. Again, the catafalque can be offset from a central position so that the mourners tend to concentrate on the minister conducting the service and not solely on the presence of the coffin.

22.5 Toilets

Many people become emotionally disturbed either before or during the service. The toilets should be easily accessible before the service, immediately after the service and at the point where relatives disperse after the ceremony. At least three groups of toilet facilities are required.

22.6 Coffin circulation

A diagram of the coffin circulation is given in Figure 32.58.

22.7 The furnace room

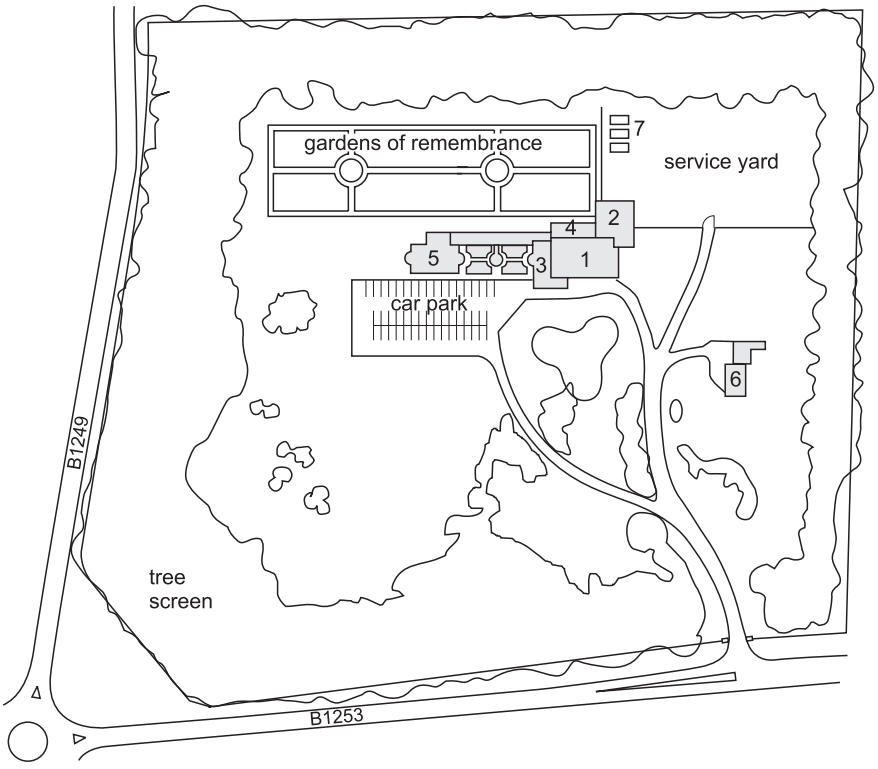
The finishes in the furnace room should be impervious and easily maintained. Blow-back on ignition may occur occasionally, and soot deposits can accumulate on walls and ceiling.

22.8 Ancillary accommodation

All or some of the following will be required depending on circumstances:

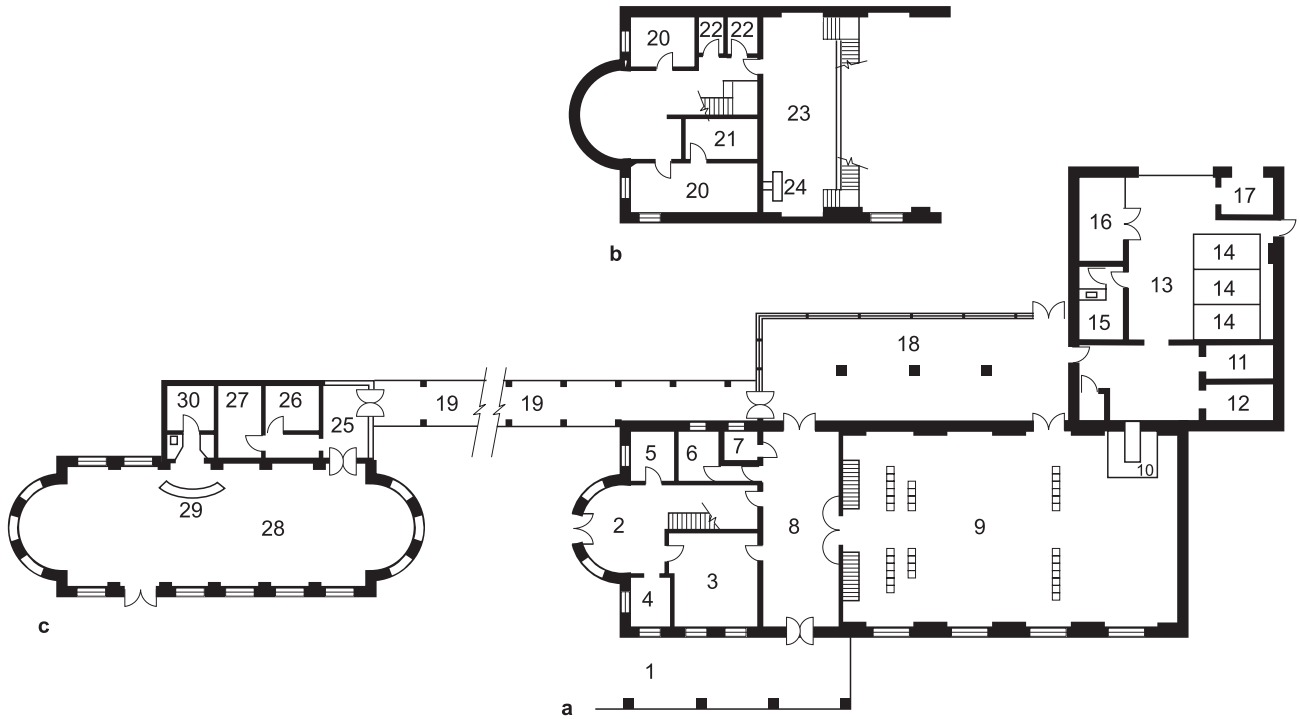
- administrative suite
- manager's office
- waiting rooms
- resting place with catafalque
- vestry for clergy
- flower room
- transfer chamber and coffin storage
- viewing room
- furnace operator's room and storage
- attendant's room
- public toilets
- gardener's store and porter's lodge.

The site plan of a recently constructed crematorium complex is shown in Figure 32.59. Plans of the main building are given in Figure 32.60.



32.59 *Site plan of East Riding Crematorium Architect: R Peter Belt DiplArch RIBA. Key: 1 chapel, 2 cremators, 3 porte-cochère, 4 floral gallery, 5 hospitality suite, 6 superintendent's house, 7 gas tanks*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



32.60 *East Riding Crematorium: plans of main building complex Architect: R Peter Belt DiplArch RIBA. Key: 1 porte-cochère, 2 entrance hall, 3 waiting room, 4 vestry, 5 enquiries, 6 men's toilets, 7 ladies' and disabled people's toilet, 8 foyer, 9 chapel, 10 canopy over catafalque, 11 flower store, 12 cold store, 13 cremation room, 14 cremators, 15 staff, 16 workshop, 17 fan room, 18 floral gallery, 19 covered walkway, 20 office, 21 records, 22 toilets, 23 gallery, 24 organ, 25 hospitality porch, 26 men's toilet, 27 women's toilet, 28 reception room, 29 servery, 30 store, a Ground floor of main area. b First floor. c Hospitality suite*

23 Bibliography

Frishman, Martin and Hasan Uddin Khan (eds), *The Mosque: History, Architectural Development and Regional Diversity*, Thames & Hudson, 2002

Heathcote, Edwin and Laura Moffatt, *Contemporary Church Architecture*, John Wiley & Sons, 2007

Heathcote, Edwin and Iona Spens, *Church Builders*, Academy, 1997

Kieckhefer, Richard, *Theology in Stone; Church Architecture from Byzantium to Berkeley*. Oxford University Press, 2004

Krinsky, Carol Herselle, *Synagogues of Europe: Architecture, History, Meaning*, Dover Publications, 1996

Kuban, D. *Muslim Religious Architecture: The Mosque and Its Early Development v. 1 (Iconography of Religions)*, Brill, 1974

Martin, Christopher, *A Glimpse of Heaven: Catholic Churches of England and Wales*, English Heritage, 2006

Meek, HA. *The Synagogue*, Phaidon Press, 2003

Norman, Edward, *The House of God*, Thames & Hudson, 2005

Places of Worship, Phaidon Press, 1999

Roberts, Nicholas, *Building Type Basics for Places of Worship*, Wiley, 2004

Stock, Wolfgang Jean, *Architectural Guide: Christian Sacred Buildings*, Prestel, 2004

Stock, Wolfgang Jean, *European Church Architecture, 1950–2000*, Prestel, 2003

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

33 Primary health care

Geoffrey Purves

Geoffrey Purves is a consultant chartered architect and has designed many primary care facilities whilst in practice. His PhD researched the design of primary health care buildings and he has published Healthy Living Centres *(2002) and* Primary Care Centres: A Guide to Healthcare Design *(2009).*

KEY POINTS:

- *The focus of health design is beginning to shift from an obsession with cost and functionality to one of quality, potential flexibility of use and whole life costs*
- *Primary health buildings closely reflect policy and guidance – as guidance changes, so do the buildings*
- *Patient choice will increasingly become a factor which drives the design of, and provision within, primary health buildings*

Contents

1 Executive summary
2 International background
3 A short history
4 Current position
5 Political framework and government policy
6 Approach to briefing and design
7 Key relationships
8 Engineering and IT services
9 Art in health
10 Holistic care
11 Conclusion
12 Case studies
13 References

1 EXECUTIVE SUMMARY

Primary care premises are generally complex small-scale buildings (when compared to hospitals) with many functional requirements to accommodate. They tend to be busy places with many people entering and leaving the building during the course of the day including patients, doctors, nurses and other service personnel. So it is understandable that the NHS has focused on issues of functionality and cost to evaluate the design of this building type. However, in the last few years there has been a fundamental shift in this approach and there is now much greater emphasis placed on the evaluation of the quality of design. Hence, this section attempts to set out that the ethos of the place is of paramount importance and the organisation of spaces within the building should flow from this overarching principle. The new wave of publications from the Department of Health recognise the importance of creating a high-quality working environment. These notes seek to guide the designer to establish qualitative factors through discussion with the users of the building and then refer to the detailed guidance on the ergonomic requirements for ensuring that room data sheets accommodate the functional requirements of a room. Current thinking is to assume that the use of rooms may change over time and, therefore, flexibility for change is also important.

Current design guidance issued by the Department of Health sets out some basic guidelines.

1.1 Robust planning

Ensure that robust strategic planning and rigorous capacity planning determine the service vision for the scheme. Demonstrate their impact on the investment decision for the physical improvements.

1.2 Forward-looking service delivery

Define organisational improvements and forward-looking service delivery plans and consider the change process involved to bring these about. Consider the impact of working practices on the functional requirements for physical space. Allow sufficient time to develop organisational changes alongside the building development programme.

1.3 Design quality

Establish design ethos. Improve design briefing by setting out quality requirements for the design of the built environment: make the design vision explicit particularly in relation to the patient experience. Encourage an integrated approach to design encompassing site planning, spatial arrangements, interior, landscape, and art.

1.4 Flexibility for the future

Devise planning and design strategies that cater for changes in service delivery over time. Seek further guidance to establish an optimal range of generic room sizes to enable greater utilisation of rooms. More detailed understanding of design approaches that facilitate flexibility will need to be developed.

1.5 Healthy neighbourhoods

Improve site planning to ensure convenient access, making the approach to the building visible and welcoming. Develop the potential for the buildings to contribute to the making of healthy neighbourhoods by considering the attractiveness of the adjoining built environment and open spaces to encourage, for example, cycle and pedestrian use.

1.6 Holistic care

Consider the sense of well-being and how personal and social factors influence our physical health. Be aware of the interaction between health and social policies in a locality and how their integration can contribute to happy personal lifestyles.

1.7 Sustainable investment

Define the requirements for sustainable investment and ensure these are fully appreciated at the start of the project. The shape and form of the building and the orientation on the site have a significant impact on sustainable performance. A social, environmental and economic approach to sustainability needs to be considered together for best results.

1.8 Training and support

Establish support for the project team on design quality throughout the project; for example, appoint client design advisors and design champions. Undertake design reviews during development as a quality check for commissioners. Develop training for project and design teams to help identify key issues, share good practice and understand how to make a step change in design quality for primary and community buildings.

2 INTERNATIONAL BACKGROUND

As we move into the second decade of the twenty-first century primary health care is increasingly viewed as an international issue

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

with government policies in many countries, including the UK, being affected by the influences and effects of health programmes around the world. This is reflected in the design of primary care buildings in the UK, which are becoming based more on a philosophical approach with greater fluidity, flexibility of use and changing treatment practices compared to the ergonomic space standards which were advocated as the framework for good design in the 1980s and 1990s.

Primary Health Care, usually abbreviated as PHC and based on practical, scientifically sound and socially acceptable methods and technology, was ratified at an international conference held in Alma-Ata, USSR (6–12 September 1978). It was jointly sponsored by the World Health Organisation and the United Nations Children's Fund where it was declared that a state of complete physical, mental and social wellbeing, not merely the absence of disease or infirmity, was a fundamental human right. The aspiration was that by the year 2000 all peoples of the world would enjoy a level of health that permitted them to lead a socially and economically productive life.

Architects, therefore, should review not only the recent health care buildings constructed in the UK, but also look at the policies and influences that have shaped buildings in both developed and developing countries throughout the world.

3 A SHORT HISTORY

Historically, there has been a long tradition of a strong relationship between patient and doctor. The Dawson report (1920) advocated primary care policies based on local services by the GP. At the same time political and social pressures led to the formation of the welfare state and the creation of the NHS (1948). The Royal College of General Practitioners was not formed until 1952. GPs at that time (mid-twentieth century) did not have an influential position in the medical hierarchy. This developed into a pattern of control in the NHS which focused on ever more ambitious plans for large, technologically advanced hospitals during the second half of the twentieth century. In turn, this culminated in the failure to deliver services on time and within budget giving rise to wide-ranging reviews on the structure of the NHS.

Due to financial pressures and social changes giving more power to individuals as consumers the NHS had to change to reflect these realities. Hence, private capital has been introduced and health policies have been focused on providing patient focused care. Services are now examined in relation to convenience and the ability for medical care to be provided in the community. Community hospitals are being built reflecting considerable similarity to cottage hospitals many of which were closed with great speed in the 1980s.

Ambulance services are also being redeployed on community needs and increasingly being linked to medical facilities (GP practices and community hospitals particularly in rural areas) once again reflecting similarity to the recommendations of the Dawson Report of 1920. The advantages of a primary led health service are also reinforced by the successful policies found in developing countries. As young doctors have the means to work throughout the world often taking a 'gap' year before or after their medical training they see the successful results of primary health care services operating in poor countries.

The changing pattern of health care is beginning to re-establish the importance of the relationship between doctor and patient. Patient focused care returns power and influence to the individual who is able to exercise greater control over the medical interventions advocated for their body. The government is addressing the challenge of providing a consistent and high quality of technical competence, but in a manner which responds and reflects the needs and aspirations of the patient rather than the convenience of the medical and administrative staff of the NHS. The architectural design quality of new buildings is therefore of greater importance today than it has been for nearly a century. The therapeutic benefits of good design are now recognised.

3.1 Functionality and cost

The NHS Estates' procurement policy has been based until recently on the Capital Investment Manual which required a business case approach to justify new investment. This led to a position where design quality was understood to be represented by functionality. Design quality was assessed by its functional suitability. That methodology was enshrined in their Estate Code document which set out a five-facet analysis process:

- Space utilisation
- Functional suitability
- Energy efficiency
- Statutory standards (compliance)
- Physical condition.

These factors were used as a basis for design quality evaluation. With this background an assessment of design quality does not include qualitative issues, or an assessment of the desired ethos of a building. The criteria set out in the analysis process did not include emotional responses such as 'pleasantness' or 'calmness' or indeed any suggestion of 'therapeutic value'. However, the problem remains that even if appropriate categories of patient satisfaction were included there would be difficulties in measuring or placing values on these factors. Design quality had to be based on quantifiable data.

3.2 Development of hospice design

A comparison with NHS policies for GP surgeries can be made with the procurement of hospices. The concept of holistic healing had been lost in the development of technical medicine in the twentieth century. A holistic approach to health care was much more central to the care of those who were ill in earlier civilisations.

3.3 Development of the NHS

Until the last few years, the government's approach to financing health care facilities, in line with all government spending, has been based largely on negotiating lowest cost tenders within annual spending budgets. This tended to downgrade the consideration of 'whole-life' costs, and it is only recently that the Treasury has begun to promote 'best value' as the basis for selecting successful bidders for government contracts.

Inevitably, this led to an approach within the NHS to concentrate on setting targets for different sizes of GP surgeries and offering guidance on the space standards that would be acceptable. This created a cultural background to the provision of buildings encapsulated within the framework of the 'Red Book'. This document has now been superseded by the Statement of Financial Entitlement (SFE) with details available on the NHS website (www.gov.uk/government/publications/gms-statement-of-financial-entitlements).

Standards were set for accommodation, maximum allowances were set down for professional fees and cost limits were established. These principles were developed over many years resulting in a well-established set of procedures with which doctors needed to comply to improve or redevelop their premises. The environmental quality of these buildings was given scant attention. The philosophy regarding design was essentially that the administrators of NHS funds would establish a framework of requirements and set cost limits in the belief that this would leave designers free to interpret the built form in an imaginative way.

Because of the relatively short timescale between inception and completion for primary health care buildings, and the personal rapport between doctors and architects, many successful small surgeries have been completed over the last decade. There could have been more encouragement from NHS Estates to the doctors under their contract to build facilities that were more flexible, more responsive to their patients' requirements and more likely to offer better value to the community.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Functionality has been a key test of previous appraisal systems, a process devised by the administrators or service providers with negligible attempts to ask patients what they wanted. Functionality was seen as a measure of how efficient the building was for staff and doctors to process the patient. The emotional wellbeing of a patient was secondary to issues such as special and ergonomic requirements.

The new NHS Plan recognises the importance of putting patients first, and opportunities lie ahead as new approaches to satisfying consumer demands begin to be developed and implemented. Thus, the effects of supply and demand and qualitative factors will emerge as patients begin to exercise their freedom to make choices (about the location of their treatment for health matters) in a market economy.

4 CURRENT POSITION

The government is looking to make changes in two areas of the health sector.

1 Several initiatives have been launched to give patients more responsibility for their own well-being.
2 Contractual arrangements are being explored between the government and private providers, giving rise to a greater number of private health care services.

There are also changes taking place in the contractual arrangements between GPs and the government. The introduction of new providers (specialist companies) is beginning to create market forces within which competition will emerge between service providers.

As alternative procurement routes are evolving for primary health care buildings both in the public and private sectors the architectural responses are becoming more imaginative. Consumers are also becoming more selective in recognising the role that quality can play in providing health care facilities.

These changes have also led to the development of a number of evaluation techniques to assess and grade the quality of health care buildings, such as Advice, AEDET, KPIs and NEAT. The earlier NHS approach to the procurement of primary care buildings was based on the Red Book. The recent changes have seen a move to give greater consideration to design quality and these evaluation techniques attempt to structure qualitative assessments as part of the appraisal system for seeking approval.

The architectural profession has become more engaged with the design of health buildings, including primary care facilities, by developing evaluation techniques. These are tools which allow evidence-based design to be articulated with conviction. Today the argument that good design is beneficial, not only for patients but the whole community, has largely been accepted and the debate has moved on to the political arena. The architectural process is now better understood and better followed than in the past and the product is under closer scrutiny. The profession has good tools (e.g. computer software) and is more confident in asserting its intellectual property rights as a designer of high-quality architecture.

The architectural profession is also influencing the political climate and the importance of the brief is now better recognised than 20 years ago. In particular, the ethos of a building is understood to be an important component in a brief, a development that has been led by the hospice movement and the design of some very successful specialist buildings such as the Maggie Centres. It is a period of growing independence of patients who are beginning to demand higher standards from their GPs reflecting service provisions offered by other business sectors.

4.1 Architectural context

New design philosophy emerging

There has been a significant shift in government policy which now recognises the importance of good design in the development of new GP surgeries. The Red Book set the standards for the *modus operandi* of GP practice in the UK for many years. It represented the outcome from a long period of development, periodic reviews and updating of data. It typifies the outcome of a bureaucratic approach in a very large organisation. The rules, costs limits and schedules of permitted accommodation were very prescriptive. Although the official briefing methodology offered little encouragement for good design a wide range of innovative GP surgeries has been built over the last decade. This framework of controls is now rapidly breaking down as new forms of procurement expand and develop in the joint public private partnerships that the government is encouraging.

A different approach to building design is being advocated for the next wave of primary care buildings. They will be buildings that are flexible and can incorporate the demands of a knowledge based economy, respond to the rapidly changing demands for information technology, and different working methods which will develop from faster communications between doctor, patient and specialist testing facilities (e.g. x-rays, consultant reports). Government procurement methods are seeking to enable future buildings to be flexible shells within which highly serviced workstations can be developed and changed over short periods of time. For example, a doctor's consulting room may have entirely different requirements in five years time than it does today – although it is likely to remain the fundamentally important space within which patient and doctor exchange information.

4.2 Finance

Life cycle costs and 'best value' – the government's approach

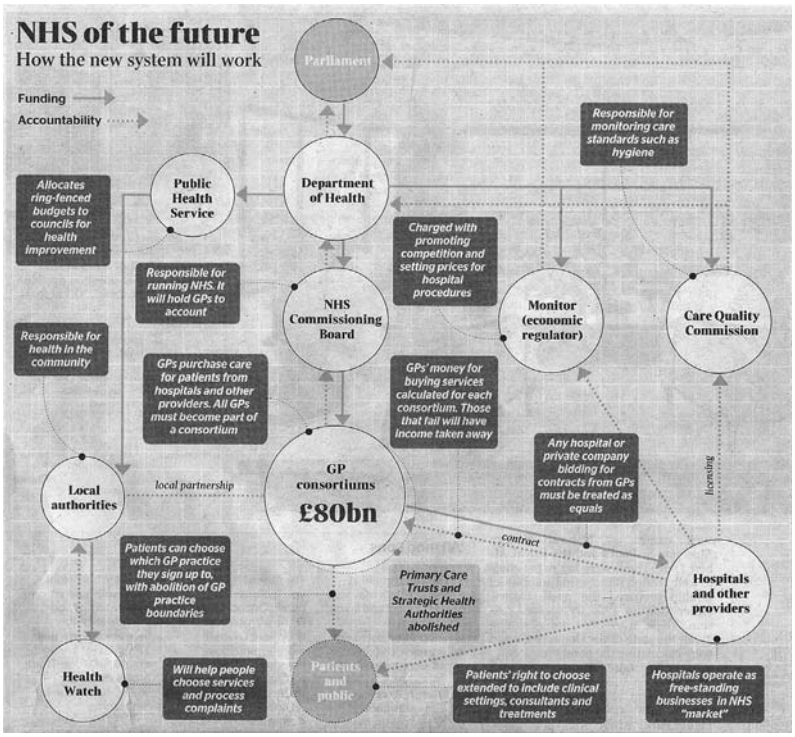
Until recently the tradition has been to award contracts predominantly on a lowest cost basis. The Treasury has now changed its policy and the interest in design quality is also manifesting itself in a reassessment of whole life costs. This approach is encapsulated under the umbrella of 'best value'. All government departments and local authorities are taking a broader look at 'best value' issues and this is providing an opportunity to develop new thinking about a whole range of tangible and intangible aspects of a building during its overall life span. At the simplest level, building material manufacturers are able to demonstrate 'best value' for their products not only as the result of initial costs but also taking into account maintenance schedules and renewal timescales. With design issues the growing recognition of user reactions and user satisfaction levels is beginning to influence the decision making process.

There is a growing group of specialist companies forming partnerships with GPs to finance new primary health care facilities. Their success rate in putting together viable procurement packages is being helped because of the changes in attitude by District Valuers. District Valuers are moving towards the creation of a special class of valuation for medical facilities, whereas previously they were seriously disadvantaged by being included with residential or local commercial values. These high valuations that are being rentalised as surgeries are enabling contracts to be written for minimum of 25 year lease periods guaranteed by local health authorities under the terms of existing procedures.

5 POLITICAL FRAMEWORK AND GOVERNMENT POLICY

Government policy regarding the design quality of health buildings has changed significantly since 2000. Procurement routes are changing. Primary health care facilities are becoming larger multifunctional buildings offering integrated health and care services. A variety of agencies and professional skills will work in them serving the local community. Private finance will be provided by specialist developers and local initiatives will ensure greater control of matching requirements with services.

This will have the benefit of allowing the new community facilities to include a wider range of services such as pharmacies,



33.1 *Extract from The Times dated 20 January 2011*

dentists, physiotherapists and alternative or complementary medical practitioners all working under one roof, linked often to paramedic and ambulance services. As health and care services become more integrated the new community buildings will grow in size and become multifunctional.

The Darzi Report (2008) was a review of the progress made in the NHS since the publication of the NHS Plan. His recommendations suggest more private providers of healthcare in the primary care sector, and this will require more flexible approaches to the contractual terms of appointment for GPs. David Cameron said on 10 October 2006 that 'he would give doctors more power, patients more choice and health providers more competition'. Now in power the new coalition government is setting about to make significant changes to the structure of the NHS including the abolition of all PCTs (Primary Care Trusts) and SHAs (Strategic Health Authorities).

This radical new model of the NHS, set out in the Health and Social Care Bill, maintains a universal health service, free at the point of delivery which allows the market to increase efficiency. Competition is being introduced to healthcare provision which should drive up standards and lower prices. This is moving from a managed system of healthcare to something more like a regulated market but with GPs in a much more dominant role than they have occupied since the formation of the NHS over 60 years ago. Primary care trusts and strategic health authorities are to be abolished. The Bill signals a significant decrease in the dominance of state-provided healthcare. These changes are illustrated in Figure 33.1.

These radical changes to the management and finance of the NHS with a major swing to the control of health care programmes by patients and their GPs do not undermine the on-going awareness that design quality remains very important. Evidence based design and the evidence base of interventions are both seen as targets for defining and measuring preventative health budgets.

Politically, the government recognises the importance of greater patient participation in the management of each individual's health care. It is moving towards better prevention and early intervention for improved health, independence and well-being. Research undertaken by the Department of Health indicates that people want to take more control of their own health and well-being but wanted more support to do this. This has led to the concept of NHS 'life check' which will be a two-part service – a self assessment followed by personalised advice and support for those shown to be at risk and is aimed at helping people to assess the risk of ill health created by their own lifestyles. Initially, NHS life checks are being developed for use at three key life stages – the first year of life, adolescence and mid-life (age 50–60). Piloting of these programmes is underway across the country.

Research has also indicated that millions of people suffer from mild to moderate mental health problems, and treating them takes up about a third of GPs' time. There is also a plan to pilot the use of individual budgets. The intention is that this will increase individual control over the services received. Individual budgets will build on some of the features of direct payments by increasing people's choice and control over the way they are supported. As well as social care funding, it will bring together different resource streams but an individual might receive, for example access to work and independent living funds, and allocate a single transparent sum to them.

Following the white paper 'Our Health, Our Care, Our Say: A New Direction for Community Services', published in January 2006 the government published a further document 'Our Health, Our Care, Our Say: Investing in the future of community hospitals and services' in July 2006. It announced that the Department of Health would invest £750 million of capital funding over the next five years in a new generation of community hospitals and services. They would:

- be locally led;
- provide high quality services;
- re-design patient pathways;
- anticipate future needs as the population changes;
- adopt new technologies;
- plan across primary and secondary care;
- be affordable for the whole health economy;
- promote integrated service solutions;
- engage and harness the potential of staff;
- enable the transition of staff;
- engage the public, the whole health and social care system and be innovative.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

The government wants the people to have a real choice of the GP surgery they register with. The right of patients to choose one surgery over another will help to ensure that those surgeries are open at times that are suitable for them. The government argues that if patient choice and PBC (practice based commissioning) evolves then health services will develop that are safe, high quality and closer to home in the community. The aim is to meet people's aspiration for independence and greater control over their lives and to make services flexible and responsive to individual needs. This will enable people to be more in control of their health care and place greater emphasis on the prevention of illness.

Four main goals are identified:

1 Better prevention services with earlier intervention. The government response to this aspiration is the introduction of the new NHS life checks for people to assess their life style risks and to take the right steps to make healthier choices. The aim is for this to be a personalised service in two parts.

   a The assessment tool will be available either on line as a part of health direct online or downloaded locally in hard copy.

   b Specific health and social care advice and support for those who need it will be available.

2 More choice and a louder voice. Patients will be given a guarantee of registration onto a GP practice list in their locality. To help them to make this choice it will be easier for people to get the information they need to choose a practice and understand what services are available in their area.
3 Do more on tackling inequalities and improving access to community services. There will be a clear focus on those with ongoing needs and the quality and quantity of primary care will be increased in under served, deprived areas. People with particular needs will be targeted including young people, mothers, ethnic minorities, people with disabilities, people at the end of their lives, offenders and other special groups.
4 More support for people with long-term needs. The intention is to improve communications between health care and social care services.

These changes are inextricably moving the original philosophical arguments set out for the NHS in 1948 towards a consumer driven service with an increasing element of private finance introduced to the provision of services. It would give GPs more responsibility for local health budgets, and it seeks to re-orientate our health and social care services to focus together on prevention and health promotion. It is anticipated that more care will be undertaken outside hospitals and in the home. Work is also underway on commissioning social care services in conjunction with medical services. Health and well-being are essential planks of this shift in policy.

General practitioners enjoy special status within the NHS, being the most public face of health care because they have most contact with the public. Just about everyone has at some time had reason to 'see their doctor'. People are more likely to know the name of their doctor than that of any other public servant. But though GPs are paid out of the public purse, few of us think of them as public sector workers. They run their practices very much as private businesses – as independent contractors and for profit, and have done since 1948. In England, private firms provide hospital services for the NHS and privately run diagnostic and treatment centres for NHS patients have cut waiting lists considerably. It seems a natural progression for this kind of investment to find its way into general practice and so help bring health care to the doorstep.

6 APPROACH TO BRIEFING AND DESIGN

Design quality is now recognised as being very important and the approach to designing health buildings is focused on achieving flexibility and a sense of place rather than the previous approach of functionality and cost. Any briefing process is complex and ultimately depends on the clarity and vision of the client to identify the ethos of the project. Of course, a successful building also requires a good architect who is able to interpret this mission statement, and balance the inevitably conflicting requirements to create an architectural solution that adds to its urban context and provides (in the case of primary health care buildings) a healing environment.

In the UK there were political moves for money to follow the patient and to create an internal market in the NHS. These attempts to adjust the original philosophical concepts of the NHS were driven by an increasingly urgent need to address the rising costs of health care. An examination of government publications demonstrates the moves towards patient-focused care with the intention of raising the importance of primary care and community-based services.

Functionality and cost were seen to be best managed by high-level project management teams and option appraisal techniques to select the most appropriate design solutions. Although there was an increased recognition of the importance of primary care facilities, there continued to be a shortage of expectations of design quality in both hospitals and primary care facilities. The design of hospices, however, began to demonstrate an alternative way of providing high-quality health care facilities. The provision of hospices usually started with a clear expectation of the desired ethos and funding was often from charitable sources. There was therefore a complete reversal of priorities in the briefing process for hospices which was in sharp contrast with the conventional understanding of NHS design. Design quality expectations were high, the spiritual needs of patients were paramount and the focus of the building was firmly centred on individual patients.

Other factors began to emerge during this period, as experiments introducing art into health buildings were undertaken and architectural research programmes began to demonstrate that there were therapeutic benefits from well-designed environments. Increasingly, international comparisons became easier as young doctors travelled more widely.

6.1 Personal choice – care in the community

The government realised that people wanted their local services to:

- Understand how they live and support them to lead healthier lives.
- Help them to live independently if they have ongoing health or social care needs.
- Be easy to get to and convenient to use.
- Be nearer to where they live, or easily available in the areas they work.

The government also aims to:

- Change the way services are provided in communities and make them as flexible as possible.
- Provide a more personal service tailored to the specific health or social care needs of individuals.
- Give patients and service users more control over the treatment they receive.
- Work with health and social care professionals and services to get the most appropriate treatment or care for their needs.

The government recognised that patients and service users should have more say in the services they needed and how they should be provided. Consequently, the government began to understand that it would be necessary for public, private, voluntary and charitable organisations to work together and in partnership to put the interests of the public first.

These political pressures, and the results of the consultation exercise, highlighted the need to adopt flexibility in the way health projects are provided, so that consumer choice is widened, but at

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

the same time patients are invited to take greater personal responsibility for making decisions about their health care.

Architecturally, this reassessment of how health services should develop over the next five years has resulted in a range of solutions for providing primary care health facilities. The mixture of public and private finance has generated a range of buildings including community hospitals, walk-in centres and community health centres, including GP surgeries, each responding to the unique requirements of a particular locality.

These moves towards greater flexibility, with a range of financial models, have also produced some regional variations and initiatives within the UK. Trends are also emerging between the needs of urban and rural sites. In England the LIFT programme, despite being subject to considerable delays in obtaining approval for many of the schemes being designed, is resulting in an interesting range of buildings, usually in urban areas.

In rural areas, PCTs are favouring the community hospital approach and it is apparent that there is a close similarity between their buildings and the cottage hospitals which formed the backbone of rural health services in the 1970s and 1980s. It is also this building type which has such close similarities to that which was envisaged within the structure for health services set out by Lord Dawson in his report of 1920. It is interesting that the review of emergency services has recognised the advantages to be found from placing trained paramedics in community hospitals in rural areas.

Therefore, we are in a much more receptive culture to accept and understand the therapeutic benefits that can arise from well-designed primary care buildings. New design performance indicators are being developed to include a 'delight factor'.

- Functionality
  - Does the building perform its purpose?
  - What is a building's productivity?

- Whole life costing
  - Sustainability
  - In use costs/adaptability

- Delightfulness
  - Is it a focal point in the community?
  - What do passers-by think?
  - Effect on the mind and the senses

These issues are not just about measuring the performance of buildings but about raising public awareness of the quality and delight that can be enjoyed from well-designed environments.

6.2 Evolution of concepts

Evidence based design

The changing pattern of the approach to health has evolved through phases of holistic care, followed by more technical solutions. More recently (over the last decade) there is emerging a greater awareness of the importance of well-designed buildings and justification for this approach is being directed through 'evidence based design' (EBD). The most widely cited and quoted researcher internationally in the area of evidence based healthcare design is Roger Ulrich, Professor of Architecture at Texas A&M University. In 2005 he worked for a year in the UK for the NHS.

In the UK MARU (Medical Architecture Research Unit) has been a leader of research into the design of health care environments and has produced a wide range of documents and publications.

6.3 Future plans

Community based health/holistic approach (echoes of Finsbury and Peckham experiment)

It is interesting to compare the latest government proposals for the provision of primary health care buildings with the Peckham Experiment and Finsbury Health Centre models of the 1930s. There is a return to providing primary health care facilities at a community level (80–90 per cent of all health care is provided by GPs outside of hospitals) through the programme of Health Living Centres and other initiatives which developed new procurement policies such as the PFI programme, Procure 21 and LIFT.

Better informed patients/consumerism

Patients are better informed today than when the NHS was introduced over 50 years ago. Consumerism will influence the attitude of patients who are used to high levels of customer care in other sectors of the economy. The influence of supply and demand in the market economy will inevitably challenge the providers of buildings to meet the new requirements.

Issues identified as being important include:

- fitness for purpose
- build quality
- sustainability
- adaptability
- safety
- efficiency
- appreciation of context
- an aesthetic impact that contributes to civic life.

CABE summarises good design as being a mix of the following attributes:

- functionality
- build quality
- efficiency and sustainability
- designing in context
- aesthetic quality.

CABE (The Commission for Architecture and the Built Environment) replaced the Royal Fine Art Commission and is now due to be wound up itself under cost savings by the coalition government. It played an important role in raising design standards particularly in the health sector.

Changing procurement systems

GP surgeries are too small to justify the competitive pre-contract procedures that potential development partners face under PFI procedures. The government policies for their Procure 21 method of procurement seem to be stalling, with considerable delays and increasing resistance from the contractors who have subscribed to the framework agreement. However there is a growing group of specialist companies forming partnerships with GPs to finance new primary health care facilities.

Primary health care buildings have been constrained by a set of procedures contained within the 'Red Book' which is now outdated. There have been enlightened solutions in recent years, by architects who have enjoyed a sustained period of work in this sector but imaginative solutions have been inhibited by the cost limits and tests of functionality. It was encouraging, therefore, that the government launched a new organisation, NHS LIFT (Local Improvement Finance Trust).

Many of the new facilities will also combine other services such as retail outlets, an optician's shop, pharmacy or other related services. Similarly, the intention is to bring primary care and social services together to improve communications, co-ordination of needs, thereby achieving a one-stop service for health, social services and housing. The NHS Plan is moving in the right direction. The new financial proposals through LIFT have introduced private finance and increased the flexibility of procuring new primary health care facilities.

We can anticipate that there will be fewer partnerships. Younger doctors, in common with many other professions, are increasingly

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

reluctant to take on the financial responsibilities of a partnership in an economy that has seen sustained and steady growth with security of employment prospects. Financial success and security can often be achieved without taking on commercial risks. The historical advantages of partnership are increasingly being overtaken by new structures for professional services.

Therefore, we can see a major shift towards greater concern for design quality as more sophisticated measuring systems are introduced to evaluate 'value for money'. Much more research is required to develop accurate appraisals of whole life costs. From an environmental stance, all five senses of the human body should be considered.

1 Touch
2 Smell
3 Sight
4 Hearing
5 Taste

Procurement routes are changing. Primary health care facilities are becoming larger multi-functional 'Healthy Living Centres' offering integrated health and care services. A variety of agencies and professional skills will work in buildings serving the local community. Private finance will be provided by specialist developers and local initiatives will ensure greater control of matching requirements with services. This will have the benefit of allowing the new community facilities to include a wider range of services such as pharmacies, dentists, physiotherapists and alternative or complementary medical practitioners to all work under one roof.

Society has become more aware of the importance of a sustainable, environmentally friendly environment and is developing an understanding for designs which embrace the quality of life factors – the joy and delight that architecture can add to the fabric of society. This highlights the need to fundamentally shift priorities in the current briefing process. The ethos of the organisation must be the springboard for the development of the brief.

Procurement routes are therefore changing, and developing to reflect these requirements:

- Criticism of the PFI route – architects have felt their influence constrained by often being expected to work speculatively, or at peppercorn rates, during the competitive bidding stages of appointment often taking many months, (if not years) to reach a conclusion, and feel subservient to the main contractor after their novation in a winning team and sometimes losing authority over their own designs.
- Procure 21 – the NHS Estates proposals for meeting government expectations for repeat business to a selected list of approved large contractors but subject to much criticism by medium sized architects and contractors.
- The LIFT scheme promised to meet many of the difficulties inherent in the other procurement routes particularly for primary health care facilities.

6.4 LIFTS (Local Improvement Finance Trust)

The launch of LIFT (Local Improvement Finance Trust) was an initiative to stimulate the funding and operation of future primary health care facilities. The NHS Plan included proposals for LIFT designed to introduce private finance in a structure which devolves responsibility down to smaller building blocks at a regional and local level. This company has a board of advisers and oversees the allocation of funds to regionally organised LIFT companies. These in turn will attract further finance from local authorities, housing associations and primary care trusts and would operate with local boards.

The regional LIFT companies seek to enter into joint venture agreements with local developers to provide new local primary care facilities. Hence, the initial government funding was designed to lever in a substantial proportion of private finance. A concern was whether the local companies would be of sufficient size to provide competencies in the key areas of:

- strategy
- construction
- FM and health services.

It might be anticipated that all these skills may be difficult to find within one company which would be of a size commensurate with the scale of project envisaged at a local level.

6.5 Local responsiveness and flexibility

To provide high quality local primary care facilities requires flexibility, and a local responsiveness to the needs and requirements that are particular to a community. It can be argued that the provision of the physical building should be separated from the provision of health services and the attendant facilities management needs during the life of a lease. Other sectors of the building industry and property market make clearer distinctions between the provision of the buildings and the operation of the services within them. As discussed elsewhere the office market has clearer structures which govern the way buildings are commissioned and occupied. Although some building owners occupy their own building, a much more sophisticated briefing process has evolved in recent years to enable a greater understanding of flexibility, efficiency and satisfaction by the people who use the spaces. The development of similarly comprehensive briefing documents should be a pre-requisite for all new primary health buildings.

Site acquisition is likely to be a critical factor, and location is a crucial component in the success of a primary health care building. It seems essential, therefore, to ensure that this imaginative initiative is fully explored at a local level, to ensure that the mechanisms are in place to provide the flexibility and responsiveness which will be required for its success. Medium sized developers, consultants and construction firms will need to work together so that collectively the competencies required are provided. This fundamentally different approach to PFI will encourage a 'bottom up' rather than a 'top down' approach to new solutions.

There are those who argue for repetition, and standardisation in the provision of primary health care facilities leading to ideas of the same building being reproduced on many sites. Perhaps there will be components of a building which could be standardised but health care needs to accommodate the social values that can flow from flexible and humane spaces.

6.6 Anticipating the future

The information age has given us the ability to share knowledge globally. There has been a new awakening of moral attitudes and responsibilities arising out of the Human Rights Act which is giving a greater sense of respect for the individual person. This is reflected in health care which is once again becoming focused on the patient as an individual. We should be encouraged by the opportunities now being presented to capture the ethos coming out of thoughtful building briefs.

Everyone involved in the provision of primary health care is increasingly aware that the individual must be the centre of their own health care, or well-being. There seems to be a universal acceptance that this policy can apply in both rich and poor economies. Health for All really is a policy for primary medical care which has no opponents, and crosses political boundaries.

The training of doctors is becoming more broadly based. Many university departments are now recognising that a scientific and technology based approach for medical education does not give a sufficiently well-rounded training for the doctors of the next generation. Humanities are being introduced to the curriculum of medical schools which reflect the recognition that doctors need to treat patients in a more holistic manner.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

The government is moving its position on health care policy with a new understanding of the importance of patients' needs. The requirements for health care are being assessed from the perspective of patients and there is recognition that the social agenda for health care needs to become more inclusive. Inevitably, this will lead to greater complexity in the organisation of services, and the crossing of boundaries between traditional concepts of health care, social services such as housing and the treatment of mental health issues. One is led down the path of recognising the importance of the built environment to provide a humane place in which to live a healthy life.

6.7 Trends

The research brings together a range of solutions from which it is possible to distil a series of common strands in the design approach.

1 Policies around the world are concentrating on improving health care services at a primary level.
2 There is universal attention to patient centred care irrespective of the size of the building, or wealth of the country, in which it is located.
3 Architecture and medicine are talking to each other. The quality of the humane healing environment is seen as a positive benefit.
4 Our well-being is reflected in the environmental quality of our new health buildings: smaller, community based flexible spaces, easily accessible and welcoming. They are designed for the benefit of the patient rather than the provider of medical services.
5 There is a high incidence of curved shapes in the design of small health buildings. The building form envelopes the user, provides comfort and is reassuring. It is non-threatening, and not confrontational. By a combination of form, light and colour, buildings around the world straddle cultural differences with an architectural language which individuals can recognise whatever their mother tongue.

6.8 Objectives of a brief

Doctors and architects need to work more closely together. Through the development of briefing documents, we should be optimistic about the opportunities that will arise for primary health care buildings in the future. They will provide the physical framework within which the complex social interaction of the community can engage with the medical profession. There is agreement that many of the better examples of good design for health buildings have been built in the primary care sector.

1 The brief should be the central and fundamental cornerstone for the provision of future health care buildings. It should set down the ethos and culture for the health care environment. Many of these over-arching objectives will be common to the design of a doctor's surgery anywhere in the world.
2 There are both strategic and practical levels of planning. It is at the practical level where there may be more substantial differences in the briefing document between one country and another.
3 The brief should set down the design aspirations. It will set out the 'wish list' and establish the sense of wonder which excites the spirit when good architecture is encountered.
4 The brief must bring together current ideas and anticipate future trends.
5 It must also capture the sense of change which is sweeping through the primary health care design field not just in the UK, and the USA, but in many parts of the world.
6 In another decade we are likely to find much broader acceptance of alternative therapies. In the West, we have only recently begun to understand and accept the contribution that alternative health remedies can bring. How much more there must be to learn about traditional Chinese medicine, for example, and environments such as the Glasgow Homoeopathic Hospital may well be the forerunner of many other buildings in the future seeking to combine traditional medicine, alternative therapies and a high quality of environmental design.
7 More sophisticated linkages are likely to emerge. Key words and phrases to consider when writing a brief are shown in Table I.

Table I Brief writing – key words and phrases

Key words: networking concepts	
• Government policy	• Finance and funding
• Community facilities	• Flexibility
• Education (training)	• Communications
• Sustainability	• Location (accessibility)
• Knowledge (transfer of skills)	• Transport policy
• Value for money	• Patient needs

An examination of these issues will assist in establishing the strategic framework for the design of a new primary health facility. It may be helpful to prepare checklists on these points as an aide mémoire during discussions with key members of the client and design team. This will give focus and direction to the establishment of both the strategic and practical aspects of the brief.

6.9 Design quality

Our modern understanding of a primary health centre was set out in the Dawson Report (1920) as 'An institution equipped for services of curative and preventive medicine to be conducted by general practitioners of that district, in conjunction with an efficient nursing service and with the aid of visiting consultants and specialists'. It remains a valid definition today.

A framework of issues for doctors and architects to discuss together when developing a brief for a healthy living centre is shown in Table II.

Table II Writing a brief – matrix of factors to consider

Issue		Architecture	Medicine
1	Functionality	space standards, initial cost effectiveness, data sheets	flexibility, meeting future working patterns
1	Multi–agency	planning flexibility, long life, loose fit	choice of agencies, services to be offered
1	Accessibility/ convenience	transport linkages, pedestrian routes, parking, disabled access	patient adjacency, alternative locations
1/2	Exemplar design models	environmental performance standards	good practice models, standard room plans
1/3	Site/location/ land acquisition	urban context, planning constraints, value for money	convenience, visibility of building, availability
2	Brief – the ethos of the building	architectural language, style, patient comfort, therapeutic benefits	personal rapport with patients, relationships, working environment, sense of well being
2	Community	quality of the place, welcoming, comfortable	friendliness, reassurance, accessible
3	Finance – procurement method, costs	contractual arrangements, PFI, LIFT, design criteria, project management, programming	PCGs/PCT's ability to influence funding, budgets, access to finance
3	Sustainability	energy consumption, life cycle costs	recycle facilities, medical efficiency
3	Standardisation	standard components within unique design, choice of materials	routine procedures, clinic requirements, compatibility with other surgery operating systems

Key
1 Physical
2 Emotional
3 Financial

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

6.10 Recurring themes

The following list sets out a number of key issues:

- Emphasis on quality of architectural design – importance of high quality environmental factors.
- Emphasis on the patient as an individual.
- Patient focused care as a local level of primary care being the hub of patient treatment rather than the start of a linear process of passing through various levels of specialisation.
- Building flexibility – design for change, openness, accessibility.
- Buildings have not played a key role in health policy, but need to in future.
- There has been insufficient recognition of the importance of environmental quality, and the effect that this can have on health care.
- Architects need to take up the opportunity to build on the new interest by doctors to embrace health and humanities.
- It is people that regenerate places, not places that regenerate people. Overreliance on economic, social and physical modelling techniques and statistical analysis at the expense of visual stimulus, undervalues the importance of architecture.
- Visual stimulus is a key ingredient of the built environment. The delight of architecture should not be squeezed out of the built environment by analytical methodologies.
- Give status to the product as well as the process (think of design as well as construction).
- Put architecture back into health.
- The patient must come first.

6.11 A framework for the brief – the ethos

Right at the beginning of the document there should be a section which encourages the design team to set out the quality aspirations expected from the building. It needs to encourage future users of the building to think about what the ethos of the building should be; to set out what the building users want out of the building; and what are the intangible values that the designers aim to achieve. For example, should the building be:

- friendly
- efficient
- welcoming
- relaxing
- comfortable
- warm
- pleasant
- accessible?

The brief should seek to encourage the achievement of high design standards through the eyes of the patient – the tests of functionality and cost should be a secondary, albeit essential, requirement of the procurement process for any new primary health care building.

Huge potential benefits are coming out of these changing philosophies in primary health care buildings which will influence the quality and procurement methodology for our health buildings at the specialised end of health care.

6.12 Strategic components of a brief

Having established a framework of ideas or ethos, and understanding the context and networking requirements for a particular building in a specific location, the strategic components of a brief can be more precisely laid down, as shown in Table III.

After the ethos of the project has been defined, and the strategic objectives have been agreed, the practical issues of functionality and cost can be explored. What this research has revealed is the benefits that would arise if a new data based handbook for primary health care facilities was available, but written through the eyes of the patient rather than from the perspective of the health service provider. Thus, new standards could be quantified and dimensioned for:

- patient control of their environment in treatment rooms, waiting rooms and other spaces;
- design of furnishings, fixtures and fittings;
- flexibility in the layout of equipment within a space;
- flexibility of use of a space;
- environmental design standards and performance specifications;
- compliance with access for the disabled;
- transportation links (on foot, cycle, car, or public transport);
- functionality;
- landscaping;
- building materials;
- cost limits.

7 KEY RELATIONSHIPS

The design of primary health care buildings has changed radically over the last few years and design quality is now seen as a very important aspect of the procurement process. This has been reflected in the recent Department of Health (DH) publications and essential reading for any architect working on a new primary care building is 'Primary and Community Care – Health Building Note 11–01: Facilities for primary and community care services'. This document, which is part of a suite of Health Building Notes, sets out an approach to designing new facilities which recognises the need for flexibility, changing relationships and how to set out firming up a brief that will result in user-friendly environments. The document does not provide detailed design guidance on specific rooms and spaces and refers to the need for planning and design teams to refer to the following publications for guidance on generic rooms and spaces.

- Health Building Note 00–02 – 'sanitary spaces'
- Health Building Note 00–03 – 'clinical and clinical support spaces'
- Health Building Note 00–04 – 'circulation and communication spaces'

This section follows this lead and does not attempt to set out generic ergonomical room data sheet type details which underpinned the design approach for primary health buildings when the main assessment criteria were functionality and cost. Rather, designers and architects working on new buildings for the future need to establish the ethos of the client and develop solutions that embrace that philosophy. Obviously, it is necessary to ensure that the practical space standards are met but this should flow through the evolution of the brief.

Health Building Note (HBN) 11–01 sets out best practice guidance on the selection and zoning of facilities for delivering primary

Table III Practical components of a brief

– **The Vision**	– how will the experience of visitors, patients and staff be enhanced by the building?
	– how will the design quality add to the expectation of excellence?
	– how will a high quality environment be achieved?
	– will it be patient focused?
– **The Process**	– select an appropriate procurement method to ensure that design quality isn't stifled.
– **Urban Design**	– will the building contribute to the sense of place?
	– will transport linkages work?
– **Benchmarking**	– is the building going to add to the level of competencies prevailing in the vicinity?
– **Value for Money**	– will it represent 'best value'?
– **Patient Centred**	– will the brief encourage good environmental design and achieve therapeutic benefits for patients and all other users of the building?
	– is it patient centred?

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

and community care services. The guidance is applicable to the following building types:

- GP premises
- Health centres
- Primary care centres
- Resource centres
- Urgent care centres (including walk-in centres and minor injuries units)
- Community hospitals (also known as intermediate care hospitals).

It describes the following:

- The range of services that may be delivered from primary and community care buildings.
- The types of space needed to deliver these services (many of which are generic).
- The way to quantify these spaces for briefing purposes.
- The way spaces can be organised into zones to create efficient, flexible, user-friendly environments.

This guide has been written with the provision of new-build facilities in mind. The principles described apply equally to the refurbishment and extension of existing buildings.

The document sets out the following.

Strategic design issues:

- Design quality
- Quality of place
- Art and integrated design
- Sustainability
- NHS identity.

Functional design issues:

- Accessibility
- Infection control
- Wayfinding
- Security
- Emergency preparedness.

As already mentioned the shift in design approach is towards flexibility and adaptability. HBN 11–01 sets out a list of criteria and offers an approach to the use of space which is multi-functional and time-managed.

Strategies include maximising flexibility and adaptability:

- Use generic patient/client contact spaces.
- Limit the number of specialist spaces.
- Standardise room sizes and position of built-in equipment.
- Consider future engineering service requirements at the outset.
- Consider flexible and adaptable forms of construction.
- Develop a modular approach to planning and construction.
- Provide space for future expansion, if relevant.

Most primary and community care services involve one or more of the following activities:

- Counselling
- Consultation
- Examination
- Diagnosis
- Treatment
- Physical therapy.

These activities may occur on a planned basis (for example specialist outreach consulting), unplanned basis (for example urgent care or walk-in services) or a combination of the two (for example GP consultation). This affects the way services are managed rather than the facilities required.

Most activities involve a practitioner and an individual patient/client, although certain forms of physical therapy and counselling may take place in groups. Most activities can be delivered from the following generic patient/client contact spaces:

- Interview room
- Consulting/examination room
- Treatment room (that is, with mechanical ventilation)
- Examination/physical therapy room
- Group room.

Generic patient/client contact spaces should be shared on a timetabled basis to maximise their use unless required on a dedicated basis for full-time use. Treatment activity requires special consideration. Treatments given in primary and community care settings fall under a number of categories, and can occur in different room types.

Non-invasive and minimally invasive treatments may take place in consulting/examination room, treatment room or examination/physical therapy room, depending on space requirements. (A noninvasive procedure is one that does not break the skin, for example changing a dressing. A minimally invasive procedure is one that breaks or punctures the skin, for example injections and taking blood.)

An invasive procedure is one that cuts the superficial layers of the skin, for example removal of moles, warts or corns, biopsies or any endoscopic procedure accessing any body orifice. A local anaesthetic or sedation may be required with an invasive procedure. Most invasive procedures and certain procedures using rigid endoscopes can take place in a generic treatment room. In addition, procedures that generate heat (for example ultrasound) and/or unpleasant odours (for example tissue viability clinic) should only take place in a treatment room (that is, with mechanical ventilation). Some invasive procedures may require all-round couch access, including access to the head of the couch.

7.1 Standardise room sizes and position of built-in equipment

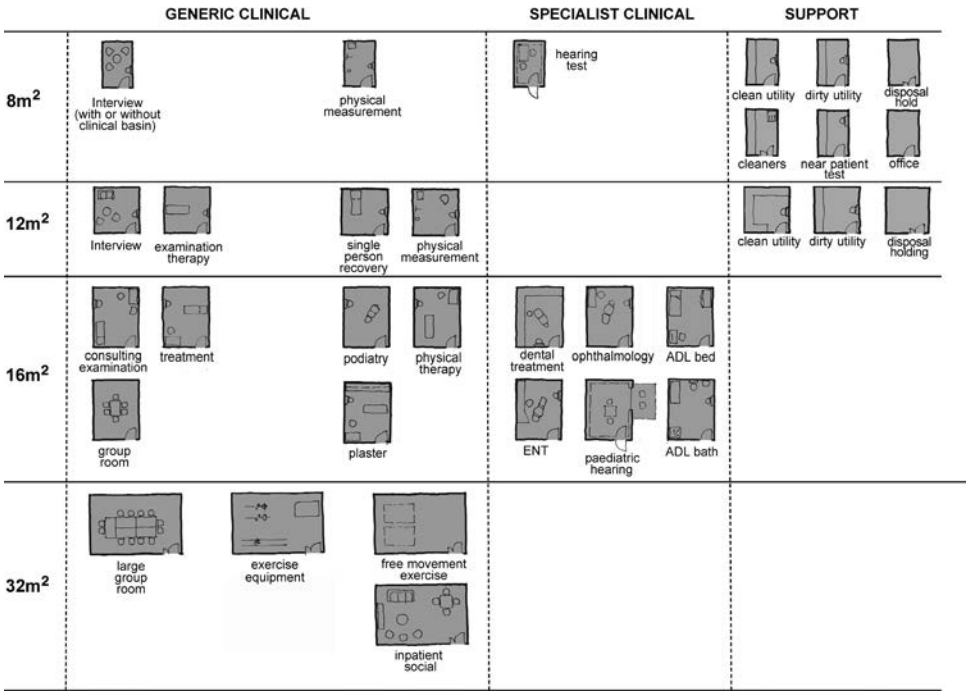
Room sizes and dimensions should be standardised wherever possible. This may mean sizing up to some extent, but results in rooms that can be adapted (for alternative use) more easily. Experience and ergonomic analysis suggests the following room sizes provide a good fit for most generic rooms in primary and community care buildings:

- 8 m^2
- 12 m^2
- 16 m^2
- 32 m^2

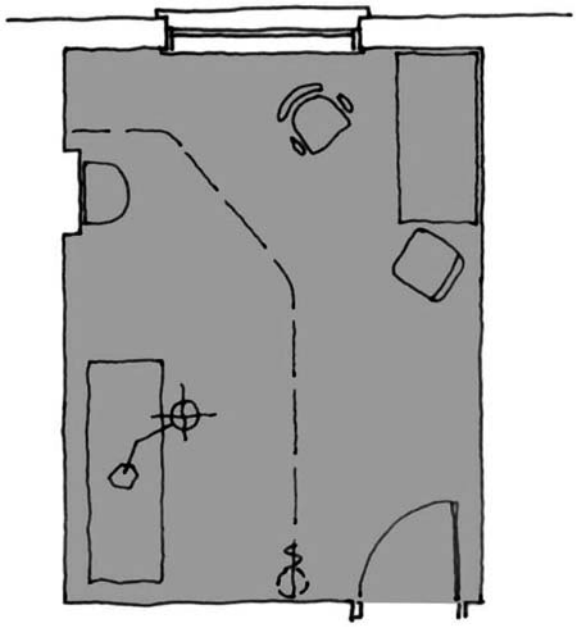
The ability to standardise the position of built-in equipment (for example clinical wash-hand basin) will further enhance adaptability. This idea is shown in Figure 33.2.

The 16 m^2 consulting/examination room in Health Building Note 00–03 shows access to three sides of the couch. This is not generally required in primary and community care settings, where the couch can be aligned against one wall, leaving additional space for patients, escorts and mobile equipment. The couch should be correctly handed, however, and the clinical wash-hand basin should remain within the cubicle area – see Figure 33.3.

The 12 m^2 consulting/examination room with single-sided couch access identified in Health Building Note 00–03 is not recommended for use in primary and community care buildings as it offers less space for equipment and patients/escorts than the 16m^2 room.



33.2 *Modular sizing concept*



33.3 *Alternative layout for 16 sq m consulting/examination room with couch against wall*

7.2 Consider future engineering service requirements at the outset

At the beginning of the design process consideration should be given to which room functions are likely to change over time and the impact this will have on engineering service requirements. Two broad approaches are possible:

- Install sufficient engineering services at the outset to accommodate future uses of the room.
- Provide adequate infrastructure capacity, plant room and containment space to upgrade engineering services at a later date.

Decisions over which approach to employ will be influenced by the ability to predict future changes in use, economic constraints, and the need to satisfy any emergency preparedness provisions, which may require rapid conversion from one room type to another.

Where it is decided to install engineering services at the outset to accommodate future use, controls can be used to set ventilation, temperature control and lighting systems at the appropriate levels.

7.3 Consider flexible and adaptable forms of construction

To ensure day-to-day flexibility, consider the use of:

- Acoustically treated folding partition walls between adjoining group rooms, allowing rooms to be opened up to create larger spaces.
- Changeable signage, allowing room names and routes to be easily modified for individual sessions.
- Mobile, rather than fixed, equipment and furniture.
- Wireless and/or internet protocol technology, where appropriate.
- Standard data outlets (for example RJ45) and common structured wiring infrastructure to create a network for telephones, data and video.

To ensure that buildings are adaptable in the longer term, consider the following:

- The use of framed construction allowing partition walls to be altered.
- The installation of suitable surface fixed trunking to allow engineering services outlets to be added or altered, particularly where large numbers and types of outlet are concentrated on a small space. This is subject to infection control requirements being met.
- The use of structured wiring for IT and communication systems and modular wiring systems for lighting and small power.
- Provision of adequate spare plant and service access space, including ceiling void depths and service access space, including ceiling void depths and service risers, to have sufficient capacity to accommodate anticipated future M&E expansion and equipment replacement.
- Developing a modular approach to planning and construction.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Adopting a limited number of room sizes can lead to building layouts that use economic structural spans, stack efficiently and allow for nature cross-ventilation.

This approach to planning assumes three broad categories of the use of space:

- Public spaces
- Primary and community care spaces
- Staff areas.

Diagrammatically they are represented in Figure 33.4.

For those embarking on the design of a new primary care or community building more specific guidance is set out in HBN 11–01 and is recommended as essential reading.

8 ENGINEERING AND IT SERVICES

This is a rapidly changing area of design. Technology is evolving and the preferred methodologies for any particular site should be carefully checked with the client and appropriate public approval bodies.

The following list is an aide-memoire of topics for the designer to consider:

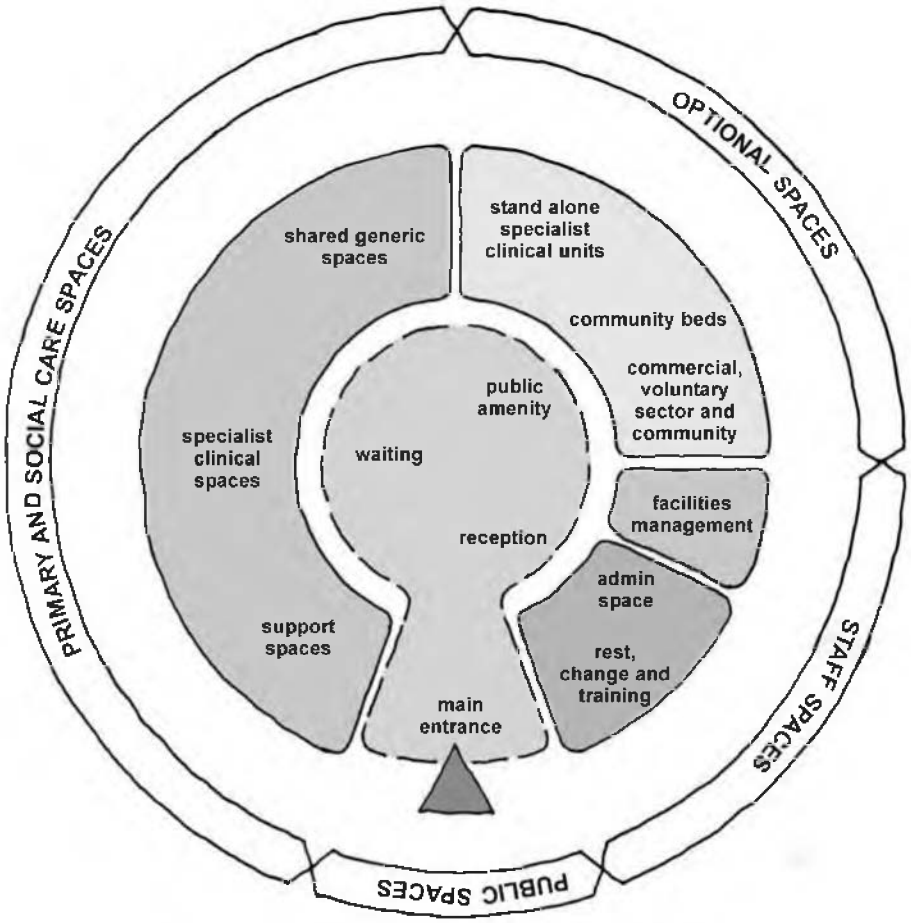
- Life expectancy of plant and equipment
- Metering
- Control of infection
- Space requirement for engineering services
- Piped medical gases
- Heating systems
- Ventilation and cooling
- Hot and cold water systems
- Acoustics
- Fire safety and alarm systems
- Lighting systems (internal, external and emergency)
- Call systems (patient/staff and emergency)
- Safety and security
- CCTV
- Car parking and control systems
- Door access control systems
- IT and telephone wiring (or wi-fi) systems
- Entertainment systems
- Document/data transport systems
- Controlled drugs storage
- Sustainability and energy efficiency
- Management and operational control of services.

The objective of the designer should be to offer the client flexibility and provoke dialogue with the users of the building to ensure imaginative solutions are considered.

9 ART IN HEALTH

The importance and influence of art, music, food and architecture have all re-emerged as significant factors in designing primary health care buildings. Designers should look at the importance of recognising that a sense of well-being includes healing the soul as well as mending the body. Broadly understood as holistic care, architects should discuss with clients, doctors, patients and other users of primary care buildings aspects of these ideas to incorporate them into the design of new projects. The briefing process for new buildings should focus on the patient and learn from the successes of good design developed in the hospice sector.

The concept of art in health buildings is at the heart of 'value for money evaluations' and applies equally in the primary care sector as well as in hospitals. Healing is a more embracing concept; it involves our minds and our feelings and our spirits as well as our bodies. It is, therefore, perfectly natural to go along with Handel's view and accept that music can heal our sadness.



33.4 *Zoning concept diagram*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

10 HOLISTIC CARE

As the focus for health care in the UK is shifting towards the primary care sector it is interesting to reflect briefly on historical attitudes towards treatment of those who are ill. In early civilisations (e.g. Egyptian and Roman) holistic care was a central part of caring for the sick. The development of hospitals began out of a wish to offer hospitality to those in need. In those early times, up until the renaissance, almost everything done for the sick in Western Europe was provided by the Church. However, with the development of scientific medicine much of this pastoral care was gradually taken out of the Church's hands and during the past two centuries the medical profession has become secularised. The development of the medical profession, in a technological sense, has developed with the creation of the Royal Colleges and the establishment of specialised qualifications. Unfortunately this led, until recently, to an attitude of mind that saw death as a failure of medical treatment.

The World Health Organisation has reported that the single most important factor for health in a hospital is the atmosphere. If this is true then the spirit in which the medicine is practised is important. However, with government policy rapidly changing the focus of attention onto patient centred care based in the community we know that the vast majority (75 per cent or more) of the health budget of the NHS is spent in the primary care sector. This would suggest that there is an urgent need to address the provision of holistic care services within the primary care sector including:

- provide appropriate spiritual and religious care to patients, staff and other users;
- provide pastoral care;
- provide regular opportunity for religious expression;
- identify and assess the needs for chaplaincy/spiritual care;
- support multi-faith working which respects and supports faiths identified.

Re-examine the role of holistic care in the primary health sector. Many GPs already have links with alternative medical treatment offering guidance on complementary medicine and alternative therapies. Should community-based GP surgeries have more direct links with chaplains or representatives of other faith groups? Should GP surgeries be encouraged to develop formal links with faith groups in their locality? Perhaps primary care buildings should reflect these issues of well-being in their design, and provide spaces for contemplation or rest. This is part of the development of an environment for healing. There is an immense shift from assessing the value of what is being done by many medical and nursing staff as a sense of vocation to assessing it in terms of cost effectiveness. Do staff need to rediscover the sense of vocation where they have to help in healing and not just regard themselves as 'service providers'? The use of language is important. A balance has to be struck between the book keeping elements of running a GP surgery and offering compassion for suffering people.

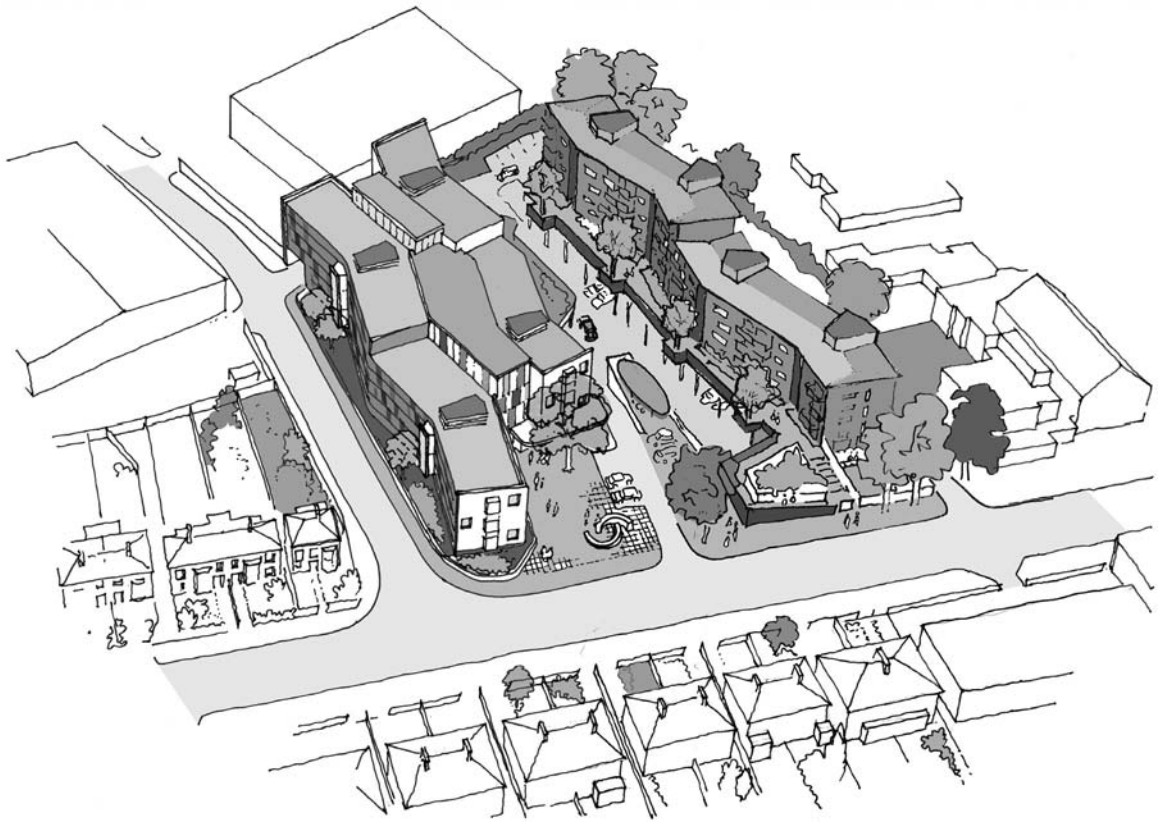
11 CONCLUSION

The primary health care sector in the UK is experiencing great change, and is also carrying a great deal more responsibility for the well-being of patients. Indeed, we are seeing government policy for health care move beyond the limitations of previous administrations to embrace wider issues such as the environmental conditions in socially deprived areas. More positively, connections are being made between the quality of the built environment and the physical well-being of patients living in a particular locality. Social policies and health policies are being recognised as interdependent.

12 CASE STUDIES

Case study 12.1

Project: The Heart of Hounslow Health Centre, Hounslow, London
Completion Date: 2007
Architect: Penoyre & Prasad
Developer name: Building Better Health
Main Contractor name: Willmott Dixon Construction
Quantity Surveyor name: Davis Langdon LLP
Services Engineer name: Whitby Bird
Structural Engineer name: Price & Myers LLP



33.5 *The Heart of Hounslow Health Centre, London. Aerial sketch view showing health centre and key worker housing next door*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



33.6 *The Heart of Hounslow Health Centre, London. The entrance and atrium maximise use of natural light to create an uplifting environment (photo by: Nick Kane)*



33.7 *The Heart of Hounslow Health Centre, London. View of atrium with waiting area in foreground (photo by: Nick Kane)*



33.8 *The Heart of Hounslow Health Centre, London. View of Main Entrance (photo by: Steve Townsend)*



33.9 *The Heart of Hounslow Health Centre, London. View of West Elevation (photo by: Dennis Gilbert)*

The Heart of Hounslow Centre for Health is now one of the largest Primary Care Centres in the UK. This centre was built in pursuit of new ambition for primary care in the NHS whereby a large range of services is gathered together in one place better to serve patients, develop staff capacities and provide 'joined up' delivery. This ambition needed to be expressed in the civic qualities of the architecture. The building was procured through a Public Private Partnership, which means that possible future uses of the building need to be considered in the design. Together with the constantly changing nature of health services that makes a compelling case for adaptive design.

The Heart of Hounslow Centre for Health currently accommodates some 14 separate departments and services. These are arranged on each floor to suit the optimum relationships. Heart of Hounslow hosts four GP practices, a range of clinical services, physiotherapy, podiatry, dentistry and speech and language services, social care outreach services, special facilities for children, adolescents and people with learning disabilities and health information/cafe. Almost half of the accommodation is workspace for domiciliary staff. All these functions are organised around a five storey high atrium with bridges and galleries that allows the parts of the building to be pointed out from the reception desk.

The concrete structure of the building is organised on a simple repetitive module that allows areas to be set up as open plan offices or as cellular clinical rooms with non-structural internal



33.10 *The Heart of Hounslow Health Centre, London. Wayfinding is clearly legible from the atrium and waiting area (photo by: Nick Kane)*

partitions. Externally windows alternating with coloured aluminium panels form horizontal bands. If necessary the window and panel position can be changed to follow internal reconfiguration; but they are positioned in such a way that partition positions can be extensively altered and still permit day lit internal rooms. The services strategy, with its ducted air heating and comfort cooling, supports this adaptability with the main distribution in a central spine following the corridor zone.

The atrium is painted white so that the coloured glass in clerestory windows and the entrance screens cast ever-changing patterns on its internal surfaces. The staff 'club' is located on the top floor with panoramic views over London.



33.11 *Loxford Polyclinic, Essex Front Elevation (photo by: Ed Hill)*

Case study 12.2
Project Name: Loxford Polyclinic
Project Location: South Ilford, United Kingdom
Architect: Devereux Architects
Completion Date: 2009
Client: Loxford Complex Limited for Redbridge Primary Care Trust

London's first purpose built Polyclinic was recently opened by Lord Darzi in South Ilford, East London and is one of up to 150 to be opened as part of the Under Secretary for Health's 2008 vision for Primary Care in the NHS.

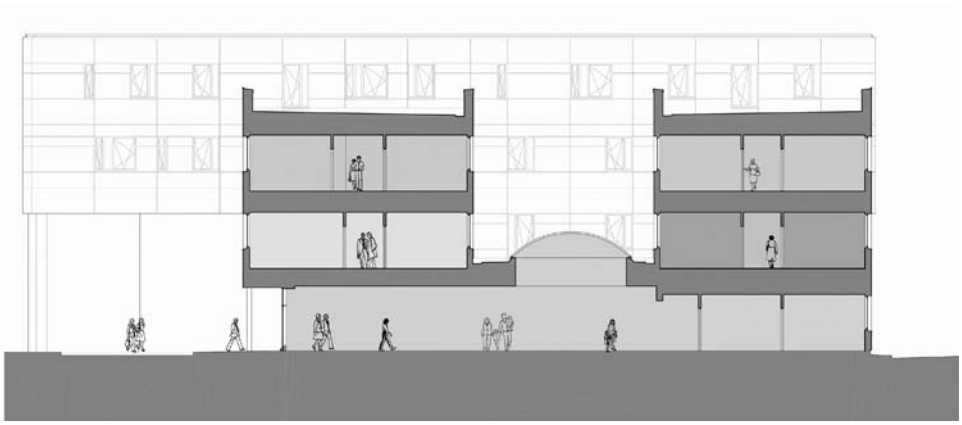


33.12 *Loxford Polyclinic, Essex Plan*



33.13 *Loxford Polyclinic, Essex. Reception, waiting and Café (photo by: Ed Hill)*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



33.14 *Loxford Polyclinic, Essex. Section*



33.15 *Loxford Polyclinic, Essex. X-ray suite (photo by Ed Hill)*



33.16 *Loxford Polyclinic, Essex. Dental surgery (photo by Ed Hill)*

Strategy
The Polyclinic sits at the centre of Redbridge PCT's new Loxford 'Polysystem': a new way of joining up health services and providing easier access to healthcare. The clinic is a Hub providing links with local Spoke facilities, i.e. GP surgeries, primary and other voluntary care services.

Innovation
The new 4 storey clinic will serve up to 50,000 local people and will offer early and late appointments 7 days a week for a comprehensive range of services traditionally provided only in hospitals. In addition to GP surgeries, new services include: minor ops, x-ray and ultrasound, ENT/audiology, phlebotomy, dentistry, podiatry, ophthalmology, rheumatology and gynaecology. To encourage healthy lifestyles there is a well-being clinic and a cardiology/physiotherapy unit complete with gym. Patients can pop in without appointment and use the Self Testing Facility for blood pressure and BMI, book into the flexible group rooms for health related activities or just relax in the community café. Complementing the Polyclinic services the '100 hour' pharmacy offers consulting facilities.

Place making
Located on a busy road within a dense residential district the building is now a contemporary landmark within the Ilford community and is easily reached on foot or by bus. On entering the building everyone is met by a 'meet and greet' point within a bright and spacious toplit waiting 'lounge' which is open plan with the café. The main reception desk provides all of the services in the building with a single control point for appointments and information. The waiting area is a designated Public Art space and the community are encouraged to contribute or just come in and view the displays.

The GP services and blood testing areas surround the waiting space on the ground floor. Above this are two further storeys of clinical services arranged around the central lightwell. Staff are well provided for with a suite of administration, changing and relaxation spaces on the third floor including a large lounge space with views over Ilford.

Adaptability
The lightweight form of panelled construction allows partition layouts to be adapted and moved flexibly to suit changing clinical requirements. Clinical spaces are standardised so that consulting and treatment rooms are interchangeable. GPs will use a 'Hotdesk' system where notes are written up in a separate suite of non-clinical rooms which will free up valuable consulting space.

Sustainability
The Polyclinic achieved a NEAT 'Excellent' rating through simple passive and active strategies:

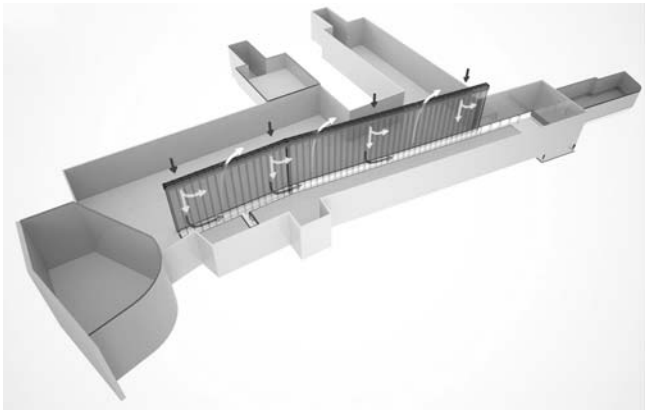
- Located on a brownfield site easily reached by public transport.
- Building shape which provides natural light and ventilation to almost every single room including many wcs.
- Lightweight offsite construction system avoiding site waste.
- Waterless urinals and low flush systems.
- PIR sensors to switch off lights automatically.
- Underfloor heating for efficient distribution of energy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Case study 12.3
Project name: Houghton le Spring Primary Care Centre, Tyne & Wear
Architect: P+HS Architects
Size: 7,500 m^2
Client: Sunderland Teaching Primary Care Trust
Main Contractor: Willmott Dixon
M&E Engineers: Cundall Johnston & Partners LLP
Engineers: Breathing Buildings
Building Services Contractors: LJJ Contractors Limited



33.17 *Primary Care Centre, Houghton le Spring. Entrance: the inviting entrance also has a civic presence*



33.18 *Primary Care Centre, Houghton le Spring. Thermal wall image: the building is naturally ventilated using a thermal wall which is based on the principles of thermal mass and the stack effect*

'Raising the bar in sustainable design for Healthcare Buildings'.

A new primary care centre under construction at Houghton le Spring, Tyne and Wear, has achieved a BREEAM 'Outstanding' at design stage; the first healthcare building in the UK to achieve this. The new 7,500 m^2 centre incorporates an existing sports and leisure facility, with the new build element dramatically extending the original to three times its size, and bringing together healthcare, sports, leisure and wellness facilities on one site.

Main contractors Wilmott Dixon and P+HS Architects are working with Sunderland Teaching Primary Care Trust and Sunderland City Council to develop the £18m scheme. The project has been designed in collaboration with both CABE and Cambridge University's 'Breathing Buildings' consultants to ensure exemplary



33.19 *Primary Care Centre, Houghton le Spring. Internal: the atrium allows light to flood into the central parts of the building*



33.20 *Primary Care Centre, Houghton le Spring. Model: the building in context with sports, leisure and wellness facilities also located on the site*

design quality and a highly sustainable solution. The project was procured under a local authority SCAPE framework contract.

Healthcare facilities in the new two storey centre will include a minor injuries walk-in centre, diagnostics facilities including x-ray and ultrasound, planned care clinical accommodation, a 24 bed rehabilitation unit and supporting accommodation, a community café and meeting rooms.

Alongside but integral to the healthcare centre will be new and refurbished sports and leisure facilities with accommodation for wellness classes, and physiotherapy facilities. Aiming for the highest BREEAM rating of 'outstanding', the development incorporates sustainable technologies to reduce the carbon load as far as possible. The building's orientation has been purposely designed to minimise excessive solar gain in summer, but to maximise sunlight during the winter months and exposed glazing is protected by solar shading.

The building is largely naturally ventilated using an innovative system designed by Breathing Buildings. Based on the principles of thermal mass and the stack effect, tempered air is delivered from an underground plenum via 49 chimneys to ventilate and condition the interior of the building. Ground source heat pumps are used to provide space heating which required 104 bore holes to be drilled on the site. Rain water harvesting is used to reduce water consumption and a sedum roof will not only encourage biodiversity but also attenuate rain overflow reducing the drainage load. Solar thermal panels are installed to provide preheated domestic hot water for

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

the building and renewable energy sources, such as, a vertical axis wind turbine and 350 m^2 photovoltaic panels further contribute to the facility's energy requirements to reducing the building's carbon footprint.

The two principal elements of the scheme, the primary care centre and the leisure/sports facilities, are positioned either side of the main entrances. Because of the sloping site, the sports centre entrance is one floor level above that of the primary care centre, which requires two entrances to be linked by a main stairway within the two storey atrium. This atrium allows light to flood into the central parts of the building where the main reception points are located together with the café, self help area and principal reception lounges. A 24 bed rehabilitation ward is located on the first floor level to provide privacy for patients and visitors. All bedrooms are single, en-suite and have glazed doors opening onto Juliet balconies. The new building is structured around a steel frame with external elevations in a combination of natural stone, render and Trespa panelling. External works involve extensive landscaping and the creation of a new multi use games area as well as the refurbishment of an existing crown green bowling facility and relocation of the existing skate park.

There are 163 car parking spaces, including car sharing bays and electric car charging points, included in the scheme, as well as secure cycle storage. In addition, a public transport drop off area is being created to ensure easy bus access right to the door of the new facility.

Case study 12.4
Project: Blaydon Leisure and Primary Care Centre, Tyne and Wear
Architect: P + HS Architects
Size: 4,000 m^2 (Primary Care Element)
Client: Gateshead Primary Care Trust
Main Contractor: Willmott Dixon
M&E Engineers: Cundall
Structural Engineer: Cundall
Building Services Contractors: LJJ Contractors Ltd

A combined Primary Care and Leisure Complex set to benefit the community, Blaydon Primary Care and Leisure Centre has been developed by NHS South of Tyne and Gateshead Borough Council. It was constructed by Willmott Dixon using the SCAPE Framework and completed in less than 15 months. The council developed Leisure Centre, includes a state of the art gym and 25 metre swimming pool together with 12 metre learner pool. There are also additional changing facilities for users of the existing athletics track and games pitches on the site.



33.21 *Blaydon Leisure and Primary Care Centre, Tyne and Wear. Atrium: a two-storey central atrium, bathed in natural light, incorporates work from local artists (photo by Doug Jackson)*

The whole development aims to promote health and well being; and as part of this, the facility is designed to encompass views out over the adjacent conservation area, designated as an area of outstanding natural beauty.

The Primary Care Centre, developed by NHS South of Tyne and Wear, includes community services for physiotherapy, weight management, sexual health, dentistry, podiatry and breast screening as well as access to health information. GP services and minor injuries are due to relocate to the new centre from an existing nearby clinic.

The Centre is bathed in natural light from a two-storey central atrium, and the incorporation of work from local artists adds to the vision of a healing environment. P+HS Architects, who designed this health facility, are well known for their work in this field, having completed numerous health projects where art and colour are an integral part of the design.

Blaydon Leisure and Primary Care Centre is one of the UK's first combined leisure and health facilities, connected centrally by a communal atrium which was designed alongside local artists, the feel of this building is one of quality, with an appreciation for its semi rural setting. The leisure centre incorporates a 25 m, 6 lane swimming pool, learner pool, large gymnasium, multi-function studio, wet changing village, dry change, outdoor changing for community use, reception area and staff accommodation.

The Primary Care Centre takes into consideration the latest 'Health Technical Memorandums' and 'Health Building Notes'



33.22 *Blaydon Leisure and Primary Care Centre, Tyne and Wear. Rear elevation – the elevation incorporates brise soleil, tinted glass and locally quarried natural stone (photo by Doug Jackson)*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



33.23 *Blaydon Leisure and Primary Care Centre, Tyne and Wear. Waiting area – generous waiting areas overlook thoughtful landscaping (photo by Doug Jackson)*

with innovation throughout. The facility incorporates a walk-in minor injury and illness unit, GP practice, podiatry, contraceptive and sexual health centre, primary care mental health service for people suffering common mental health problems, community physiotherapy, CATS service, X-ray services, speech and language therapy, community dental service, breast screening, audiology service, abdominal aortic aneurism (AAA) screening, healthy lifestyle services touch screen kiosk with access to health information, MRI 'plug in' facility and Japanese garden.

The aspiration for a highly sustainable project took precedence for both clients and Willmott Dixon right from the outset. Monthly review meetings were held between the BREEAM coordinator, Willmott Dixon and both clients to ensure that the correct decisions were made not just based on cost but on functionality and sustainability. BREEAM ratings of 'Very Good' for the Leisure Centre and 'Excellent' for the Primary Care Centre were achieved by continuously scrutinising design mindful of end user aspirations.

Sustainable features included glulaminated beams, rainwater harvesting to flush the WCs, biomass boilers and CHP which resulted in annual CO_2 emissions being reduced by 29,000 kg. 94 per cent of waste was diverted from landfill due to an on site two tier waste segregation system. Tinted glass and brise soleil to prevent thermal gain were installed. In addition to this, the M&E services have been designed to include leak detection on mains incoming services, auto-shut off to water supplies in public toilets, infra-red activation of light fittings, enhanced metering strategy to monitor mains services usage

The main external wall finish – a natural stone was quarried from a local quarry thus reduced carbon emissions from delivery vehicles by 25 per cent when comparing it to a material sourced outside the area. Local spend was a keen area of focus for the project team. Mindful of this, the site team managed to allocate 77 per cent of the contract value to businesses based within a 40 mile radius of the site. Sustainable operations were at the heart of the project with incentives given to site operatives who brought an environmentally positive aspect to the project such as car sharing and achievement of waste diverted from landfill targets.

Note: P+HS designed the Primary care element of the scheme. The leisure centre was designed by another firm of architects and the two schemes join at the central atrium.

13 REFERENCES

Anon. (2011) *Sickness in Health, Financial Times*, Wed 19 January 2011, p. 10.

CABE (2006) *Designed with Care: Design and Neighbourhood Healthcare Buildings,* Commission for Architecture and the Built Environment.

Department of Health (2006) *Our Health, Our Care, Our Say: New Direction for Community Services – A Brief Guide.*

Department of Health Publications, www.dh.gov.uk/publications.

Department of Health (2007) *NHS Next Stage Review (Darzi Report) – Interim Report,* Department of Health Publications.

Department of Health (2009) *Primary and Community Care Health Building Note 11–01: Facilities for Primary and Community Care Services.* Estates and Facilities Division of the Department of Health.

(Details have been prepared based on information available at the time of publication. Any discrepancies or changes should not be interpreted as an attempt to provide false or misleading information but simply give due recognition for registered products and services.)

Francis, S. (2006) Healthcare Design Development in UK. *Design and Health IV – Future Trends in Healthcare Design,* International Academy for Design and Health, pp. 69–79.

Lister, S. (2011) Private sector waiting in wings as GPs take charge of £80 bn budget, *The Times*, 20 January, p. 8.

Loppert, S. (1999) 'The Art of the Possible'. *The Arts in Health Care: Learning from Experience,* eds. D. Haldane and S. Loppert, The King's Fund.

NHS Estates (2002) *Improving the Patient Experience: The Art of Good Health: Using Visual Arts in Health Care*, HMSO.

NHS Estates (2004) *Enhancing the Healing Environment: A Guide for NHS Trusts,* The King's Fund.

Purves, A. G. (2008) Unpublished PhD thesis, 'Design of Primary Health Care Buildings'.

Purves, A. G. (2009) *Primary Care Centres: A Guide to Health Care Design* London: Elsevier Limited. www.elsevier.com.

Royal College of General Practitioners (RCGP) *History of the College.* Available at: http://www.rcgp.org.uk/about_us/history_heritage__archives. aspx (accessed 16 February 2011).

Weaver, M. (2000) Delight Detector, *Building Design*, 24 November, 1.

World Health Organisation (1978) *Alma-Ata, 1978: Primary Health Care, 'Health for All' series, No. 1,* World Health Organisation.

This page intentionally left blank

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

34 Restaurants and foodservice facilities

Fred Lawson

Fred Lawson is a Visiting Professor at the University of Bournemouth, an international consultant on hotel and foodservice planning and the author of a number of books (published by the Architectural Press/Elsevier) in this field

KEY POINTS:
- *Services must satisfy customer demands and operating criteria*
- *A highly competitive sector at all levels of expenditure*
- *Labour intensive requiring efficient planning*
- *New concepts continuously being introduced*
- *Design life cycles are often short*

Contents

1 Introduction
2 Basic planning
3 Public areas
4 Food production areas
5 Restaurants
6 Cafeterias and food halls
7 Fast-food outlets and take-aways
8 Public houses
9 Hotels and resorts
10 Bibliography

1 INTRODUCTION

1.1 Profile

Restaurants and other facilities providing food and drink for consumption on the premises are labour intensive services which invariably operate in a highly competitive environment. These cover both *commercial businesses* aiming to attract the public and achieve profits from the investment and *semi-* or *non-commercial services* provided in institutions, places of employment and elsewhere. The latter need to meet specific requirements, including set cost limits, and are often operated by *catering contractors*. In all cases, the efficiency of every part of the operation needs to be maximised and this calls for careful planning and organisation.

Customer choice will vary with individual circumstances such as the location, time available, spending power, experience and particular requirements. The characteristics of potential market demands can be classified and quantified and this is used in market research to identify suitable locations and facilities.

The role of design in foodservice premises is to:

- attract identified markets of customers and communicate a suitable image (merchandising);
- create a comprehensive style and quality of ambience appropriate to customer expectations;
- plan the layout, equipment, technical installations and operating systems as integral parts of the overall concept;
- ensure the facility can meet the objectives, costs and other criteria set by the operator.

The design must reflect the basic concept, including range of menu and food preparation involved, style of service and staffing requirements, space allocation, desired atmosphere and other factors which influence customer choice.

1.2 Product development

Consumer requirements evolve with a desire for change, new styles of fashion and wider experiences of meals abroad. New concepts in food and beverage service operations are constantly being introduced and those which can be shown to be successful are invariably developed as specific product brands. Branding enables the same formula to be adapted to other sites as a chain of company owned, leased or franchised units with further advantages in marketing, customer confidence in quality and value, economies of scale and profitability. The development of new products also reflects socio-economic changes in an area, trends and influences on consumers such as promotion and health concerns (Tables I and II).

Table I Trends in foodservices

Influences	Effects
Markets (socio-economic changes):	convenience, informality, increase in demand, take-away food, mature designs
Changes in habits, Social acceptance, Multiple incomes, Single households, Demographic shifts	
Product supply (promotion, efficiency):	systemisation
Franchising	standardisation
Multiple outlets	branding
Promotion	
Consumer choice (education, experience):	lighter meals, self-service, ethnic foods
Healthy eating, Personal selection, Variety, wider interest	

Table II Product development

Trends in products reflecting market preferences	
Self choice:	food displays, food halls, multiple choice counters, buffets, self-help starter and salad bars, assisted service, carveries, trolleys
Variety:	displayed cooking, showmanship, 'ethnic' options, featured designs, pub meals, bistros, dining clubs, themed experiences, memorabilia eat in, take-away, home delivery
Reassurance:	attention to hygiene, cleanliness, environmental responsibilities, 'healthy' menu options, information, value for money, inclusive prices, confidence in standards, branding

1.3 Types of facility

Eating and drinking establishments fall into a number of broad categories:

- Commercial restaurants with self-service and waiter service operations, possibly licensed for sale of alcohol. Includes cafes and snack bars.
- Take-aways; fast-food outlets with or without customer seating space, supplying prepared food for consumption off the premises.
- Hotels and resorts: depending on standards, offering one or more restaurants, room service, banquets, bars, lounge services.
- Public houses, clubs: alcohol sales with or without food service.
- Semi- or non-commercial operations providing meals as a service in educational and institutional establishments and for employees in places of work.

Differences between these operations lie in:

- variety of food offered;
- method of service;
- space and facilities available to the customer;
- amount of food processed on site;
- emphasis on the sale of alcoholic drinks;
- décor and degree of sophistication;
- price level.

Boundaries between these factors can be blurred and the whole field is constantly changing.

1.4 Location

Location will determine the success or failure of a facility. Commercial food service establishments must be located where people need to obtain meals and refreshments such as:

- city and town centres;
- resorts and visitor attractions;
- at stopping places along main highways;
- airports, main railway stations;
- shopping centres.

These are best served by different types of outlets appropriate for the main markets involved. For instance, chain fast-food outlets are sited in busy high streets within city and town centres to attract a large demand from passers-by (*'footfall'*). Up-market restaurants are usually in less prominent locations, in or near good hotels, prime commercial districts and high class residential areas. Food services are also provided to complement existing business as in pubs and places which attract visitors.

A balance has to be found between:

- the availability of customers;
- cost of location and investment;
- operational considerations such as space, customer parking, goods access.

Major locations such as an airport or motor service station usually provide a selection of outlets allowing customer choice in types of meals, prices and time available (Figure 34.1). In city and town centres there will usually be a range of different restaurants: fast-food, bistros, ethnic, themed, food-speciality and high spend restaurants, as well as pubs, wine bars, cafes and snack bars.

Visibility is critical for casual trade and restaurants tend to be clustered in and around popular places, tourist attractions, squares and nearby side streets. Those sited in basements or on upper floors are at a disadvantage without specific promotion, attractive, easy access and designed facilities for transporting food deliveries and for the disabled.

1.5 Institutional foodservices

Foodservices provided in institutions and places of work generally fall into two categories:

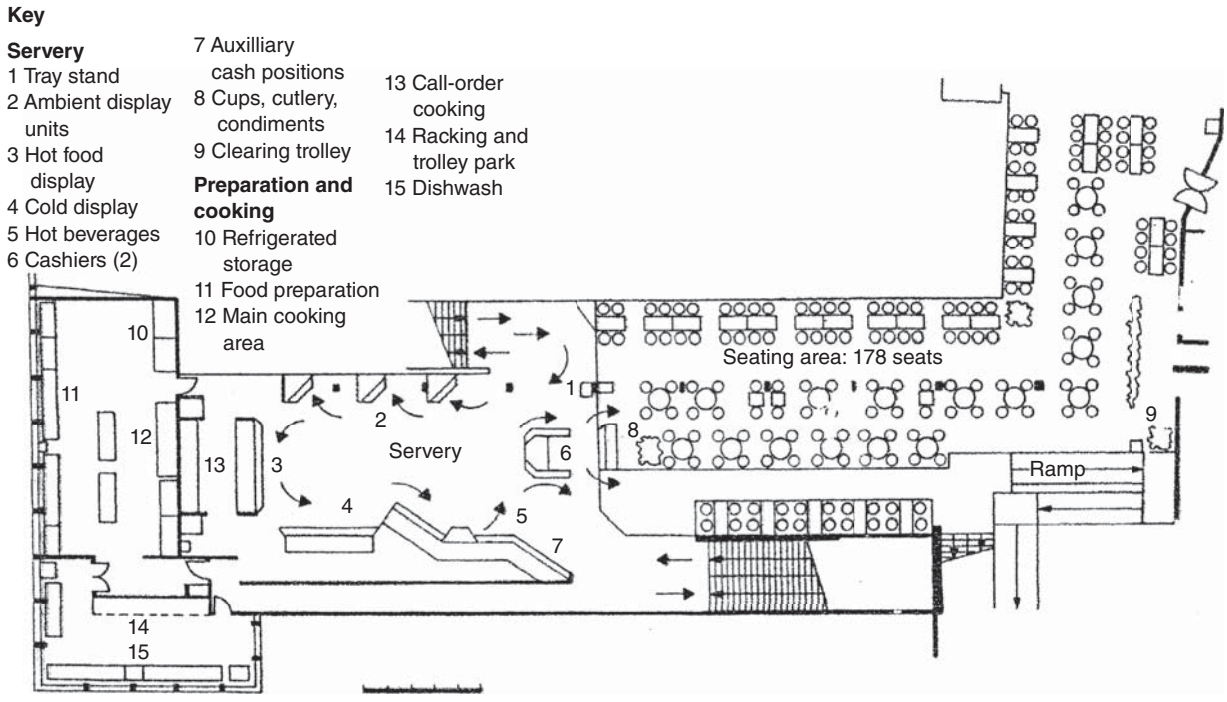
- Centrally grouped: main cafeteria, refectories and/or restaurants sited conveniently for most of the people involved. The location often provides a refreshing contrast to the workplace environment and is adjacent to the food preparation facilities.
- Dispersed: remote service of food to individual stations such as in hospitals, some institutions and remote work sites.

In most cases these catering services are operated by contractors specialising in this field.

This also applies in other main locations such as airports, motorway service stations and shopping centres.

1.6 External considerations

Separate vehicular access and parking is essential for delivery of food and other supplies together with suitable provision for hygienic storage and collection of waste. In large premises, a staff entrance may also be required. Outside city centres well served by taxis and public transport, customer car parking is essential, particularly for evening dining and functions. Hotels need to make extra provision for this non-residential use. In restricted urban sites, nearby public car-parking is an advantage.



34.1 *Foodservice facilities at Prestwick Airport, UK. Located on a balcony above the concourse, the new self-service restaurant was designed to attract attention and provide an interesting range of local food specialities. Emphasis has been put on prominent signage and staircase design, as well as in menu graphics. Catering consultants: Tricon Foodservice Consultants Ltd. Client: British Airports Authority*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

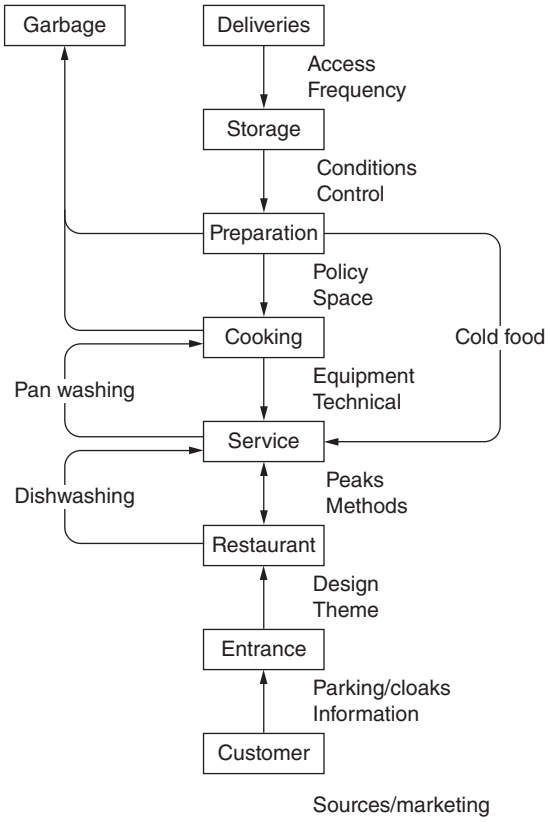
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

External appearance is important for self-advertising and communicating information, with views of the interior, display of menus and prices and, for evening dining, flood-lighting. The customer entrance must be clearly defined, distinctive and easy to use including provisions for people with disabilities. To attract passing customers, popular restaurants and cafes in large shopping centres, hotels, and airports may be seated within public concourses and atrium areas (Figure 34.1).

2 BASIC PLANNING

2.1 Foodservice operations

All foodservice operations involve three overlapping processes: production, service and customer areas (Figure 34.2). Each area will have specific requirements which will vary depending on the nature and scale of the operation.



34.2 *Food service planning*

Production

- Delivery and checking of food supplies, beverages and other items.
- Storage: separate for vegetables/fruit, dry goods, chilled and frozen foods.
- Preparation: using fresh ingredients, partially or fully prepared foods.
- Cooking: with large scale centrally grouped or back-bar equipment.
- Assembly of meals to order, ready for service or refrigeration/freezing.
- Dish-washing of utensils and tableware and disposal of solid waste.

Service of meals, designed around self-service or table service:

Self-service using display counters accessible to the customers.

- Waiter/waitress service collected from a servery and taken to the tables.
- Collection of soiled dishes and return to the kitchen.
- Side tables and storage: for table items, condiments, equipment, furniture.

Customer facilities

- Location: surroundings, character, site restrictions, parking.
- Entrance with cloakroom, toilets, reception services and bar if required.
- Seating areas: interior design to reflect concept and customer profiles.
- Billing and payment facilities.

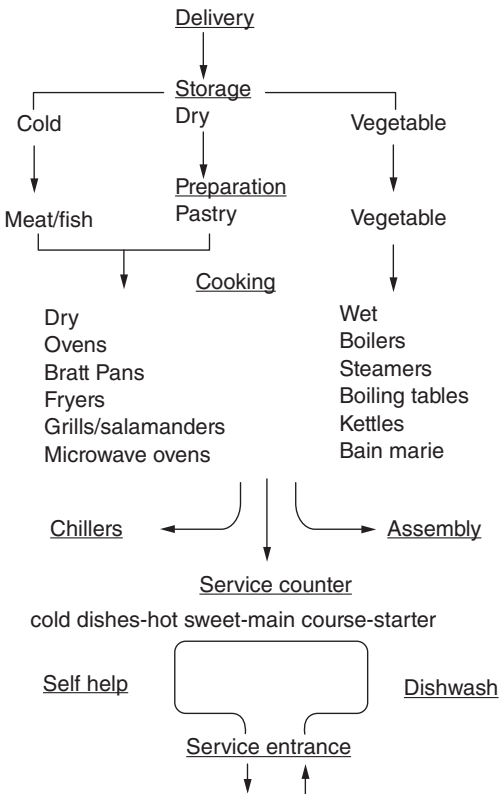
2.2 Central food production

Large scale foodservice operations usually involve two stages of production: Bulk preparation and prime cooking followed by rapid chilling or freezing of the foods for later end-cooking (regeneration) when required near the place of service. *Cook-freeze* systems provide rapid cooling down to –20° C for frozen storage (typical up to 1 month) whilst *cook-chill* equipment rapidly reduces food temperature to 1–3° C for refrigeration storage up to a maximum of 3–5 days. Chilling is commonly used in hotels and institutions for pre-preparation of meals on site to improve efficiency and hygiene.

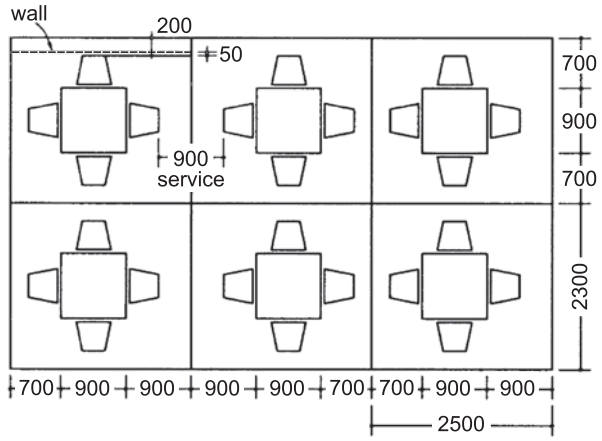
Fast-food outlets use highly developed systems with specialised end-cooking equipment designed to provide rapid delivery of a limited menu of meals to order. Central cook-freeze systems are also used to supply prepared convenience foods to restaurants, airlines and other offsite catering arrangements. Cook-chill systems are more suitable for short time holding of meals prepared in advance of use, as in banquets and functions (Figure 34.3).

2.3 Legislation

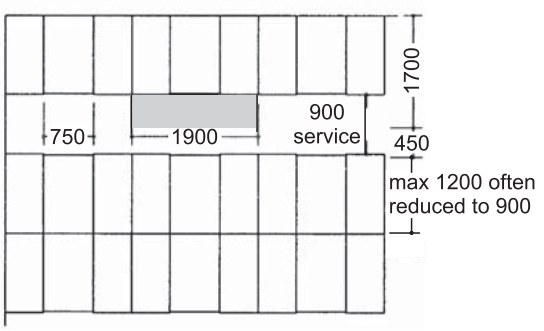
Food service establishments are subject to Town and Country Planning and Building Regulations, disability discrimination, health and safety, food standards and hygiene requirements.



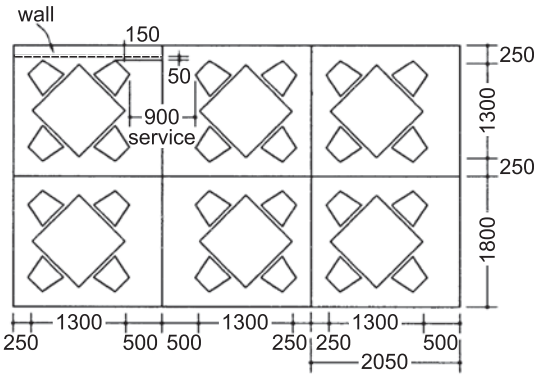
34.3 *Large-scale production*



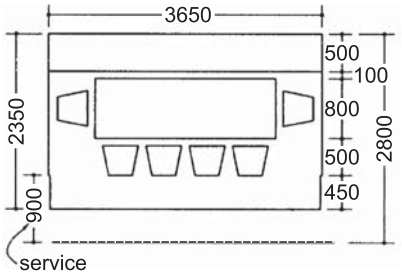
a *Square tables, square layout, local density 1.4 (in m² per diner)*



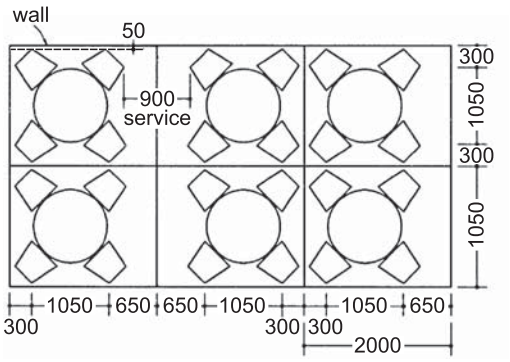
d *Banquette seating in booths, density 0.8*



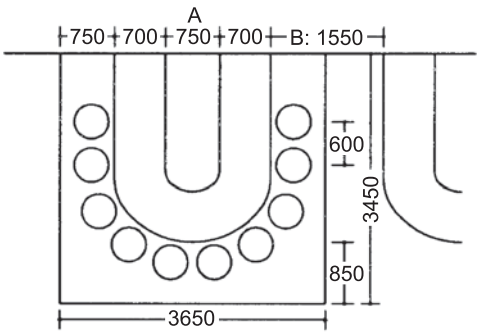
b *Square tables, diagonal layout, local density 0.92*



e *Large booth in recess, density 0.86 for 10 people, or 1.1 if only two people sit on bench seat*



c *Circular tables, diagonal layout, density 0.82*



f *Counter service, density 1.26. (Dimensions A and B are increased where more than one waiter is employed)*

34.4 *Layouts for restaurant tables*

Premises selling alcoholic drink must also be licensed. In the work areas safeguards must be taken to reduce risks of accidents (e.g.: burns, scalds, cuts, falls, exposed machinery, electric shock and fires). Instruction and first aid facilities must be provided. Hygiene requirements include training in food handling and the provision of suitable clothing and hand-washing facilities. Specific fire and smoke protection requirements apply.

3 PUBLIC AREAS

3.1 Concept

Restaurant design is developed around the concept of the operation. This will take account of the intended market, the clients' objectives and proposals, the location and type of premises, structural changes involved and cost targets. Brand led designs, including franchised and licensed outlets, are usually limited in scope but may be adapted to the type of building available.

The concept and operating strategies are invariably decided by the clients. Details of design may be set for brand consistency and customer assurance in chain operations. This applies particularly to middle and popular market requirements, including fast-food operations. However, entrepreneurs are also aware of social trends and changes in consumer requirements and new innovative design concepts are constantly being introduced.

3.2 Marketing criteria

Customer choice is influenced by price and expectations which vary depending on the occasion. Factors such as convenience, value and social atmosphere may be paramount. For others the sophistication,

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

menu choice and style of service may by important. Markets can be classified according to socio-economic categories which broadly indicate spending power and types of services required. Market studies also assess competition, changes in the area and optimum locations.

3.3 Design criteria

Interior design has to satisfy a number of requirements, both functional and aesthetic. It has to reassure confidence in standards, stimulate appropriate emotive responses, interest and visual appeal, and provide conditions which create the desired social atmosphere.

Considerations include:

- *Function*: operation, efficiency, order, hygiene, durability, maintenance.
- *Ambience*: luxurious, sophisticated, exotic, homely, romantic, lively.
- *Characterisation*: operating style, theme, food specialisation, features.
- *Seating plans*: room proportions, horizons of interest, windows, perimeters.
- *Perception:* attention to detail, consistency, linkage of areas, personalisation.

3.4 Coverage

A comprehensive design scheme covers:

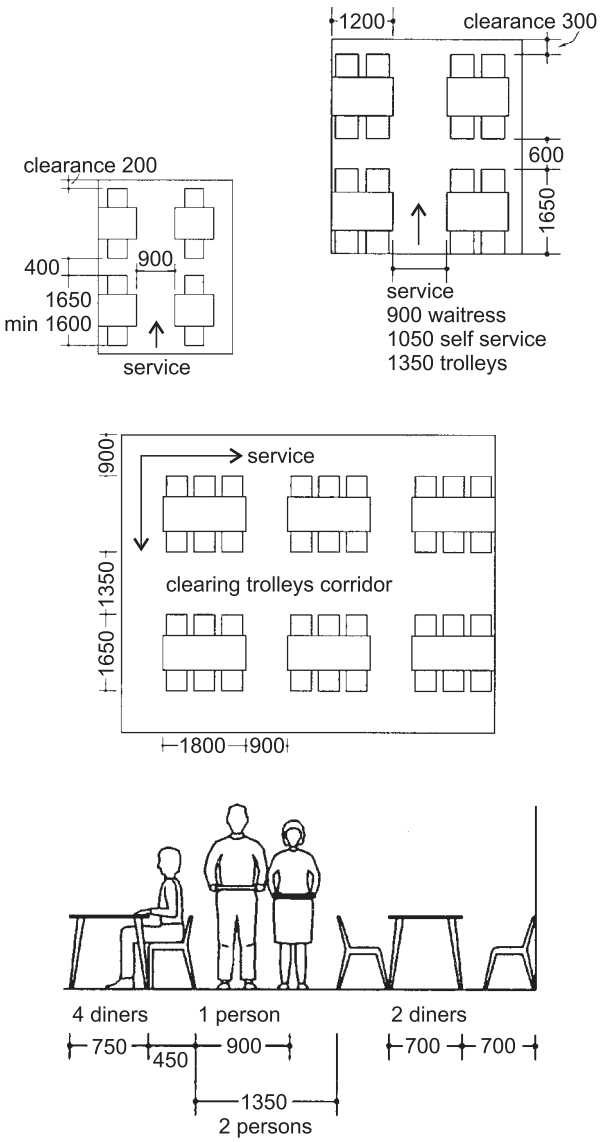
- interior finishes, fittings and equipment, decoration;
- theme design, furniture, furnishings and features;
- tableware, linen, table appointments and uniforms;
- display counters, service equipment, circulation plans;
- lighting, airconditioning and technical installations;
- motif, graphics, menu and drinks folders;
- desks, registers and monitoring equipment.

Shop-fitting frontage, entrance, cloakroom and ancillary bars are normally included. Kitchen equipment including their technical plant, services installation and utensils may be treated as a separate contract but must be planned as part of the whole project. Client requirements for accounting and management systems and equipment must also be incorporated.

3.5 Seating plans

For meals consumed on the premises, maximum numbers of customers are dictated by numbers of seats (covers), mealtimes served and seat turnover. Customer densities (in m^2 per diner) depend on the room dimensions, method of service, table and chair sizes, seat groupings and layout within the room (Figures 34.4, 34.5, 34.6; Table III).

- Functions, banquets and conference groups require adaptable stackable furniture (Figure 34.7–34.10).
- Self-service requires wide aisles leading to and from the counter(s), orderly lines with increased space between tables (Figure 34.5). Waiter service layouts can be more flexible but service and customer circulations must not conflict.
- Table and chair sizes increase with sophistication and length of meal. Popular restaurants mostly provide tables for 4 which may be fixed or loose, square or round, in open or booth type layouts depending on style of operation. High-spend restaurants provide a higher ratio of tables for 2, often allowing grouping together for parties of 4, 6 or more as required. Employee and institutional arrangements use rows of tables to increase density which may also be removable for alternative use of the area.
- Layouts are influenced by windows and views. Individual seating areas may be separated by levels and partitions to extend choice (personalised areas, perimeter seating) and interest (features).
- Large hotels and resorts provide a choice of restaurants and facilities offering different menus, sophistication and prices (Figure 34.11).



34.5 *Minimum space between tables to allow for seating, access and circulation*

Table III Space allowances

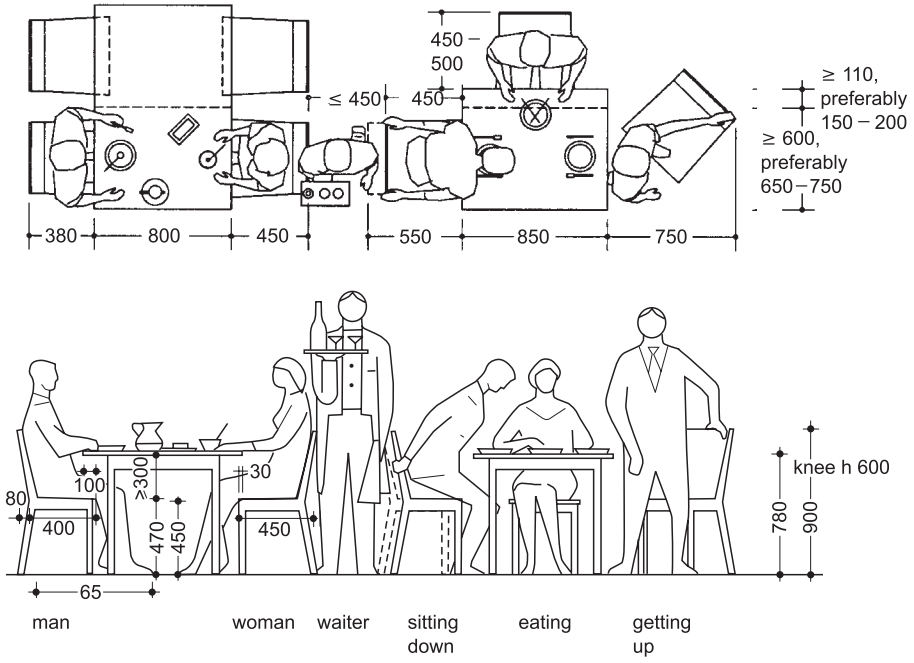
Type of restaurant or service Example	Area per seat (m^2)	Service add (m^2)
Fine dining Traditional 80 seats	2.0–2.4	table service
Food speciality or ethnic High standard 80 seats	1.6–1.8	table service
Mid-market restaurant Limited menu 100 seats	1.5–1.7	counter 0.2
Cafeteria 140 seats Single line counter	1.4–1.5	servery 0.4
Popular chain restaurant Limited menu 100 seats	1.2–1.4	table service
Fast-food/takeaway Set menu range 50 seats	0.8–1.0	counter 0.6
Pub bar (25% seating) Including counter	0.6–0.9	
Bar lounge (50% seating) Including counter	1.1–1.4	
Banquet hall dining area 200 seats	0.9–1.2	pantry 0.2
Employee cafeteria 200 seats	1.1–1.2	servery 0.2
Primary school Counter/family service	0.75–0.85	
Secondary school Including counter	0.9	
College refectory	1.1–1.2	servery 0.2

Note: Depends on rooms dimensions, circulations and type of furniture.

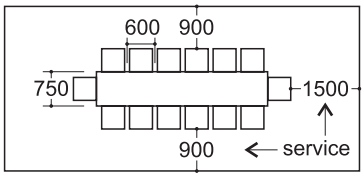
3.6 Furniture and table top design

Restaurant furniture must be strong, durable and resistant to soiling. Depending on the type of operation this includes:

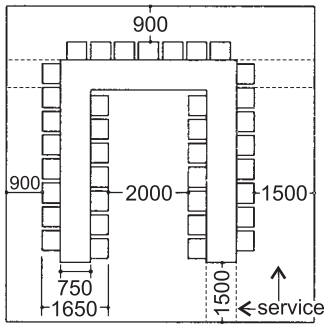
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



34.6 *Restaurant critical dimensions*



34.7 *Small formal dinner arrangement*



34.8 *Banquet layout. The U arrangement can be extended in both directions to the limits of the banqueting room*

- Fitted counters and bars. Fixed bar/counter stools. Fixed tables, usually pedestal or cantilevered for leg clearance, with loose chairs or fixed booth-type seating (Figures 34.12, 34.13).
- Movable tables with loose chairs or fixed banquette seating.
- Stackable tables and chairs with carrier systems. Tables with extension brackets or alternative tops (square/round). With level access to storage area.
- Side tables and designed trolleys for food presentation and service at the table.
- Reception and cash desks with terminals, screens, cash registers and other equipment.

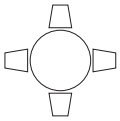
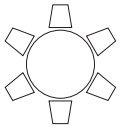
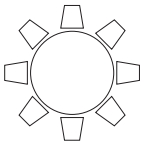
Table top design must be compatible with the overall concept and style of operation. It will range from high class sophistication requiring

number of seats	table size: drinking mm	table size: eating mm
1	450 to 600	600 to 700
2	600 square	750 square
4	750 square	900 × 950
	–	1500 × 750
6	–	1400 × 950
	–	1700 × 750
8	–	1750 × 900
	–	2300 × 750

34.9 *Recommended rectangular table sizes relating to place numbers*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

number of seats	table size: drinking mm	table size: eating mm
1 	450 to 600	750
2 	600	850
4 	900	1050
6 	1150	1200
8 	1400	1500

34.10 *Recommended circular table sizes for various place numbers*

quality linen, china, glassware and silverware to stylised easy clean laminated surfaces with durable ware and stainless steel utensils.

3.7 Steps in interior design

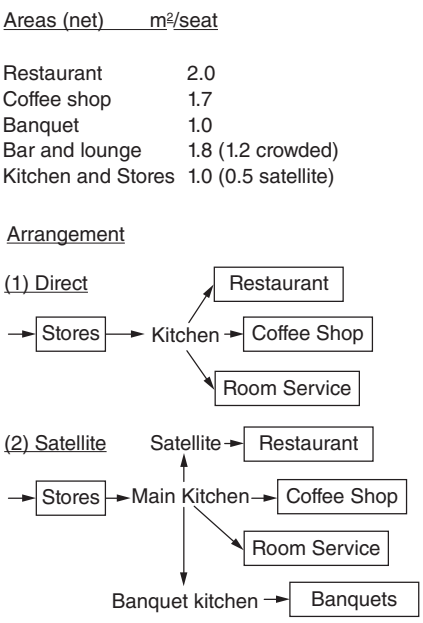
- Brief, terms of reference: scope, aims, guidance, requirements, programme.
- Sketches, proposals: design concept, visual ideas, preliminary estimates.
- Schematic drawings: perspectives, images, key features.
- Sample board: selected materials, finishes.
- Detailed drawings: scaled drawings for construction and installations.
- Specifications: requirements, quality, quantities.
- Suppliers: sources costs, discounts, replacements.
- Contracts: conditions, coverage of work, critical dates.

3.8 Maintenance and life-cycle planning

Food and beverage service areas are subject to intensive use, breakage, spillage and damage requiring daily cleaning and frequent replacement or substitution. Carpets and finishes are selected to camouflage scratching or staining. Furniture and equipment must be durable and retain good appearance over the planned life-time of use.

Flexibility may be required to adapt to variable needs such as table groupings and re-arrangements or changes in service style from daytime to evening dining or for entertainment. This will call for furniture stacking and equipment storage facilities

The life cycle of a restaurant will be affected by many factors such as changes in the surroundings, fashion and meal preferences; increasing competition; decline in standards and obsolescence. Kitchen equipment is usually planned for 7 years usage but furniture and furnishings may need replacement in 5 years. In planning major refurbishments it



34.11 *Food and beverage services in large hotels*

is opportune to revise the original concept and introduce changes in menu, design and style to meet new market opportunities.

4 FOOD PRODUCTION AREAS

4.1 Size and type

The size of the kitchen depends on the number of seats (covers) served at the peak period of demand – lunch or evening. It will also vary with the type of the menu and the extent to which food is prepared in advance. With a fixed menu, equipment and labour can be rationalised and ready-prepared food enables the kitchen to concentrate on finishing the meals to order. Conventional kitchens providing a varying (usually cyclical) range of menu choice are required in institutions and employee catering. They are also required in high class restaurants and hotels and have a size ratio of 0.3 to 0.5:1 in relation to the size of the dining area. Convenience food is prepared in advance in bulk in central kitchens and chilled or frozen for distribution and storage prior to use (see Section 2.1). This allows economies of scale, larger, purpose designed equipment and factory type processing. Finishing kitchens can be reduced in size and equipment with a size ratio of 0.1 to 0.3: 1 in relation to the size of storage and dishwashing.

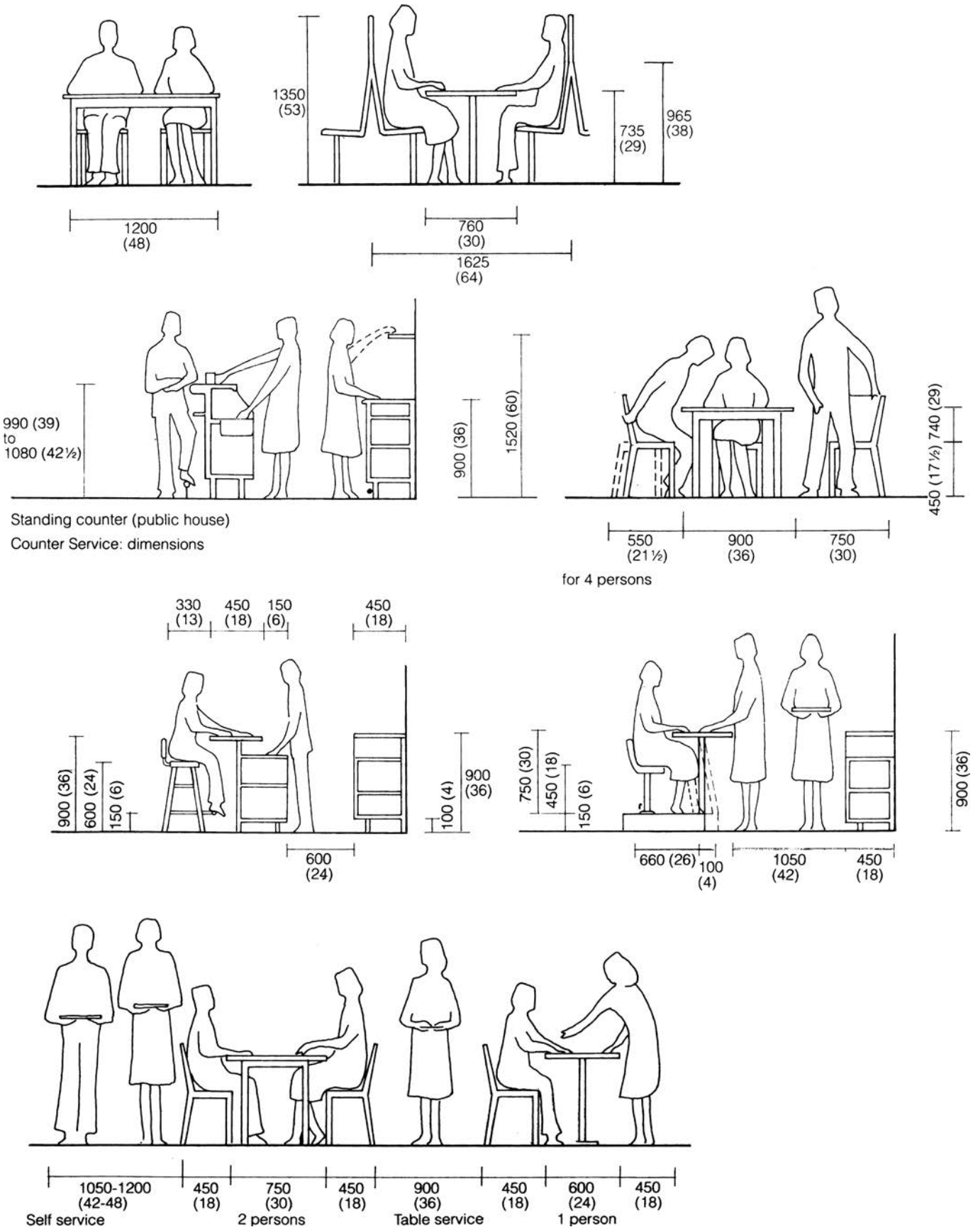
Examples of kitchen areas are indicated in Table IV. Space requirements in large kitchens show the economies of scale by centralisation (Figure 34.14). In large hotels, a central food production and dishwashing area may be located to serve a number of alternative restaurants directly or by circulation to more remote outlets such as in room service and banquet serveries.

4.2 Goods access

For sizes of vehicles see Chapter 39. Typical delivery arrangements are:

- dry goods: weekly or fortnightly;
- frozen goods: weekly;
- vegetables and fresh fruit: twice weekly;
- perishable foods: daily;
- refuse and waste removal: depends on size and contract: weekly.

Large premises use bulk refuse containers (0.57 m^2–0.85 m^2) together with separate bottle, broken glass, metal compaction and packaging storage areas. Food waste must be sited in a refrigerated



34.12 *Typical counter and table service dimensions*

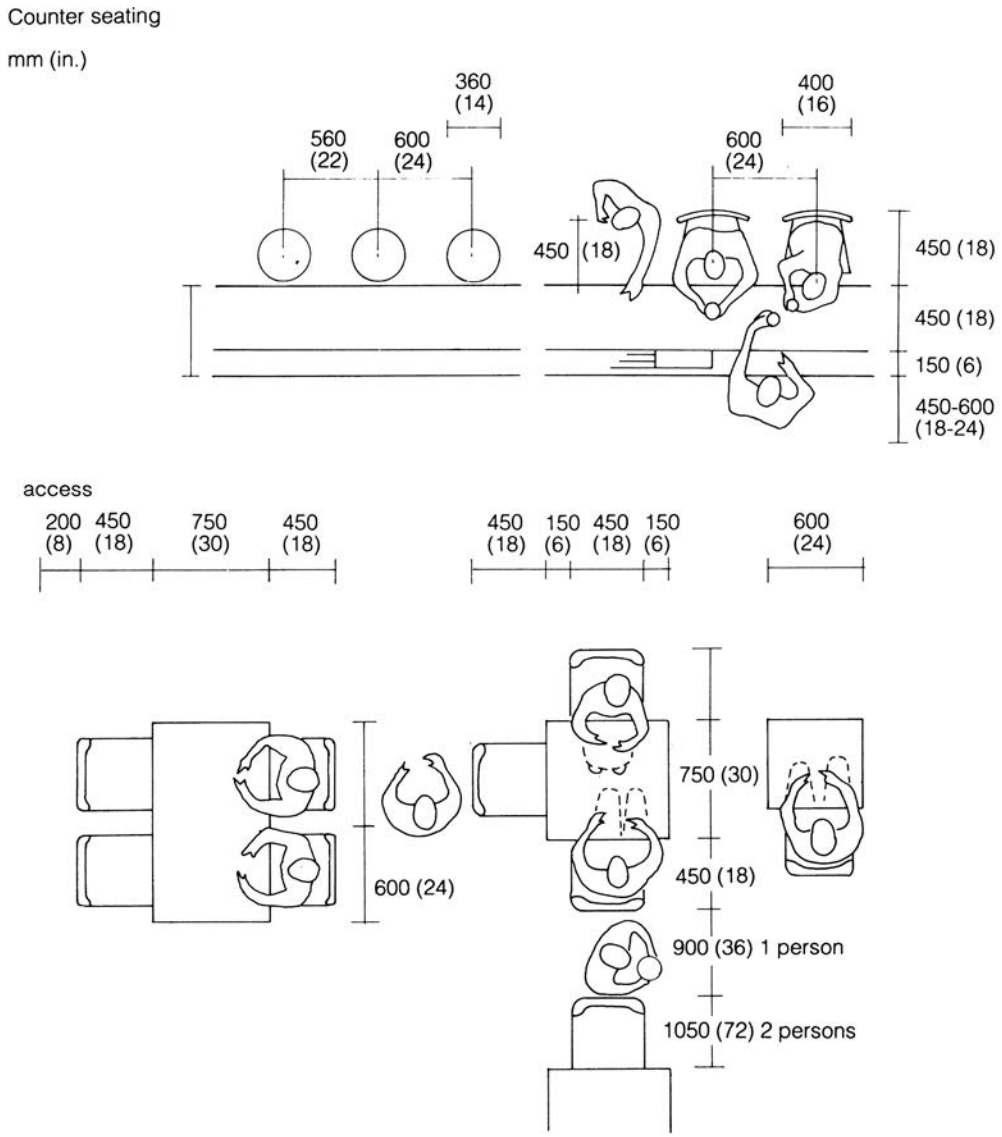
area (3–5° C) with suitable screening, vermin exclusion, washing facilities and drainage.

4.3 Storage areas

Storage depends on throughput and frequency of deliveries. Cold stores are grouped together and preferably entered through chilled holding areas to save energy. Floor slabs may need to be recessed to allow level wheeled entry to the store. Vegetable stores have direct access to their preparation area.

Purpose designed moveable racks are used in food stores. Racks and shelves should allow about 50 mm between and above packages for easy access. The top shelf should not be higher than 1800 mm and

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



34.13 *Dimensions for various tables and local seating densities*

the lowest at least 200 mm above floor (Figure 34.15). Shelves for heavy and frequently used items are best between 700 and 1500 mm high. Space may be required for containers awaiting return to suppliers.

4.4 Preparation areas

Kitchen areas and layout are determined by:

- the sizes of equipment and benches;
- space for working access and circulation.

Some typical dimensions are:

- Work top and sink rim height 870–900 mm.
- Wall bench width 600–750 mm.
- Island bench or table width 900–1050 mm.
- Length of work area with convenient reach 1200–1800 mm.

Four main areas are required for conventional food preparation:

- fresh vegetables, salads and fruit;
- meat and fish;
- pastry;
- general including assembly of cold foods.

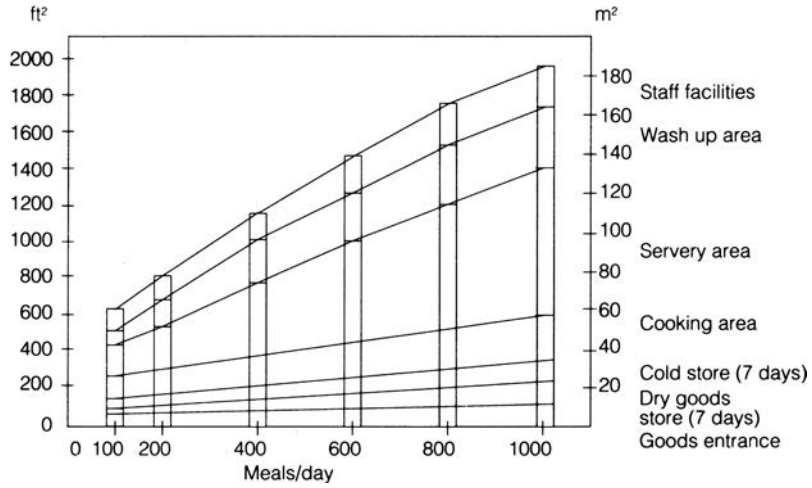
Table IV Typical food production areas per restaurant seat

Type of restaurant Example	Kitchen area (m^2 per seat)	Type of food prepared
Fine dining 80 seats	0.9	choice menu, fresh food cooked to order
Speciality food/ethnic 80 seats	0.7	a la carte menu, cooked to order
Midmarket restaurant themed 100 seats	0.6	limited menu part convenience food
Cafeteria 140 seats	0.4	cooked and cold choices part convenience food
Popular restaurant 100 seats	0.4	standard menu convenience food
Fast-food/take-away 50 seats	0.8–1.0	system production high volume sales

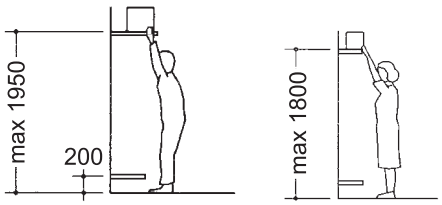
Note: Preparation, cooking and dishwashing take up about 50% of the total kitchen areas. Storage, service and staff facilities the remainder.

Specialised operations may require separate bakery and cake decoration areas. Preparation areas may be segregated in separate rooms, by low walls 1200 mm high between the areas and main kitchen or the grouping of benches and fittings in specific areas around the sides (Figure 34.16). Cross-contamination of food must be avoided and adequate work space with separate sinks provided in each area as well as for pan washing.

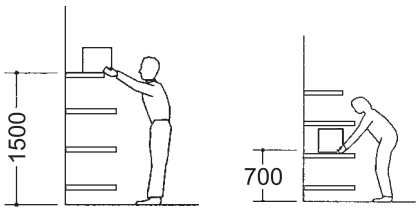
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



34.14 *Kitchen space requirements for various functions*

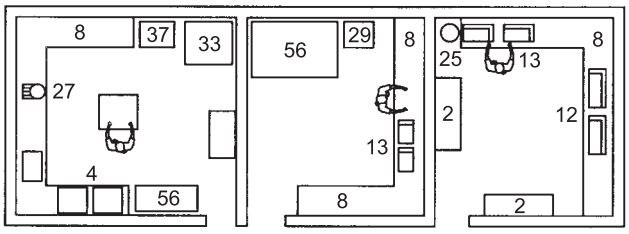


a *Limits for maximum reach for men and women*

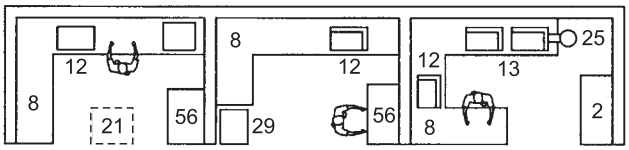


b *Convenient reach for heavy or frequently used items*

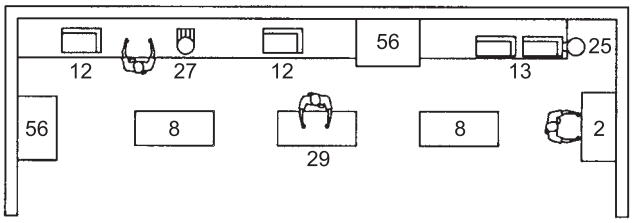
34.15 *Heights for storage shelving*



a *Separate rooms*



b *Bays*



c *Open plan kitchen*

34.16 *Alternative preparation area arrangements (see Figure 34.31 for key to numbers)*

4.5 Cooking equipment

About 30 per cent of the kitchen floor is occupied by equipment, 10–20 per cent by benches and trolleys and 50 per cent for circulation and access. Crowded space can lead to obstruction and accidents but excess space adds to circulation cleaning, energy and maintenance costs (Figure 34.17).

Details of typical modern equipment are given in Table V. Size and duty is related to output and most ovens are designed to receive gastronorm sizes of dishes and trays. Some items are shown (Figure 34.18). Combination ovens incorporate both steam and hot air convection modes. Other accelerated cooking includes microwave power with hot air convection. Vitreoceramic induction hobs may be used instead of open burners.

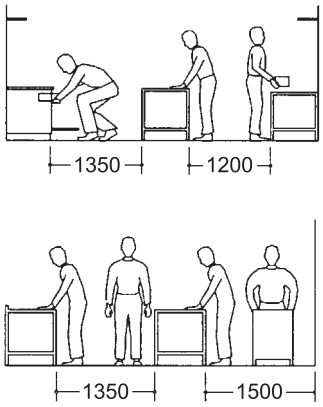
A typical kitchen layout is shown in Figure 34.19 with elevations in Figure 34.20.

Back-bar equipment fitted along a wall behind the serving counter is common in small kitchens and for finishing meals enabling savings in engineering services, space and labour. Island grouping in the centre is better in larger units giving easier access from all areas, cleaning and maintenance. Engineering services, including fume extraction and floor drainage, are concentrated and perimeter sites can be used for refrigerators, storage, preparation areas and service counters. The minimum aisle width is 1050 mm but may need to be increased to 1500 mm to allow for cooker door swings or if trolleys are used.

4.6 Dishwashing

Dishwashing is expensive in terms of space, equipment, labour and energy costs. Disposables may be used in fast-food and transport catering but give a poor image and problems in disposal. Methods of collection for used dishes include self-removal with trays, trolleys or waiter removal. This must be decided at the initial planning stage. Trolleys will require straight aisles with minimum 1050 mm width and screened trolley parks.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



34.17 *Minimum space between equipment for working and circulation*

Manual dishwashing in a double sink is inefficient and unhygienic for public foodservices. Spray machines may be intermittent or continuous through-flow and designed for corner (small kitchens) or in line position (Figure 34.21). Water softening is often used and modern machines incorporate energy and water saving devices. Space is required for depositing soiled dishes, scraping/spraying and loading as well as separate unloading sections. Trolley spaces should be allowed for return of clean dishes and utensils to the servery. Typical sizes for table ware are given in Table VI and allowances for dishwashing spaces are show in Table VII.

4.7 Serveries

Arrangements for plating and serving food depend on the type and scale of operation. In each case, circulation routes must be planned. Counters are designed to avoid risk of accidents, spillages and contamination, keep food hot, cool or chilled and retain an attractive hygienic presentation of the foods on offer.

Table V Kitchen equipment

Type	Main features	Typical size and rating	
Ovens	Transfer heat to food within an enclosure. May use hot air (circulated by natural or fan-assisted convection), infrared or microwave emission	(s) –small units (m) – medium duty (h) – heavy duty	
General-purpose	Using hot air for baking, roasting or reheating. May be raised on stand or in tiers. Preloaded mobile racks used for speed and convenience. Working capacities: Trayed dishes 65–75 kg/m^3 (4–5 lb/ft^3) Poultry, meats 110–130 kg/m^3 (7–8 lb/ft^3)		
Oven range	Ovens combined with boiling hob top. Oven capacity based on shelf area 0.015m^2 (24in.2) per meal	(s) 801. (m) 160 1. (h) 200 1.	11kW 14kW 16kW
Forced convection oven	Hot air circulated at high velocities up to 4.5 m/s (900ft/min) with directional flows to provide rapid heating, larger batch loadings, even temperatures. Normal cooking cycle: frozen food 25–35 min Combination (Combi) ovens incorporate both hot-air and steam convection modes. Accelerated cooking ovens include hot-air convection and microwave.	(s) 50 1. (m) 110 1. (m) 200 1. (h) 300 1.	2.6 kW 6kW 9.3 kW 13.3kW
Pastry oven	Tiered shallow ovens to give uniform heating for baking, pastry, pizza, etc. Capacity based on area: 0.004^2 (6 in.^{2}) per meal		
Roasting cabinet Rotary or reel ovens	Special cabinets for roasting meat, or mechanised spit roasting (poultry, joints, kebabs)		
Low-temperature ovens	Specialised equipment for large-scale bakeries and continuous-cooking ovens For slow cooking of meat, etc. at 107° C (225° F) to reduce moisture loss. Specialist applications		
Microwave ovens	High-frequency (2450 MHz) alternating electromagnetic waves used to generate heat in dipolar molecules of food and water. Energy conversion factor high. Typical cooking cycle: 45–60 s (reducing with quantity)	(s) 20 1. (m) 28 1. (h) 28 1.	0.G kW 1.3 kW 2kW
Infrared ovens	Interspaced rows of heating elements in quartz tubes emitting mainly radiant heat in waveband 1.5–5.0 mm. Mainly used for reheating frozen food. Heating cycle 20–25 min		
Steam ovens Pressure steamers	Free steam at or near atmospheric pressure: 3.5kN/m^2 (1/21 b/in.^{2}) Used for large-scale catering Pressure steam up to 103kN/m^2(15 lb/in.^{2}) using jets for rapid heating of frozen food. May have option of free-vented steam	(m) 200 1. (m)	9kW 120kW
Boiling and frying	May use loose pans and containers placed on or over external heat (gas burner, electric element, heated plate) Larger units incorporate heaters as part of design (with thermostatic control)	(s) 2 ring (m) Solid	3.6 kW 11kW

(continued)

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table V (Continued)

Type	Main features	Typical size and rating	
Boiling tables	Usually provide four or six open burners or solid tops with tapered heat. Used as supplement or alternative to oven range	(s) 1 ring (m) 2 ring	3.6 kW 7kW
Halogen elements	Alternative to gas burners and electric radiant rings. Used in hobs to provide instantly adjustable heat output		
Induction heaters	Electromagnetic alternating currents of 25 kHz directed through ceramic hob. Used to induce eddying currents in steel pans producing indirect heating for boiling or frying		
Boiling pans and kettles	Containers heated directly or indirectly (preferred) Emptied by tap or by tilting over drain Output 451 pan root vegetables – 100–150 meals Soup- 150–200 meals	(h) 4 ring (m) 45 1. (m) 90 1. (h) 135 1.	14kW 7kW 11.5kW 14.5 k W
Bratt pans	Shallow tilting frying pans which are also used for stewing and braising. 150–350 mm (6–10 in.) deep. Mounted on trunnions for emptying	(m) 0.28 m^2 (h) 0.44 m^2	6.4 kW 12kW
Deep-fat fryers	Food immersed in heated oil. Frying temperatures typically 160–190° C (320–375° F) Fume extraction required Cooking cycles: typically 6–7 min	(s) 5 1. (m) 7 1. (m) 16 1. (h) 20 1.	3kW 5.8 kW l0kW 20 kW
Pressure fat fryers	Fryer fitted with sealed lid. Operated at 63 kN/m^2 (9 lb/$in.^2$), combining frying with pressure steaming of moisture Output: 80–90 portions/h		
Griddles	Shallow frying using surface contact with heated plate. Temperatures. 170–220° C (340–430° F)	(s) 0.17m^2 (m) 0.4m^2	4kW 7.5kW
Grilling	Food exposed to elements emitting high-intensity radiation in wave band 0.7–2.2 mm(s)0.1 m	(s) 0.1m^2 (m) 0.25m^2 (h) 0.27m^2	3kW 5.7kW 7.5kW
Salamanders, broilers Grills, chargrills, charbroilers	Top heating over food on grating or branding plates Bottom heating using red-hot tiles, plates or charcoal. Fume extraction required. May be featured in display cooking	(s) 28 l./h (m) 48 l./h (h) 68 l./h	2.8kW 5.3kW 7.5kW
Water boilers, beverage-making equipment	Includes boilers operated by steam pressure or expansion of water May be installed in kitchen, in vending units, under service counter or as cafe sets. Capacity: Per litre 4–5 cups Per gallon 18–20 cups	(s) 2 units (m) 4/6 units	0.5kW 2kW
Holding units	Used to keep food hot or cold until served. Mainly incorporated into service counters		
Bains-marie	Heated well fitted with loose containers (standardised sizes). May be dry or water filled. Thermostatically controlled at about 74° C (165° F)		
Chilled shelves, wells and plates	For cold storage and display of salads, dairy products and prepared sweets. Usually incorporates under-counter refrigerator. Temperature about 3.5° C (37–41° F)		
Hot cupboards	Heated cabinets to keep plates and food warm prior to service. May be under-counter units. pass-through cabinets or mobile. Temperature kept at 76–88° C (170–190° F). Capacity: Standard 1,200mm (4 ft) counter unit holds about 300 plates	(m) 1.2m wide (m) 1.8m wide	3kW 4.5kW

Waiter/waitress service

Service counter sited within the production area with hot, cold and refrigerated sections, shelves for plates and dishes and adjacent pantry area for supplementary serving items. Provided with a lobby which must be noise and glare screened from the dining area and have separate in-out doors, opening in direction of flow. May be supplemented by:

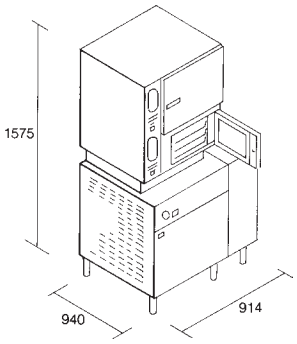
- sideboard(s) within dining area;
- side table or trolley circulation, including flambé preparation/service at the table;
- featured display cooking section for special dishes;
- family service or self selection from dishes brought to the table.

Self-service

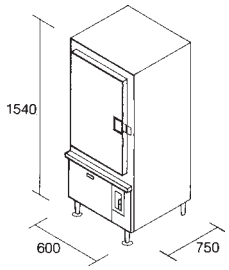
Serving counter arranged for self selection of meal items with planned circulations for customers and food replacement (Figure 34.22). Display counters arranged in sequence of meal choice. Variations include:

- cafeteria style service for high throughput and sales promotion;
- food hall and food court service with alternative counters and a common seating area;
- temporary or installed buffet presentations, including assisted service at the counter;
- snack and/or beverage vending machines with or without seating areas.

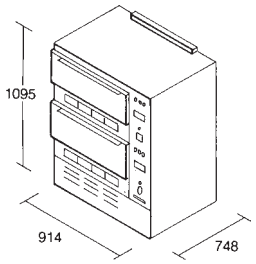
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



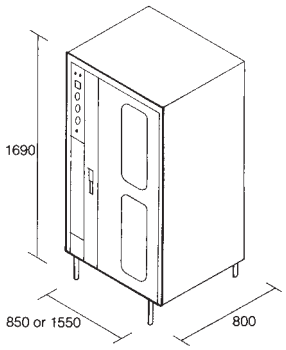
a *Convection steamer with two compartments*



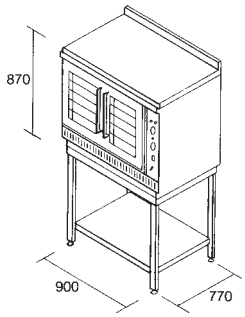
b *Atmospheric steaming oven with steam generator in base*



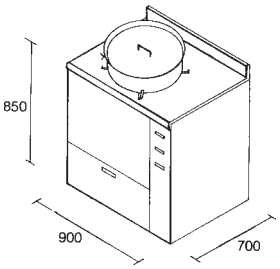
c *Tiered convection ovens, each 65 l rated 8.8kW*



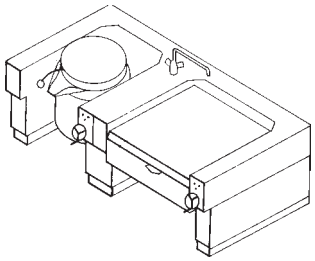
d *Autoreverse convection oven*



e *Forced convection oven on stand, 145 l, 9.2kW*

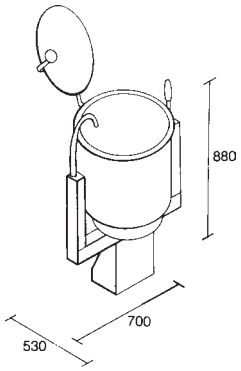


f *Dual-purpose boiling pan, 90 l Direct fired or steam jacketed*

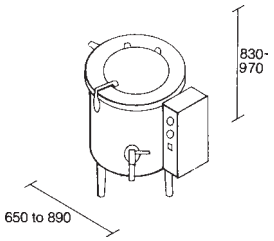


g *Tilting kettle and braising pan console:*

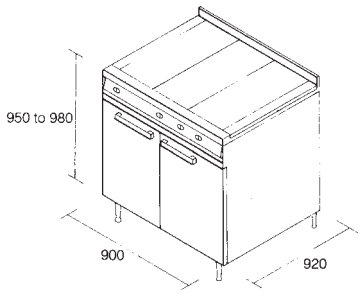
Unit width	*Kettle*	*Bratt pan*	
Capacity	*Rating*	*Capacity*	*Rating*
1200mm	*70 l*	*15kW*	*68 l9kW*
1400mm	*200 l*	*27kW*	*89 l12kW*



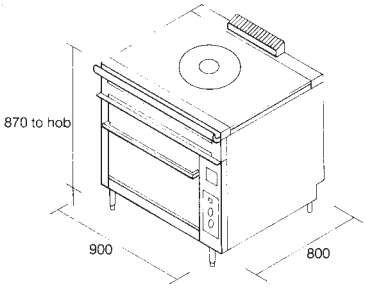
h *Tilting kettle with swivel cold water feed, 40 l capacity, electric or steam heated*



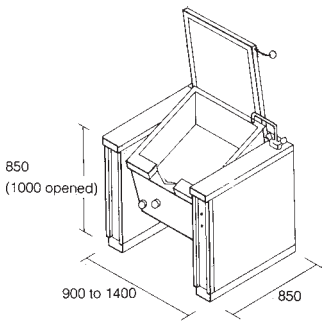
i *Vacuum boiling pan with electric or steam heated jacket, 20, 90 or 135 l*



j *Heavy-duty oven range, 200 l, 18kW (electric), hob with three solid hotplates or griddle plate*



k *Heavy-duty oven range, 150 l, 16.5kW, with drop-down door and solid hob top with tapered heat*

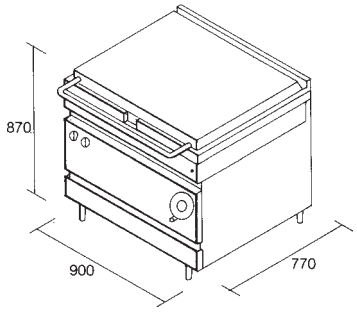


l *Bran or braising pan with pillar support:*

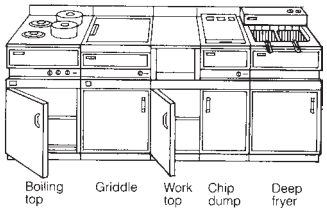
Capacity	*Width*	*Rating*
40 l	*900mm*	*6.4kW*
80	*1200*	*11.8*
100	*1400*	*14.8*

34.18 *Kitchen equipment (continued over)*

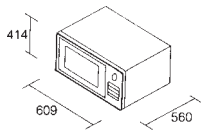
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



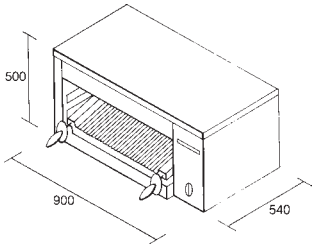
m *Tilting Bratt pan with operating wheel and trunion*



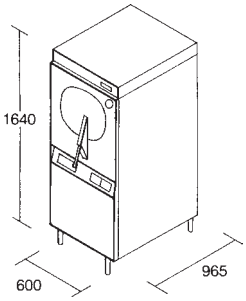
r *Example of combined units with under-counter cupboards*



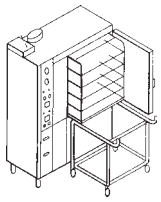
w *Microwave oven, 2.6 kW supply, 1300 W output rings, 8 kW rating*



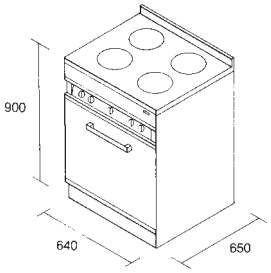
x *Salamander grill, wall or stand mounted, 7.5 kW rating*



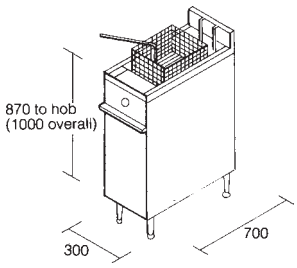
n *High-pressure steamer on stand, 12 kW rating*



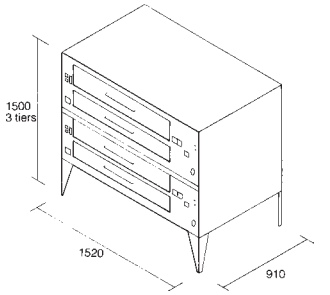
s *Bulk loading system with mobile transporter*



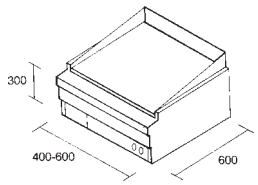
y *Medium-duty oven range, 84 l with four radiant rings, 8 kW rating*



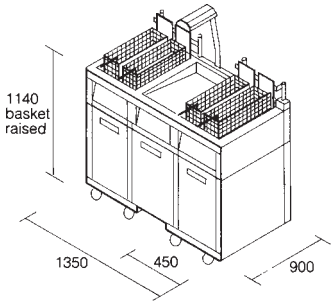
o *Deep fryer with one basket of 16 l oil capacity, 9 kW. Output 22.7 kg chips per hour*



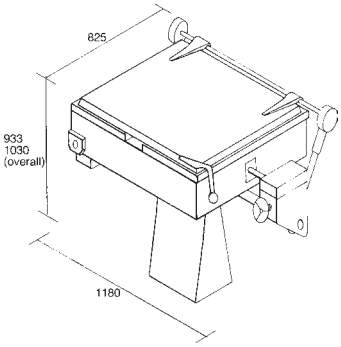
t *Tiered pastry or pizza oven*



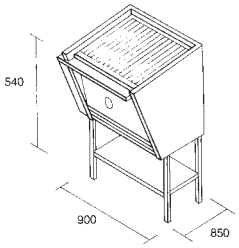
z *Griddle, counter or stand mounted, 8 kW rating*



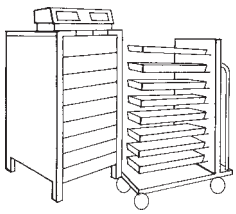
p *Combination of fast-food fryer with dual deep fryers and central chip dump. Each fryer 21.5 kW. Automatic basket lifting, integral oil filtration*



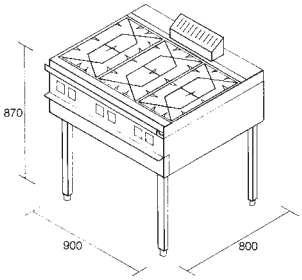
u *Tilting bratt pan*



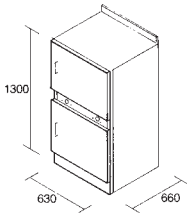
aa *Underfired grill, 37 kW*



q *Infrared (regethermic) oven system, 4.7–5.0 kW*



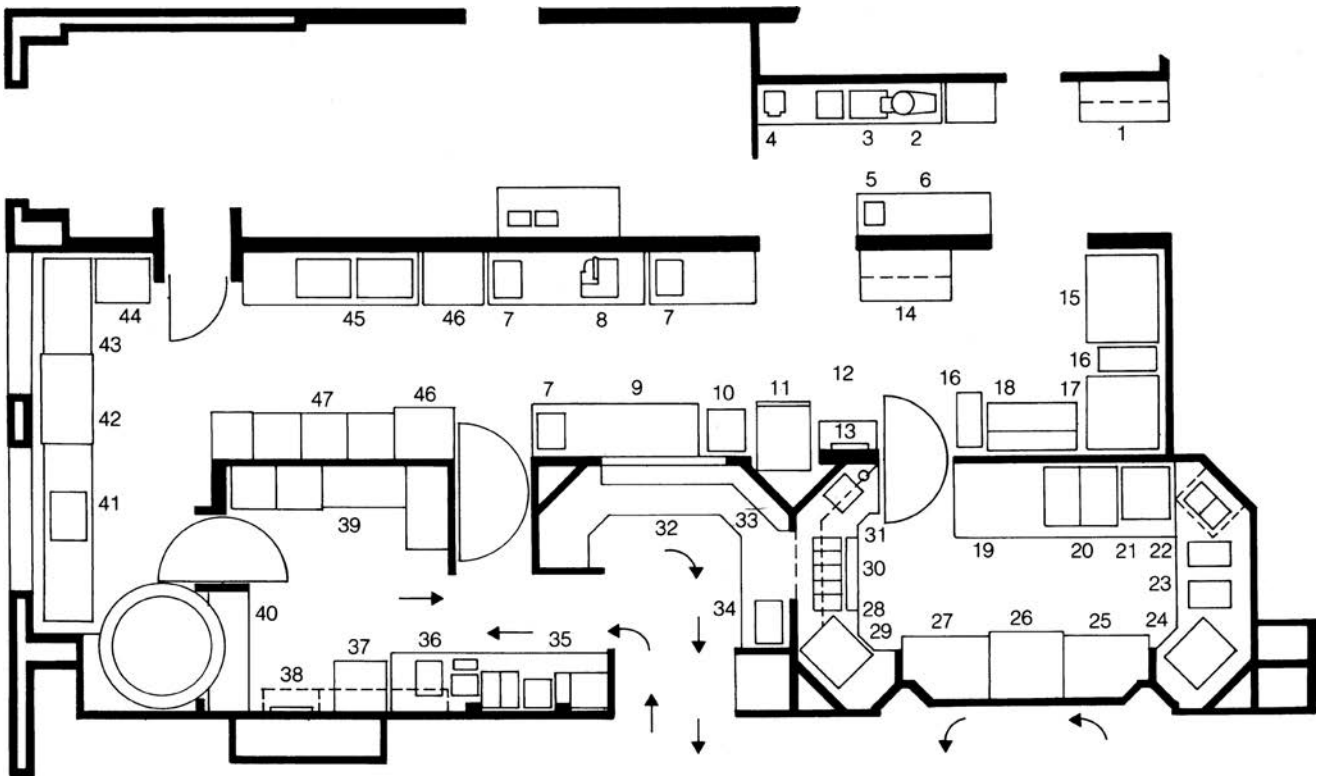
v *Heavy-duty boiling table with open gas burners*



ab *Two-tier general purpose oven each 80 l capacity*

34.18 *(continued)*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



34.19 *Kitchens of Post House Hotel, Sevenoaks. Development: Trust House Forte Ltd. Plans prepared by Stangard Ltd (see key in 34.31)*

Central service
Distribution of centrally prepared dishes as hot, chilled or frozen foods to other locations for service. Central production calls for a fully integrated system, with standardised containers, equipment, transport and controls. Examples include:

- commissary systems to supply meals to finishing kitchens and in transit;
- hospital systems to distribute meals to wards and individual patients;
- banqueting systems to prepare meals in advance of functions;
- central production of convenience foods for catering and restaurant outlets.

4.8 Facilities for staff
Employee ratios vary widely with the type of establishment and demand. The ratio of total employees to meals served over the peak period is about one employee to 8 meals served for full-menu, table service restaurants, 20 meals in limited menu table service and institutions, and 33 or more in fast-food outlets. Changing rooms, lockers and sanitary facilities are required for total full and part-time employees.

5 RESTAURANTS

5.1 Investment
Commercial restaurants are affected by location, image, association and publicity. Location is critical in dictating the catchment area and potential market which may be based on local or transient customers. The image and association helps to create demand. However, sustained success depends on the customers' valuation of the meal experience.

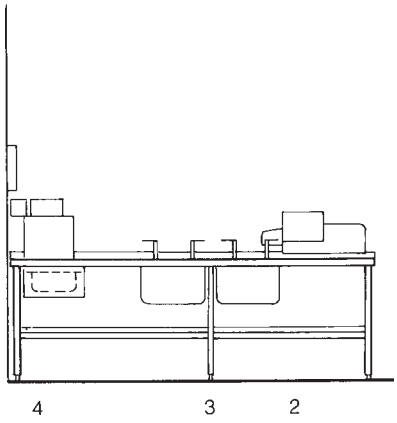
Commercial restaurants are notoriously subject to fashion. They tend to have a short life, not often more than eight years, and both the types of food served and facilities may need to be frequently changed. Investment has to be recovered within the planned life cycle period, requiring careful control of finance and operation.

Full-service high class restaurants are only 5 per cent of establishments. The mid-market range includes steak and seafood restaurants, grilles, brasseries and most ethnic restaurants. Commercial restaurants usually offer table service but self-service (see Section 6.1) from attractive counter displays is common in departmental stores and some of the larger mid-market restaurants for convenience and sales promotion.

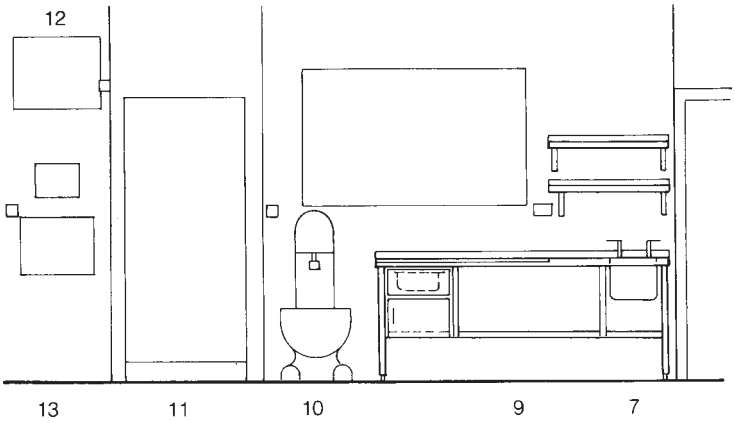
5.2 Ethnic restaurants
In Britain the increase of ethnic restaurants – particularly Chinese and Indian/Pakistani – has displaced many of the traditional establishments. Ethnic restaurants are the main choice for evening dining. Design is often symbolic rather than authentic and it is essential to research the types of foods, spices, traditional preparation and cooking methods represented. Specialist cooking equipment is often required to supplement the standard range normally used and in international hotels separate Western, Oriental and other types of finishing kitchens are required to serve the variety of restaurants provided (Figure 34.23).

Ethnic restaurants cover a wide range of quality and sophistication. The range of food choice is ever increasing with travel, holidays abroad and migration. Chinese food divides into four regions: Canton, Peking, Szechuan and Shanghai. The kitchens need to provide the extensive menus which can be up to 300 items. 'Indian' food is strongly spiced and much of it can be cooked by standard equipment although special ovens may also be used. Japanese food is subtle: preparation and service are seen as an art form and used as part of the presentation. Scandinavian food usually requires a counter display of smoked food, fish and cold meats. Greek restaurants are often designed as peasant-style tavernas and this approach is common in Turkish, Mexican, Spanish, Thai and other popular ethnic restaurants. These traditionally use family service with a series of communal food dishes brought to the table. Italian food is more universal ranging from themed trattorie to specialised pizza chain outlets with purpose designed ovens and preparation areas (Figure 34.24).

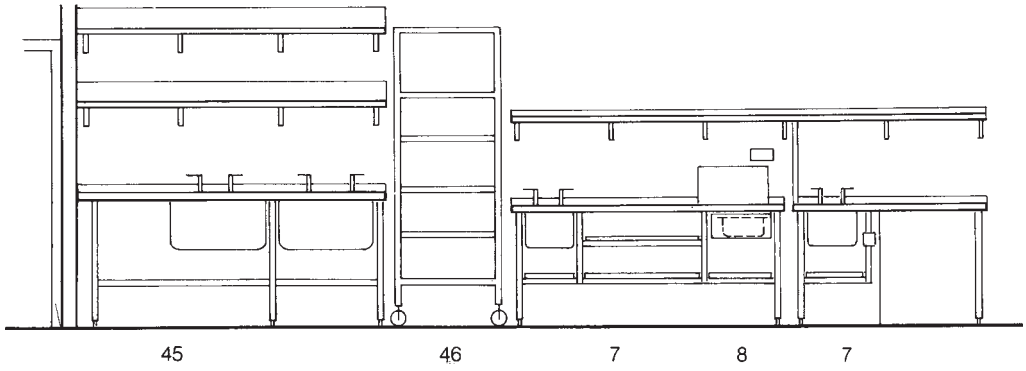
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



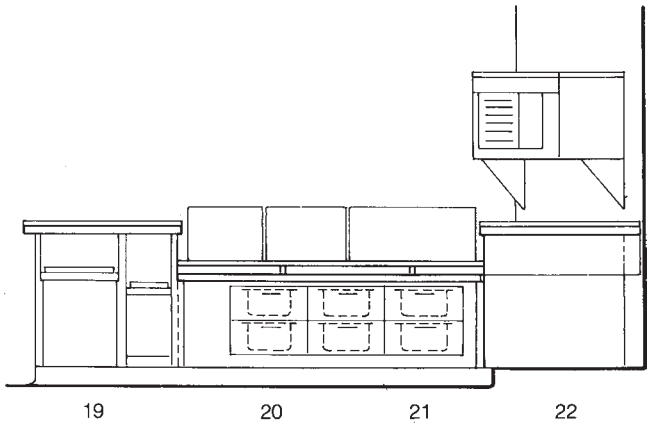
a *Vegetable preparation area*



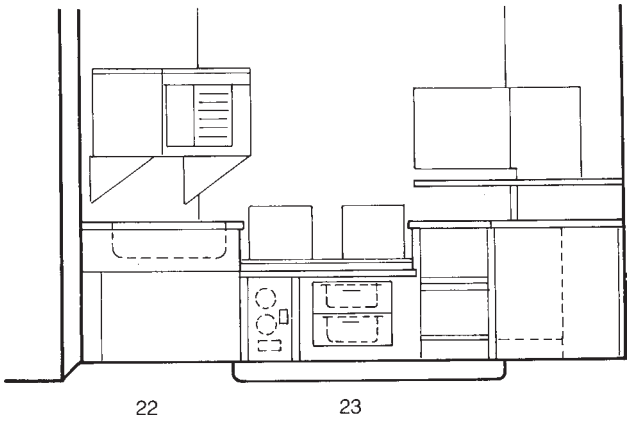
b *General preparation area*



c *Potwash and preparation area*



d *Display kitchen, finishing area and servery*



e *Display kitchen, finishing area and servery*

34.20 *Elevations of installed kitchen equipment (continued opposite)*

5.3 Cafes, coffee bars and snack bars

Typically, these have limited space and seating. The menu range of food offered is short and simply produced, normally operated with counter service and back-bar equipment. Beverages are an important product, particularly in the more specialised coffee bar chains. Cafes tend to emphasise a domestic character and are often located in shopping and visitor areas. Snack bars and sandwich bars have very restricted seating areas and primarily cater for local workers and others requiring snack meals or take-away food prepared to order. Compact table or booth areas and/or counter seating are used. Chains of specialist coffee bars have expanded into almost every town using standard designs and equipment which offer a quick service of selected coffee beverages and pastries in comfortable surroundings.

6 CAFETERIAS AND FOOD HALLS

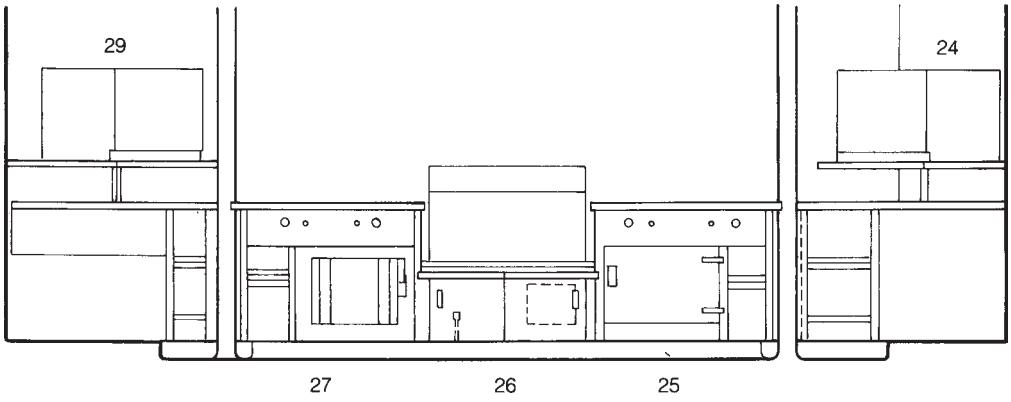
6.1 Cafeterias

Self-service is mainly used in employee, educational and institutional catering, airports, motorway service stations and other locations which serve large numbers of people at peak meal times or in which time for meals is limited.

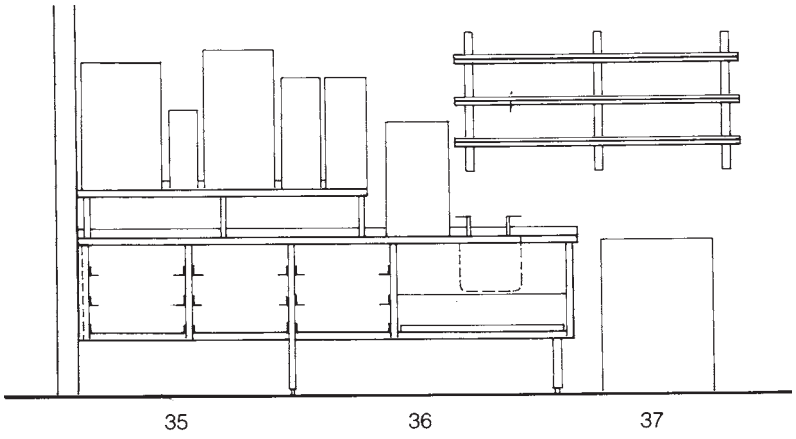
Characteristics:

- Scale of operation: usually large numbers of meals served allowing economies of scale in production.
- Concentrated demand: a short service period or limited time available for a meal demands a high rate of service with minimum delay. Above 600 meals per day, free-flow and multi-counter service is practical and the counters are often grouped in a food hall separate from the seating areas.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

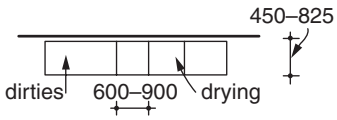


f *Display kitchen, finishing area*

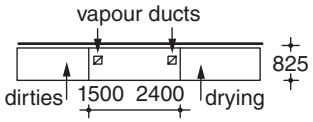


g *Beverage counter*

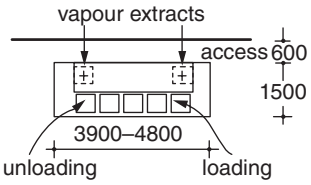
34.20 *(continued)*



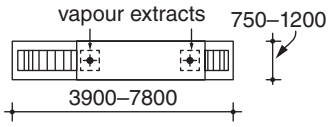
a *Small spray-type dishwasher*



b *Medium-size automatic conveyor dishwasher*



c *Rotary conveyor-type dishwasher*



d *Large 'flight'-type dishwashing machine with continuous escalator type conveyor*

34.21 *Alternative layouts for wash-up areas, with equipment dimensions*

- Space: counters add 0.2–0.3 m^2 to area per seat in the dining room
- The average rate of customer flow through a single counter is 6–9 persons per minute, dictated mainly by the speed of beverage service, cash payments and variety of menu choice.
- By-pass arrangements, duplication of the counter and cash point can increase the flow to 14–16 persons per minute. Beverage service may be in a separate area.
- Larger numbers require multi-counters choices, each serving particular types of meals and these may be arranged in a food hall separate from the seating areas.
- The layout must allow for direct access to the production area for easy food replacement.
- Menus: balanced to meet nutritional standards. The extent of choice will determine counter layout and length.
- Counter sections are heated or refrigerated and fitted out for food holding and display. Critical features are the design of tray slides, easy access to the food items with protection from contamination.
- Cash-out desks are sited at or near the end of the service lines, duplicated where necessary and fitted with tray slide waiting areas. Cutlery, condiment, etc. stands must be sited to avoid congestion.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table VI Range and sizes of tableware in general use

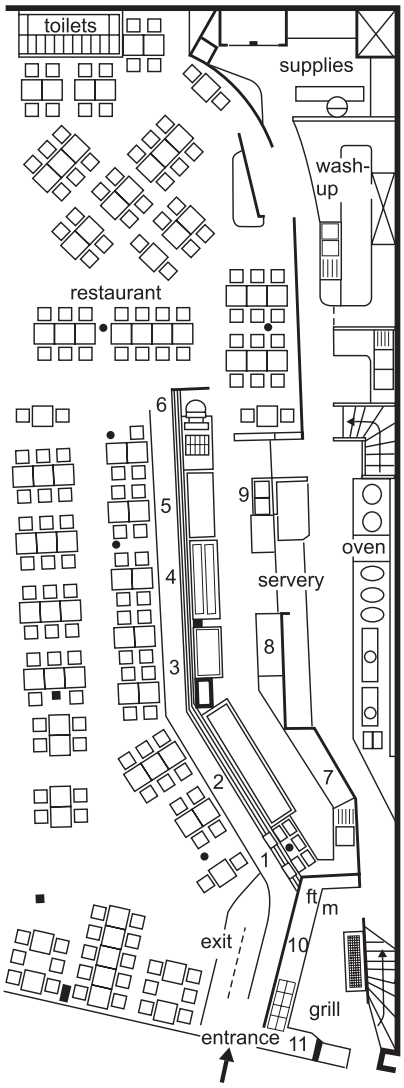
Type	Range	Size (rounded)
Pots (related to cups and pint sizes)	Tea	430, 570, 850, 1140 ml
Jugs	Coffee, hot milk/water	280, 570, 850, 1140 ml
	Cream	30, 40, 70 ml
	Milk	140, 280, 430 ml
Cups	Tea	170, 200, 230 ml
	Coffee (demitasse)	110 ml
Saucers	Size related to cups but should be interchangeable	
Plates	Side	165, 180 mm
	Dessert	190, 205 mm
	Fish/dessert	215,230 mm
	Meat	240, 255 mm
	Oval meat	240, 255 mm*
Bowls	Cereal/fruit	155, 165 mm
	Sugar	90 mm
	Soup	215, 230 mm

*Usually maximum size for a dishwashing machine.

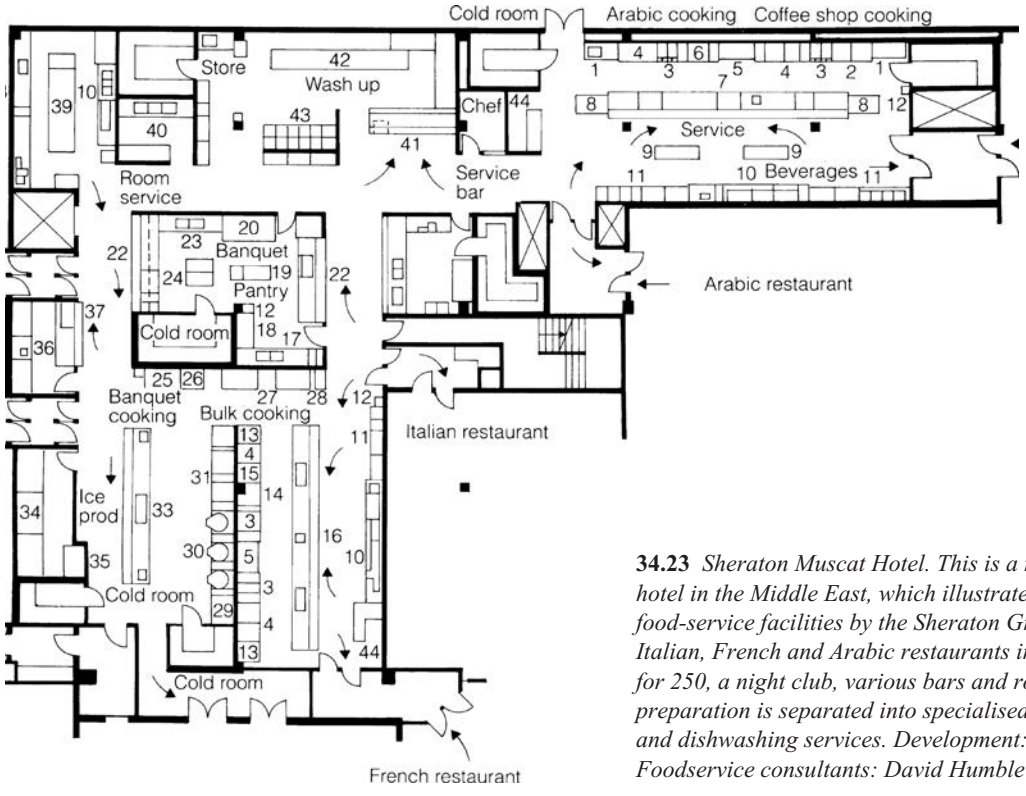
Table VII Allowances for dishwashing spaces (intermittent use)

Area/activity	Space (mm)
Collection area for unsorted tableware prior to sorting and scraping	600 length per 10 meals* Minimum 900 Maximum 2400
Stacking area for tableware sorted and stacked for manual washing	300 length per 10 meals† Minimum 900 Maximum 3600
Loading onto racks for machine washing	Depends on rack/basket size Minimum 1000
Draining and drying in racks or baskets after washing and sterilising	Minimum 1200 – Conveyor or spray-type machines up to 3600
Unloading baskets and racks for clean crockery awaiting removal	100 length per 10 meals Minimum 600 Maximum 2400
Spray-type machines with mechanised conveyor systems	Space occupied by machine conveyor system
Rotary conveyor type (600–1000 meals/h)	Width Length 1500 3900–4800
Flight-type escalator conveyor (over 1000 meals/h)	750–1200 3900–7900

*Based on self-clearance. Smaller areas suitable where part stacking is provided.
†Assumes some accumulation of dishes before washing up. The lengths relate to tabling 750 mm wide.

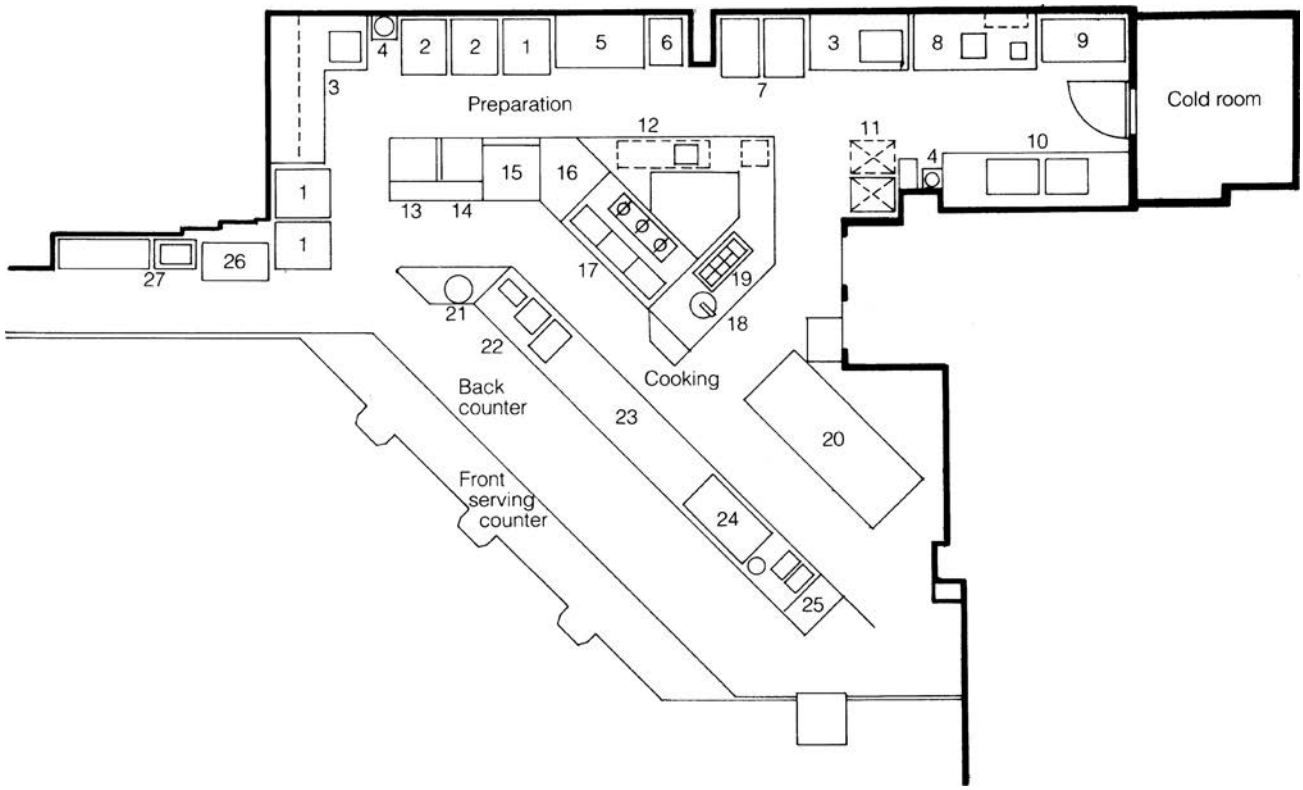


34.22 *Self-service restaurant in Paris. Architect: Prunier*



34.23 *Sheraton Muscat Hotel. This is a recently built 350-room hotel in the Middle East, which illustrates the careful planning of food-service facilities by the Sheraton Group. It offers a choice of Italian, French and Arabic restaurants in addition to banqueting for 250, a night club, various bars and room service. Food preparation is separated into specialised areas with common storage and dishwashing services. Development: Sheraton Corporation Foodservice consultants: David Humble Associates*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



34.24 *Seasons pizzeria, London*

Self-service arrangements require seating areas to be arranged in regular order with wide aisles, particularly in the circulation to and from the serving counters. Self-clearance or/and trolleys may be used. Furniture must be durable, easily cleaned and retain good appearance. Counter arrangements are shown in Figures 34.25, 34.26 and 34.27 indicate equipment requirements although these will depend on the type and range of menu. To minimise food handling, counters are designed to receive standard gastro-norm containers (Figure 34.28). An example of a mid-sized employee cafeteria is shown in Figure 34.29 and a large hospital arrangement in Figure 34.30 with the standard key for three kitchens in Figure 34.31. A large scale, multi-choice layout is illustrated in Figure 34.32 and a large employee service in Figure 34.33.

7 FAST-FOOD OUTLETS AND TAKE-AWAYS

7.1 Fast-food systems

Fast-food has been a rapidly growing sector accounting for about one-third of the market for meals outside the home. Outlets mainly concentrate on a limited range of popular products such as hamburgers, chicken, pizza. Food is highly standardised and operations are designed around systems which enable tight control over production and costs to ensure fixed competitive prices. Most outlets are chain operated.

Investment costs are high with sophisticated equipment designed for high volume output with low skill operatives. Locations are critical and prime high street sites having large pavement flows are preferred for major franchised units. The average size of large counter and table service outlets ranges from 320–460 m^2. Operations often extend over 15 hour day, 7 day week to finance high investment and operating costs.

7.2 Operation

Most fast-food operators aim for a maximum door time (entering to leaving) of 3.5 minutes, 2.5 minutes queueing and 1 minute serving. Counters are designed for rapid ordering and service with multiple stations. Production processes use automated equipment with control over cooking and holding time, portions and additions (Figure 34.33).

Food is delivered to outlets ready prepared, portioned and frozen or chilled. The entire procedure is tightly controlled and unsold hot food kept only a fixed period then discarded. Employees have specific roles as till operators, backers and crew. Disposable containers are used for all food and beverage items and suitably designed waste receptacles and cleaning services must be provided in store and the vicinity.

Depending on the type of outlet, most fast-food stores also provide table and counter seating areas for meals on trays. These are grouped clear from the take-away routes and may be on upper or lower floors. Seating areas are designed for a high turnover, with self-service and self-clearance. Arrangements include fixed tables and seats, loose seats and wall counter seating. High standards of hygiene, cleaning and maintenance are important in system design. Trends are towards health conscious eating with emphasis on lower fat, salt and sugar products and additional choice of salads, vegetarian, fresh fruit, yoghurt and real juices.

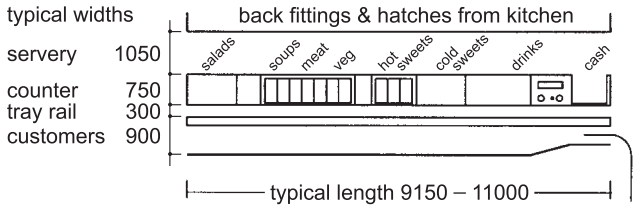
7.3 Food courts

Food courts are provided to offer a wider range of choice with a number of food outlets serving alternative products grouped around a common seating area. They may be provided in shopping centres, airports, universities and other places where the demand is high. Serving counters are backed by end-cooking, preparation and storage areas supplied from a service corridor (Figure 34.34).

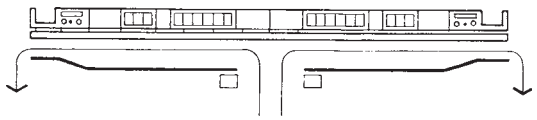
7.4 Other foodservice outlets

Food and refreshment services are required by motorists, coaches and truck drivers. These are mainly grouped with filling stations, lodges and other services at convenient stopping places along main routes, near major junctions and within scenic tourist attractions (Figure 34.34).

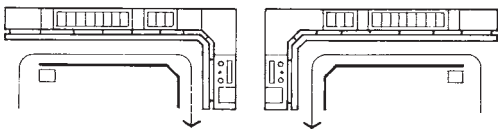
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



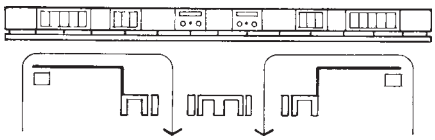
a *Single-line counter, 60–90 customers per min*



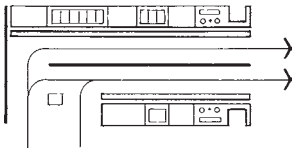
b *Divergent flow*



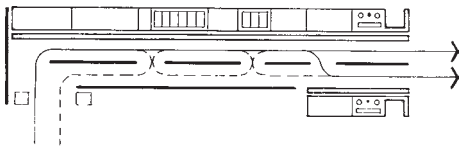
c *Convergent flow*



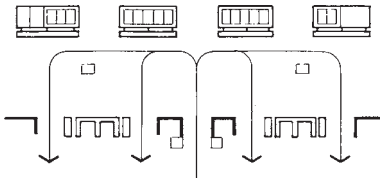
d *Multiple outlets*



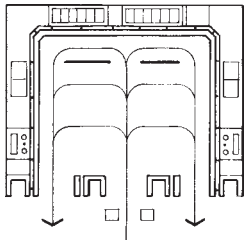
e *Parallel flow*



f *Bypassing*

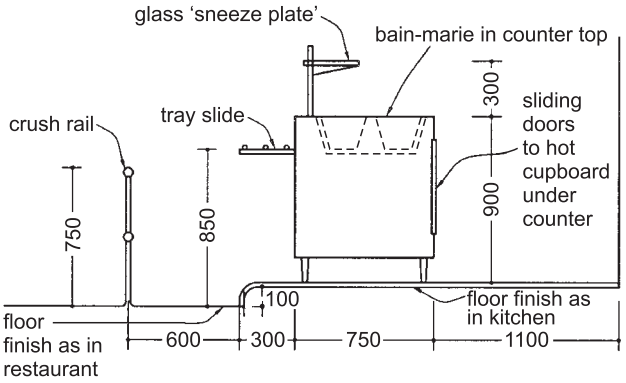


g *Free flow with counters in line*

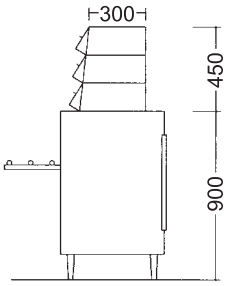


h *Free flow with counters in perimeter*

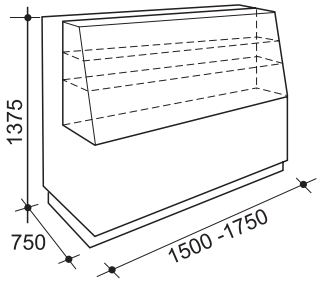
34.25 *Alternative arrangements for self-service counters*



a *Section through counter for hot food*



b *Section through cold-food counter*



c *Refrigerated showcase*

34.26 *Servery equipment*

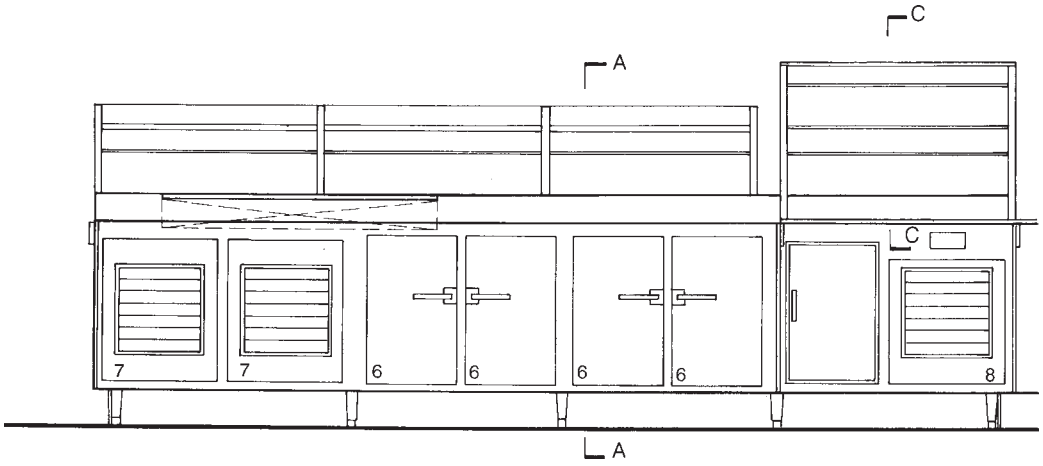
Snack bars, most delicatessens and food shops offer food ready for consumption off the premises. This may range from products freshly prepared, baked or cooked to order, including fish and chips, pizza, pies and pastries to pre-packed sandwiches and vended beverages. Some include limited table and counter seating areas. Many popular and ethnic restaurants also offer a take-away facility, some with home delivery.

8 PUBLIC HOUSES

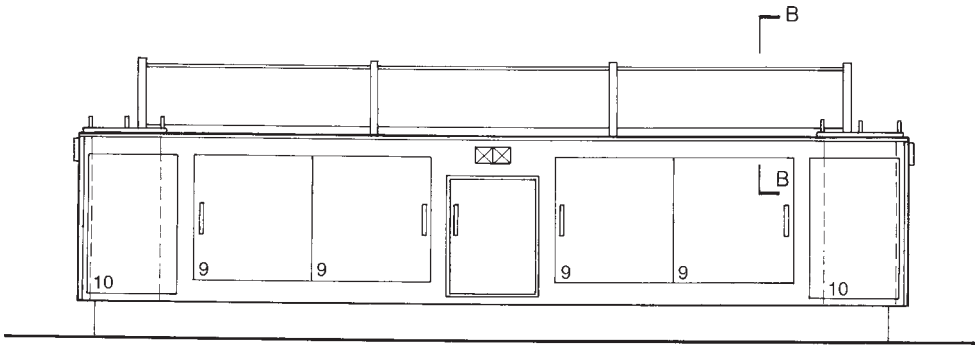
8.1 Licensing

The requirements of public houses and wine bars are different from other food-service outlets in that alcohol sales are the dominant rather than a subsidiary activity. Licenses to sell alcoholic liquor are granted only if the applicant and premises are suitable for the purpose. Safety, means of escape, sanitary facilities and separation of bars from other areas must be approved before a license is granted as well as approval of any structural alterations before renewal. Few new public houses are built. The majority of works are alterations to update the facilities and provide food services.

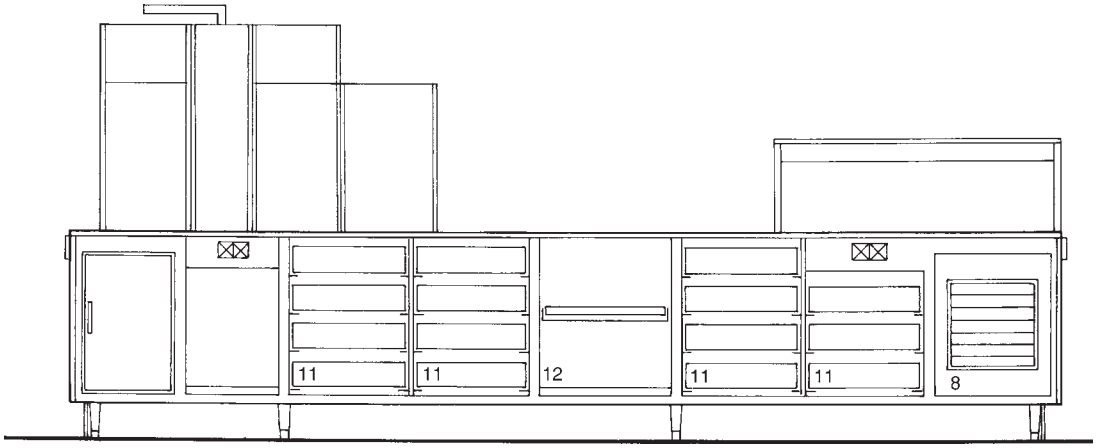
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



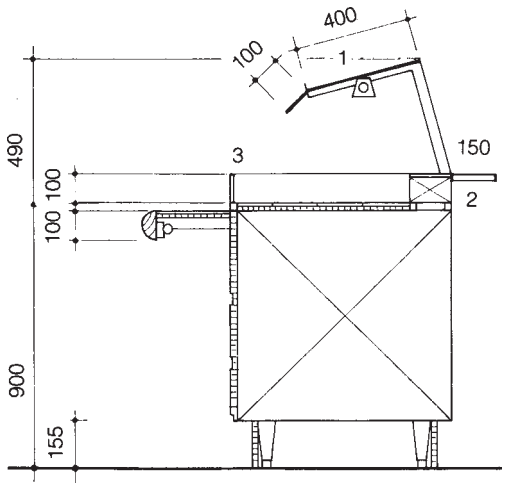
a *Elevation*



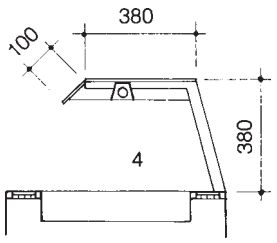
b *Elevation*



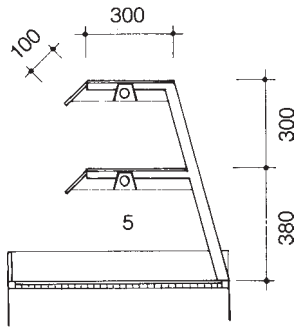
c *Elevation*



d *Section A-A*



e *Section B-B*

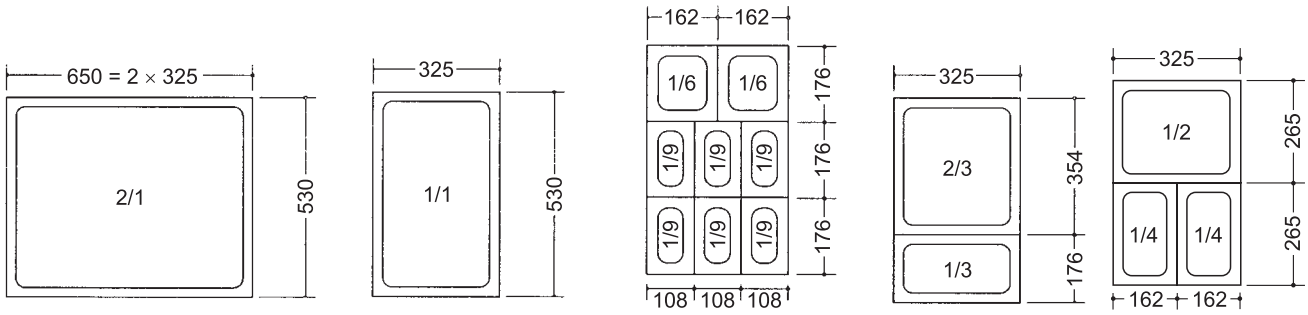


f *Section C-C*

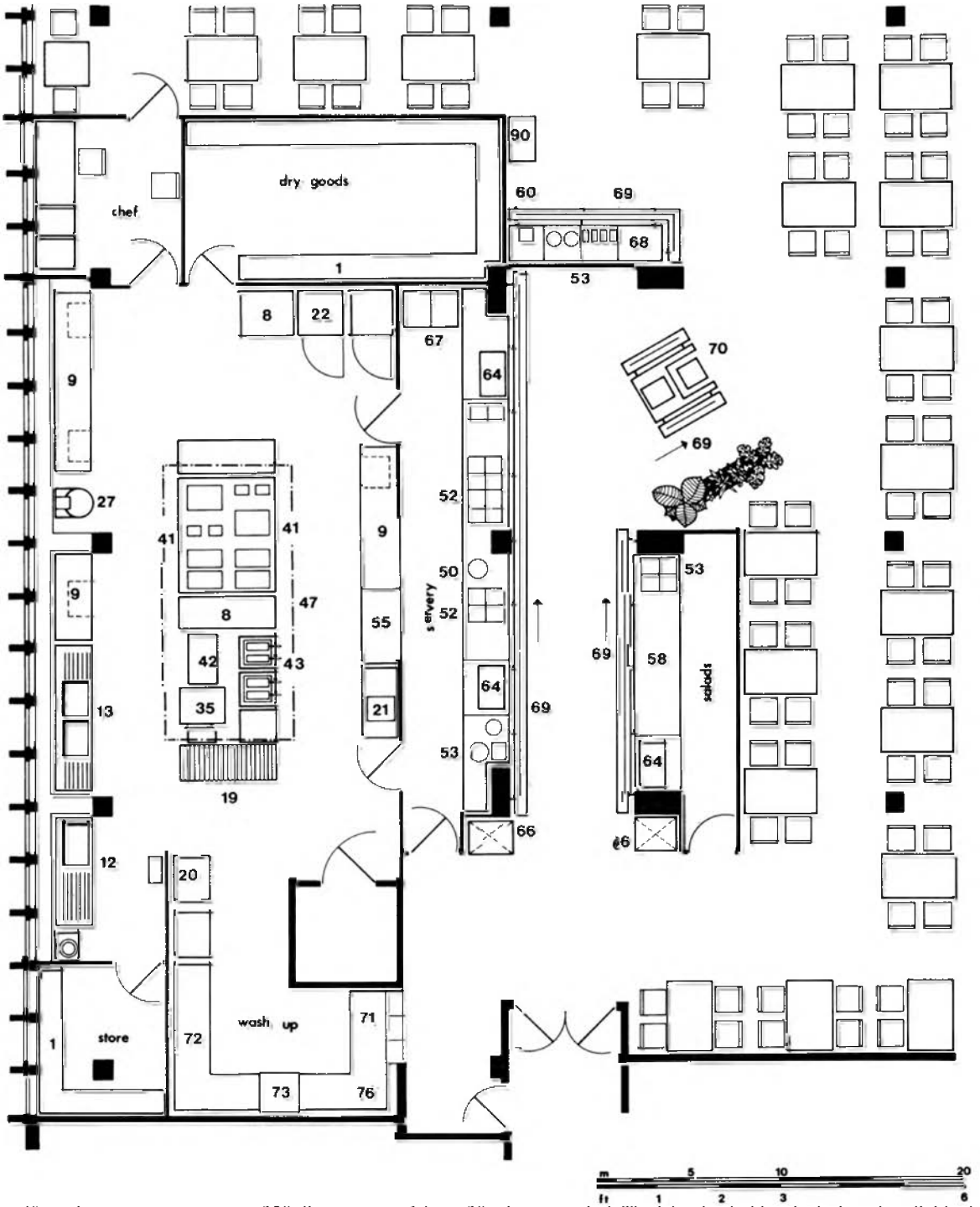
1 *Sneeze guard*
2 *Fan cooler*
3 *Tiled tray slide with inset nylon runners*
4 *Refrigeration well*
5 *Two-tier shelves with fluorescent tube lighting*
6 *Refrigerated base*
7 *Refrigeration compressor*
8 *Electrical housing*
9 *Heated cupboard*
10 *Heated cupboard with plate lowerator*
11 *Open cupboard with cup basket*
12 *Open cupboard with shelves*

34.27 *Self-service counter*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

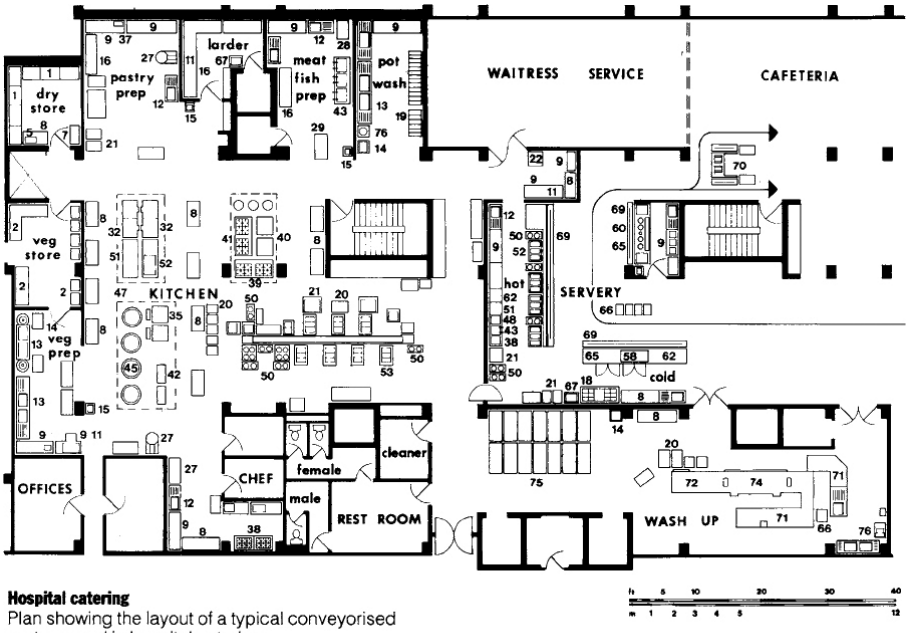


34.28 *Module sizes for gastronorm containers*



34.29 *A self-service restaurant to serve 350 diners over a 1 hour 30 minutes period. The island salad bar is designed to divide the flow and increase the speed of service. Standard key, Figure 34.31*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



Hospital catering
Plan showing the layout of a typical conveyorised system used in hospital catering.

(see general key)

34.30 *Plan showing the layout of a typical conveyorised system used in hospital catering*

Storage areas
1 *Shelving*
2 *Vegetable racks*
3 *Vegetable bins*
4 *Storage bins*

Preparation areas
8 *Worktable or bench*
9 *Workbench with cupboards/drawers*
12 *Single sink with drainer*
13 *Double sink unit*
14 *Mobile sink*
15 *Wash-hand basin (with dryer)*
16 *Marble-topped bench*
19 *Pot rack*
20 *Trolley*
21 *Mobile trays*
22 *Refrigerator*
25 *Potato peeler*
26 *Chipping machine*
27 *Mixing machine*
28 *Slicing machine/vegetable mill*
29 *Chopping block*

Cooking area
34 *Forced-air convection oven*
35 *Steaming oven/pressure steamer*
36 *Microwave oven*
38 *Boiling top with oven top*
39 *Boiling top with solid top*
41 *Oven range with boiling top*
42 *Griller or salamander*
43 *Deep fat fryer*
46 *Open-well bain-marie*
47 *Extraction hood over equipment*

Serving area
50 *Plate lowerator or dispenser*
52 *Hot cupboard with bain-marie top*
53 *Bench type bain-marie unit*
54 *Pass-through unit – heated*
55 *Pass-through unit – cold*
56 *Refrigerator under-cupboard/drawer*
57 *Refrigerated cupboard with doleplate*
58 *Refrigerated display cabinet*
59 *Milk dispenser*
62 *Counter unit – unheated*
63 *Counter unit with infrared lamps above*
64 *Counter display cabinet*
65 *Compressor or boiler under counter*
66 *Tray stand*
67 *Ice cream conservator*
68 *Cutlery stand*
69 *Tray rail*
70 *Cashier's desk*

Wash-up area
71 *Receiving table for soiled dishes*
72 *Stacking table for clean dishes*
73 *Dishwashing machine – semi-automatic*
76 *Waste-disposal unit or scraping point*

Dining areas
90 *Beverage vending unit*
91 *Food vending unit*
92 *Waiter/waitress serving station*

34.31 *Standard key for three kitchen examples*

8.2 Separation

Pubs require two separate parts:

- public areas: bars, lounges, dining areas, toilets and circulation used by customers;
- private areas: serveries, storage (cellars), kitchen and accommodation used by staff.

Most pubs traditionally offer a choice of public bar and lounge areas. Drink storage areas must be easily accessible to each bar servery. Access to the kitchen is required for taking food orders from the counter and serving food directly to the dining area.

The main pub entrance and secondary entrances from car parks are usually through lobbies to control temperature and airconditioning. Facilities must provide suitably located toilets of adequate size, separated for men, women and disabled and entered through a screened, ventilated lobby. Relationships between areas are illustrated (Figure 34.35) in a modernised town pub.

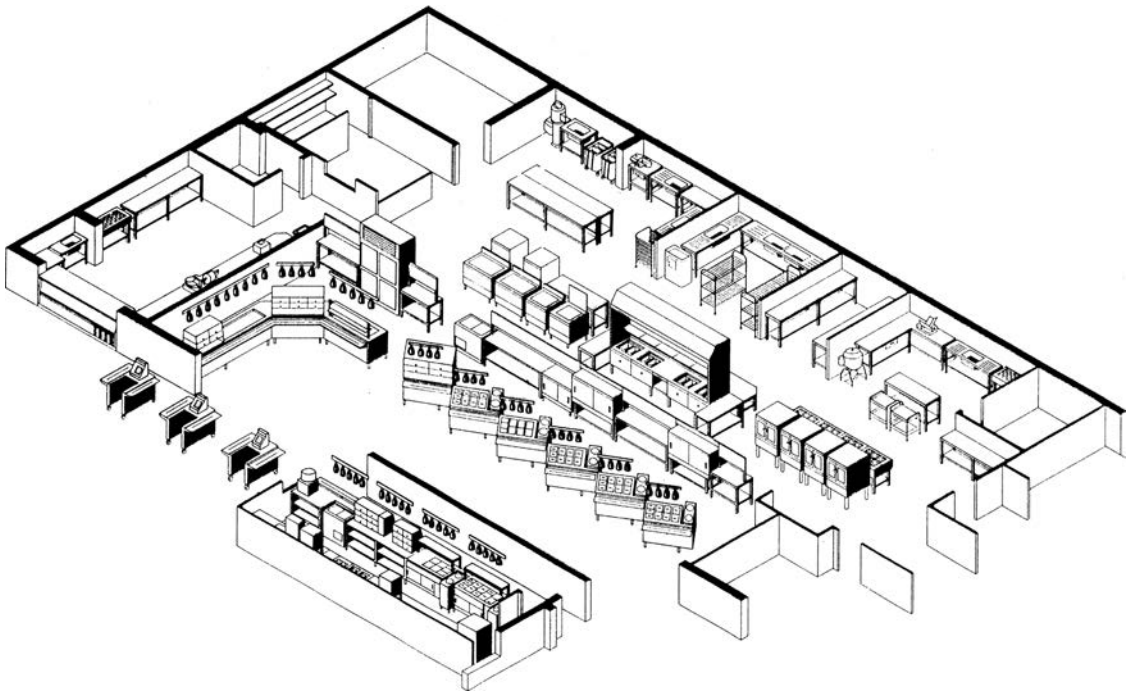
8.3 Pub meals

Most pubs offer meals to boost their sales by attracting a wider clientele and increased use of existing facilities and staff. Usually a separate room or area of the lounge is used for food service with access (directly or via food hoist) to the kitchen. In country inns, glass-house extensions are common to extend the space into a garden environment. Most menus are standardised around popular choices with daily special additions to add variety – often with blackboard listings. Much of the food is bought in ready prepared. Kitchens are typically fitted with backbar equipment (e.g. microwave oven, grill, griddle, convection oven, boiling hob), together with preparation worktops, sinks, dishwasher, under-bench cupboards and refrigerators including chilled salad and food counters. An example of a pub conversion is shown (Figure 34.36).

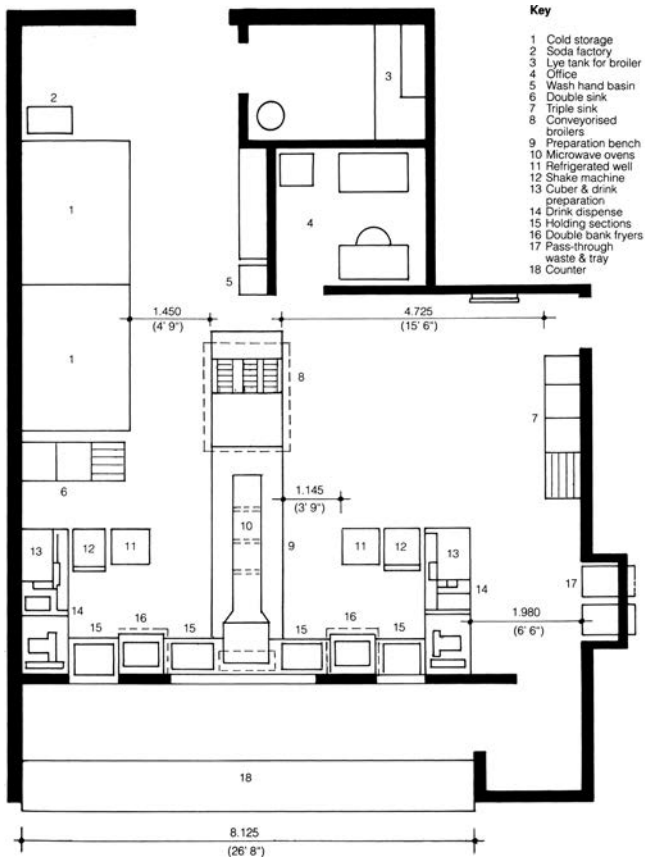
8.4 Drink storage and bars

Traditional drink storage is in naturally cool cellars with CO_2 pressure or pumps to transfer ale and other brewed drinks from metal kegs or barrels to ground floor bars. Access to adjacent truck bays must be provided for deliveries (Figures 34.37, 34.38, 34.39, 34.40). Temperature control is critical and cooling may be required for the 'cellar' (including secure wine stores) and may be installed in the pipeline to dispense cold beer and other beverages. Pipelines are contained in ducts, usually insulated and may supply more than

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



34.32 *Example of large-scale catering using multi-choice counters*

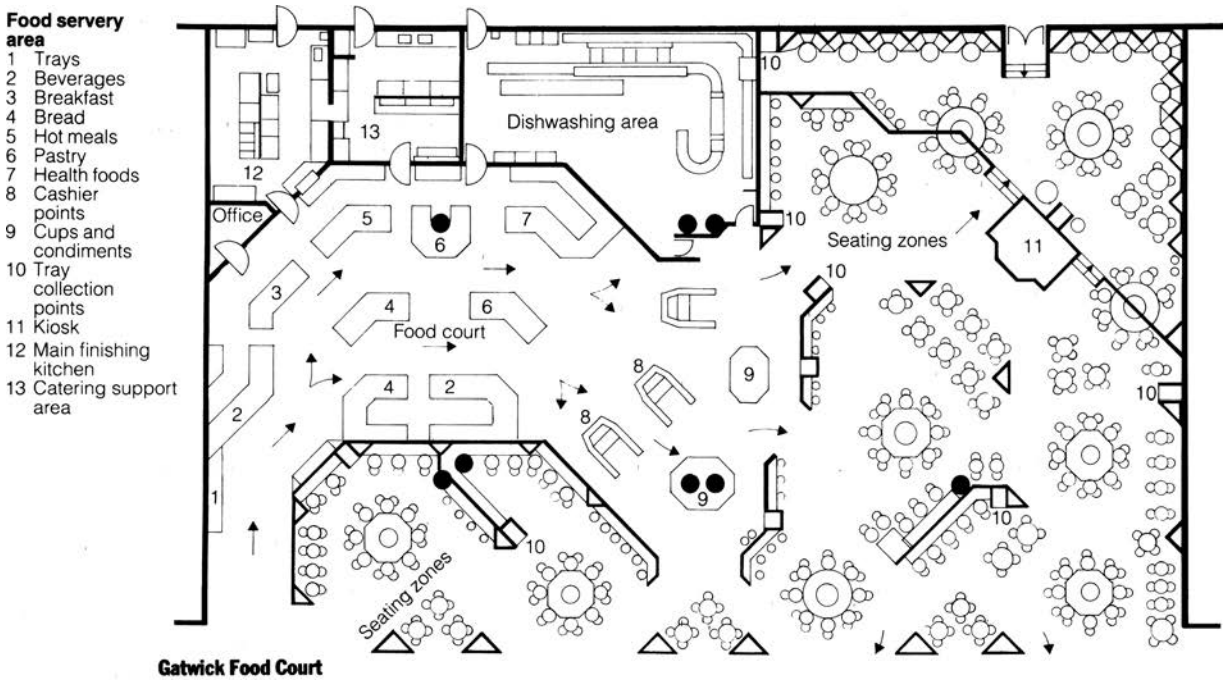


34.33 *Fast-food outlet*

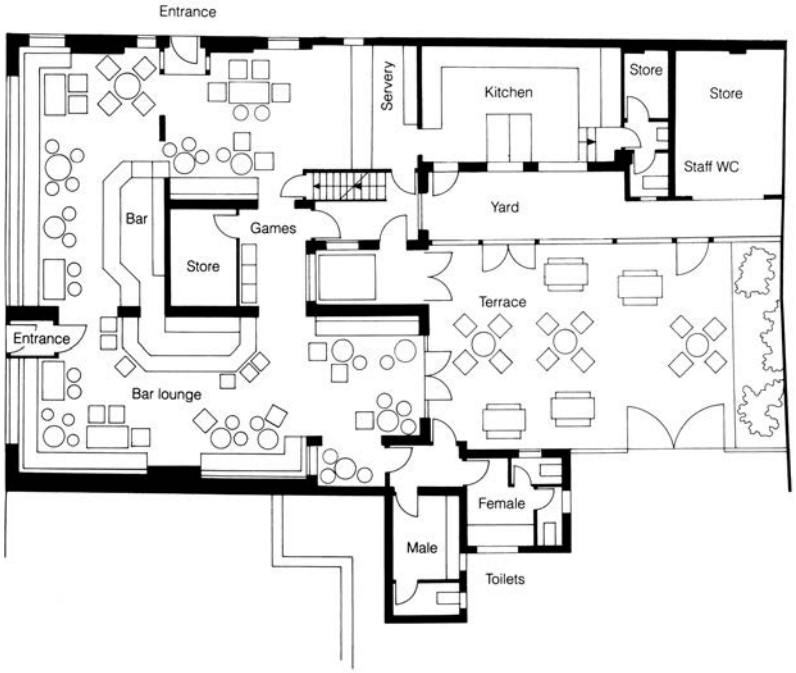
one floor level (Figure 34.41). Hoists can be used to transport cases of drinks.

Drink serveries are usually centrally located to serve more than one room and provide a bar counter, and back bar fitting with work space between having access to the bar store. Counter lengths vary but the height and width are standard. A worktop with inset sink is provided below the counter top and dispense points. The backbar is designed as a decorative feature and includes a sideboard with cooled shelves, a display for spirits ('optics'), wine and glasses, cash register, cooler and glass washing machine (Figures 34.42, 34.43).

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



34.34 *Gatwick food court*



34.35 *Example of a modernised town pub*

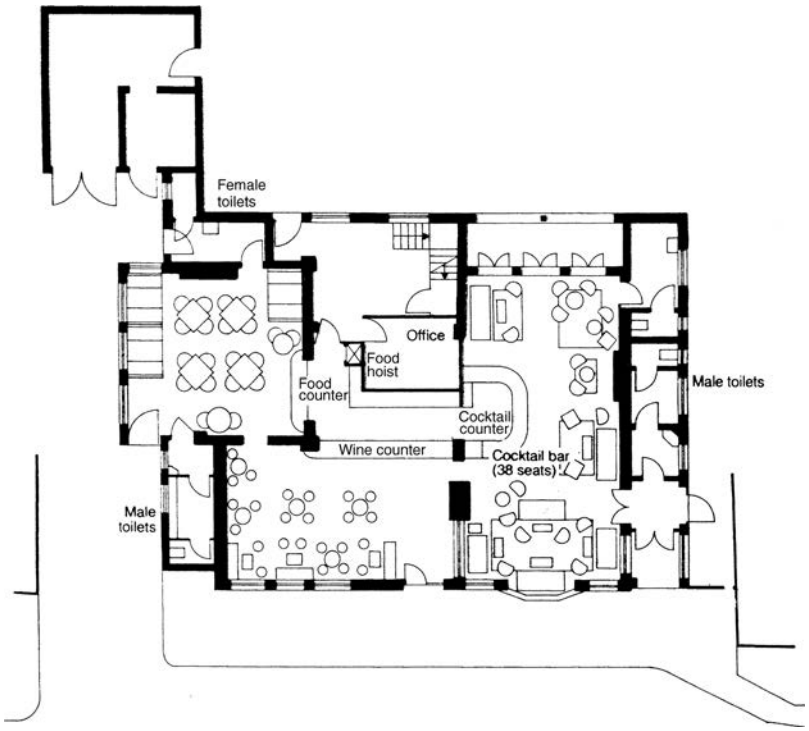
An alternative choice of bars is often provided and one may be adapted for food service. A high proportion of drinkers stand at the bar and stools may be fitted or loose. Traditional pub tables are heavy, with cast iron base or wood frame, and used with peninsular seating and stools.

Depending on trade, drinking bars often provide a large screen television for sports interests and areas may be set aside for darts, pool, game machine(s) and a piano (Figure 34.44). Located mainly in city commercial districts, wine bars are more upmarket and often offer a bistro-type food outlet. Cocktail bars are sophisticated in design and service style, usually associated with high class dining facilities, hotels and clubs.

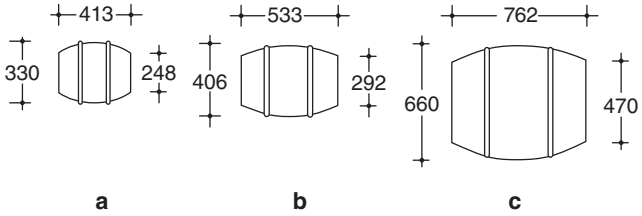
8.5 Clubs

Clubs tend to specialise in late entertainment together with sales of beverages. Food may be served as in night clubs. In each case the design is specific to create the desired atmosphere and mode of operation. Entertainers require changing rooms with direct access to the stage. Sophisticated lighting, projection and sound systems with programmed control equipment are required as well

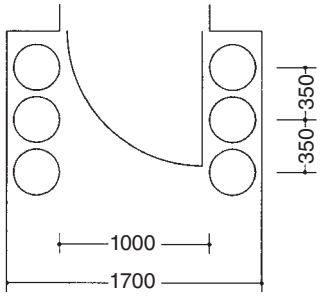
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



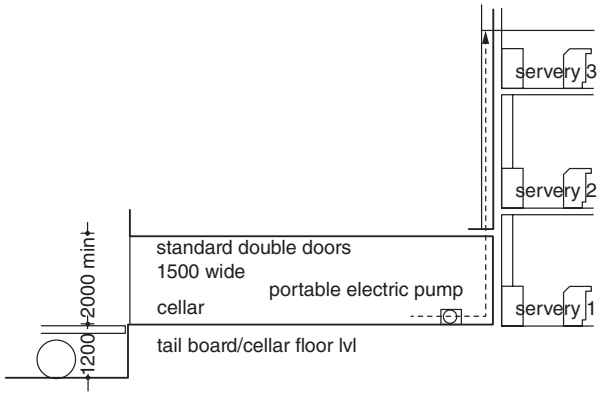
34.36 *Example of first-floor conversion of public house to provide an upmarket bistro-diner and cocktail bar. Lee Associates Ltd*



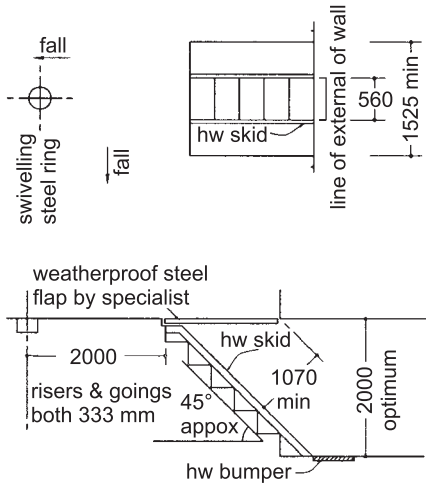
34.38 *Traditional sizes of metal barrels or kegs*



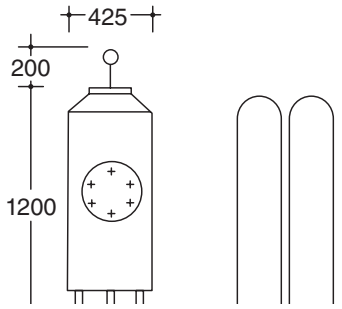
34.40 *Keg storage*



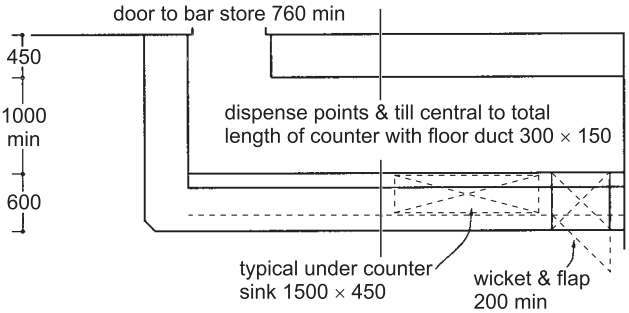
34.41 *Beer supplied through several storeys from ground-level cellar. A standard electric cellar pump will raise beer up to 9 m*

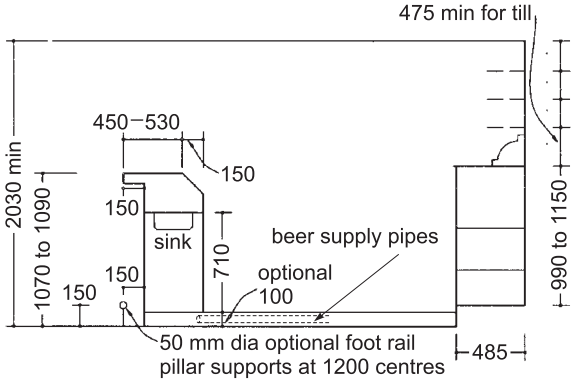


34.37 *Cellar flap and barrel chute for below ground storage of metal barrels or kegs*



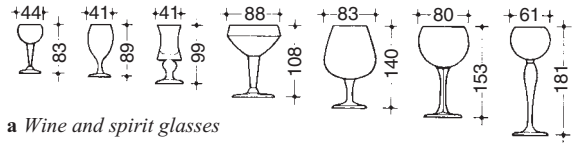
34.39 *Bulk storage in typical CO_2 canisters. Larger canisters also exist*



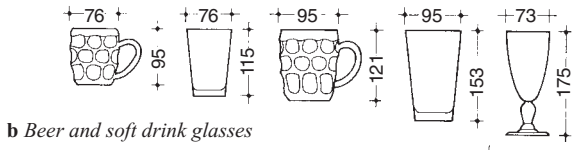


34.42 *Plan and section of a bar servery. Dispense points for various brands of drinks are usually sited at 225 mm centres along the counter top*

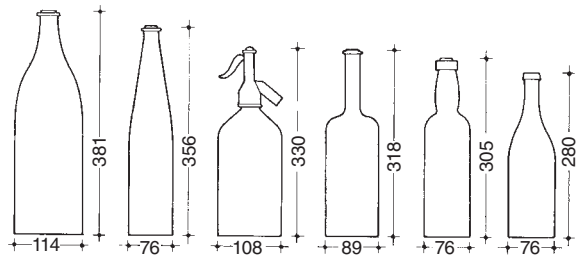
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

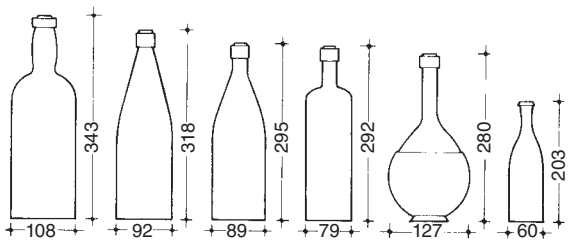


a *Wine and spirit glasses*



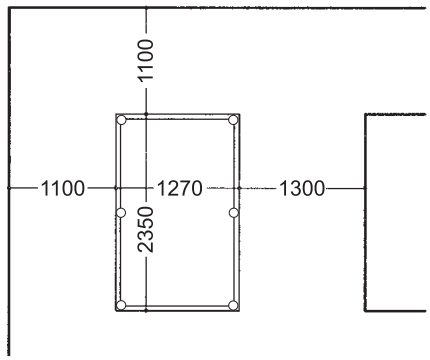
b *Beer and soft drink glasses*



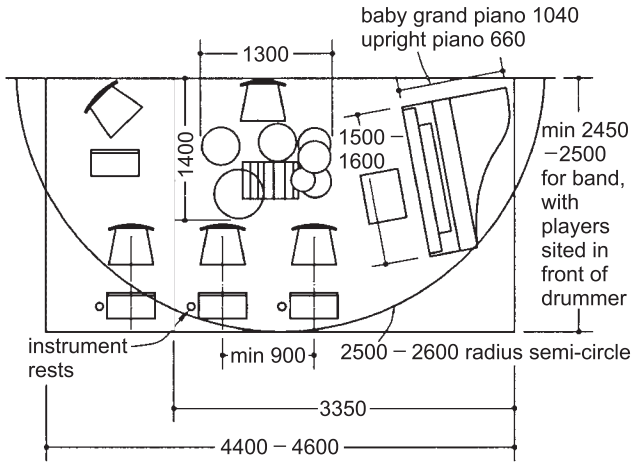


c *Bottles*

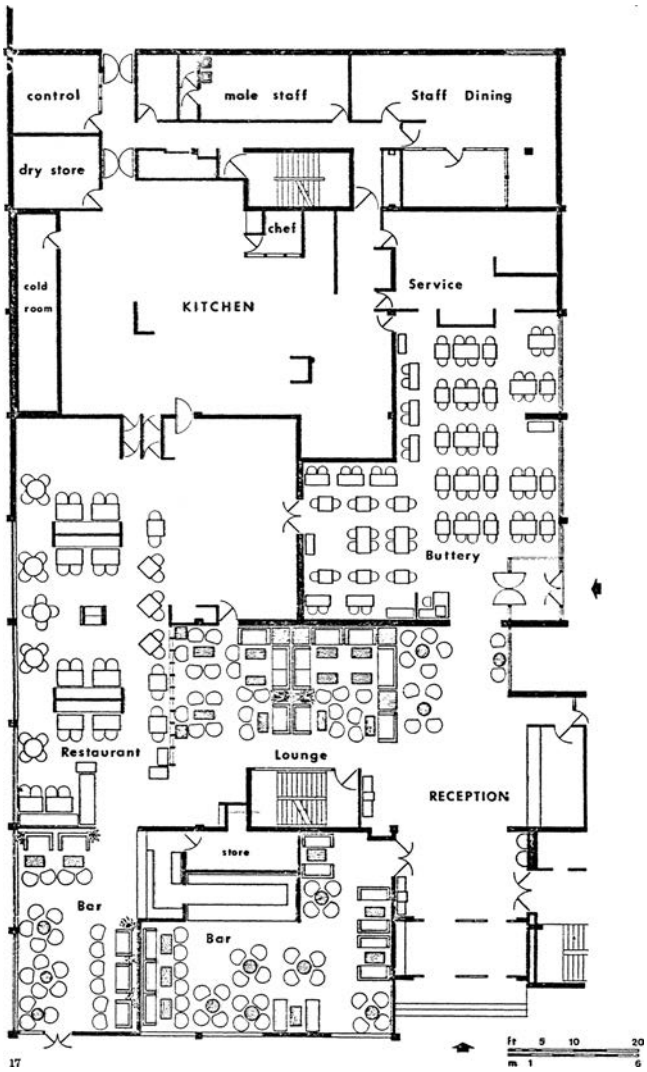
34.43 *Sizes of pub glassware:*
a *Wine and spirit glasses*
b *Beer and soft drink glasses*
c *Bottles*



34.44 *Smallest size of pool table with cue space (for short cues) now common*



34.45 *A band platform. Club entertainers use own equipment*



34.46 *Variety of food and beverage outlets in a hotel*

as discotheque music centres. A traditional band stand is illustrated (Figure 34.45).

9 HOTELS AND RESORTS

9.1 Hotels and cruise ships

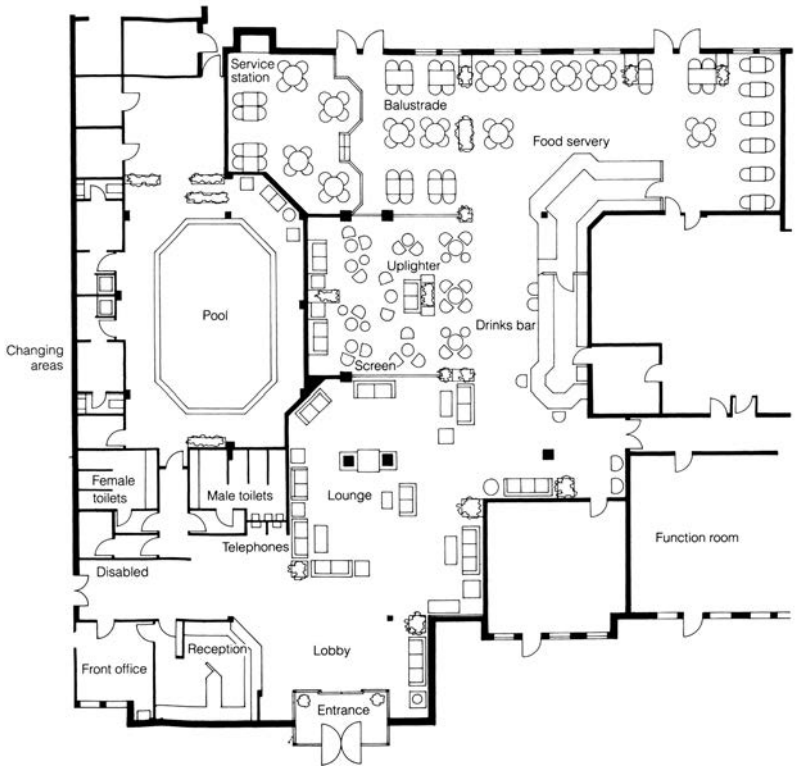
Hotels are graded according to the quality of accommodation, price and range of services offering to guests. The extent of restaurant provision will also depend on the location and number of rooms. Typical space allowances are shown. Food production arrangements are rationalised to enable the main kitchen to supply several outlets directly or via satellite kitchens (Figure 34.11). An example of food production in a large international hotel is shown in Figure 34.23.

A high grade city centre hotel with more than 200 rooms will usually provide at least two restaurants offering choice between fine dining and coffee shop style operation – this also serves the peak breakfast demand (Figure 34.46). Resident demand for midday meals is often limited and a speciality restaurant may be featured to attract outside market interest. A hotel of this standard will also provide room service of meals, banquets for group meetings and events and meals for staff. Separate lobby, lounge, bar and restaurants may be designed to allow spatial continuity (Figure 34.47).

Resort hotels of high grade also offer guests and visitors a choice of restaurants and bars, including poolside bars. Bar and dining areas are commonly grouped together to serve evening entertainment. In mid-grade establishments, restaurant and bar provision is

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



34.47 *Ladbroke Hotel. The restaurant (90 seats) is operated with a carvery buffet counter and table service of starters and sweets. The drinks bar allows dual purpose use of the lounge with areas separated by changes in floor level, balustrades and screens*

rationalised and budget accommodation may use external restaurants in the vicinity. Food production is generally centralised.

Cruise ships are broadly similar to high grade hotels and need to provide a variety of foodservice outlets and bars to accommodate the number of passengers and crew involved. These services are often an important part of cruise attraction and are linked to entertainment and other facilities. Menu planning is complex to take account of dietary requirements, choice, variety of outlets, supply provisions and hygiene standards. Extensive storage and preparation facilities are involved with added fresh foods at pre-arranged supply ports.

9.2 Resorts and attractions

Self-contained holiday centres and villages offer food service options, ranging from all-inclusive to self-catering facilities. In a large complex, a variety of themed restaurants, cafes, bars and other outlets is provided, often operated independently under license. Large visitor attractions usually need to provide cafes and restaurants as part of the facilities. These are invariably operated by catering contractors who supply the food partially or fully prepared to rationalise kitchen and staff requirements.

10 BIBLIOGRAPHY

Fred Lawson, *Restaurants, Clubs and Bars: Planning, Design and Investment*, 2nd Edn 1994, Architectural Press.

Fred Lawson, *Hotel Planning, Design and Refurbishment*, 1995, Architectural Press.

Walter A. Rutes, Richard H. Penner, Laurence Adams, *Hotel Design – Planning & Development*, 2001, Architectural Press

Bernard Davis & Sally Stone, *Food & Beverage Management*, 4th Edn, 2007 Butterworth Heinemann

Peter Coleman, *Shopping Environments: Evolution, Planning and Design*, 2006, Architectural Press

Fred Lawson, 'Restaurants and Catering Facilities', in Quentin Pickard (Ed), *The Architects Handbook*, 2002, Blackwell Science Ltd, pp. 322–334

Magazines

Hotels, Reed Business Information, Oak Brook, IL, USA

Catering Update, Reed Business Information, Sutton, UK

Restaurants and Institutions, Cahners Business Information, Des Plaines, IL, USA

Leisure Management, Leisure Media Co Ltd, Hitchin, UK

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

35 Retail shops and stores

Fred Lawson

CI/Sfb(1976): 34

Fred Lawson is a Visiting Professor at the Department of Service Industries, University of Bournemouth. He is also an international consultant and author of several books on planning and design

KEY POINTS:
- *Retail trading is affected by marketing, competition, polarisation, and store locations*
- *Market research of customers and focus groups is highly developed*
- *New concepts, innovations and efficiencies in operation are continuously being introduced*

Contents

1 Introduction
2 Terminology
3 Markets
4 Shops and stores
5 Small shops
6 Department stores
7 Variety stores
8 Supermarkets
9 Hypermarkets and superstores
10 Shopping centres
11 Retail parks
12 Regional centres
13 Bibliography

1 INTRODUCTION

1.1 General

Retail outlets consist of buildings or rooms where goods or services are sold to the public. They include shop and store premises and also concessionary space.

1.2 Scale and polarisation of business

A total of 33.7 per cent of consumers' overall expenditure in Great Britain in 2004 was spent in retail outlets. This proportion has progressively reduced from 37.5 per cent in 1995, showing the benefits of scale and sourcing made possible by polarisation of retail business into large groups serving particular segments of the consumer market. In 2004 the total turnover in predominantly food stores was over £112 billion and in non-food stores £128 billion.

Polarisation of retail business has also had a dramatic impact on shop numbers and the retail landscape. In 2006, 6452 multiple grocers with 10 or more stores commanded over 70 per cent of the total grocery turnover. This compares with 67 590 individual and other small grocery outlets that together achieved less than 30 per cent. A similar concentration of business has occurred in non-food retailing with some 90 000 stores belonging to multiples now dominating this sector. With corporate finance to pay increasing rents and building conversions to represent the brands, the character of High Street shops has lost much of the variety of individual tenancies.

1.3 Changes in space and location

Total shop floor space has grown with the penetration of chain stores into further market catchment areas as well as to extend individual store space for more product lines, customer choice and self-service checkouts. In 1992, following extensive development of shopping centres, retail warehouse parks and standalone superstores in the 1980s, total shop floor space had risen to 93 million m^2. By 2004 this total was estimated to be over 100 million m^2, much of the increase arising from large-scale regional shopping centres and brownfield redevelopments.

2 TERMINOLOGY

2.1 Shopping activities

Shopping activities vary with different needs and may be described as essential, convenience, comparison, purposive (specific), leisure or remote (mail order, teleshopping, internet retailers).

2.2 Selling methods

Personal service: individual service, usually over counters or desks by staff in attendance. (Examples: high-value goods, technical equipment, specialist boutiques and salons, delicatessen shops, financial and travel agency services.)

Self-selection: by customers who handle, compare and select goods prior to taking them to cash points for payment and wrapping. (Examples: department stores, variety stores.)

Self-service: of prepackaged groceries and durables collected in baskets or trolleys and taken to checkout points for cashing and packing. (Examples: supermarkets, superstores, discount stores.)

Assisted service: self-selection by customers combined with despatch of similar goods from stockroom to collection point or home delivery. (Examples: hypermarket, warehouse stores, furniture stores.)

2.3 Stock

Forward or displayed stock: held in sales area.

Support or reserve stock: in stockrooms ready for replenishing sales. The method of replacing displayed stock is a critical consideration in planning and organisation.

Amounts of stock in reserve are related to the stock-turn (average time held prior to sale), weekly turnover, delivery frequency and stock control. Electronic point of sale (EPOS) monitoring is used to predict sales patterns, reduce reserve stock and coordinate distribution and manufacture.

2.4 Areas

Gross leasable area (GLA): total enclosed floor area occupied by a retailer. This is the total rented space and includes stockrooms, staff facilities, staircases, preparation and support areas. It is usually measured to outside of external walls and centre line between premises.

Net sales area (NSA): internal floor space of a retail unit used for selling and displaying goods and services. It includes areas accessible to the public, e.g. counter space, checkout space and window and display space. Net areas are used to calculate the density of trading turnover (sales per m^2 or ft^2).

The ratio of sales to ancillary space ranges from about 45:55 in small shops and departmental stores to 60:40 in supermarkets.

2.5 Rents

Rents are based on gross floor area measured in ft² or m² (1 ft² = 0.0929 m²). Three main types of rental agreement are used:

Guaranteed rent: with minimum annual rent guaranteed by the tenant irrespective of sales.

Percentage rent: based on a stated percentage of the gross sales of the tenant.

Turnover lease: the rent being related to the actual gross turnover achieved by the tenant, based on the total trading receipts less stated allowable deductions.

Rents are normally subject to review every four or five years.

Leases usually include the right to assign after an initial period (five years) and may provide a landlord's option to buy back. Premiums may be charged when leases are sold for premises in good trading positions with favourable lease and rent review conditions.

2.6 Retail operations

Independent: Shops and stores operated by individual or sole trader with less than ten branches (usually one or two). May be affiliated to a collective marketing and purchasing association.

Multiple: Mainly joint stock companies, with ten or more branches operated as a chain of shops and stores including large space users. Goods may include own-branded products.

Cooperative societies: Development has polarised into large supermarkets/superstores and small convenience shops serving local communities. Goods may be sourced through the Cooperative Wholesale Society or competitive suppliers.

Concessions: Granted rights to use land or premises to carry on a business – which may involve selling or promotion. The agreement may be based on rent, fees or profit sharing. (Examples are department stores, concourses in shopping centres and catering operations.)

Franchises: Contractual relationships between two parties for the distribution of goods and services in which the franchisee sells a product designed, supplied and controlled by and with the support of the franchisor. (In the UK franchising has been mainly used in fast-food brands, launderettes, car maintenance, bridal wear and some electrical trading.)

3 MARKETS

3.1 General

A market is a public area, open or covered, provided with stalls, where traders may sell their wares on recognised market days subject to payment of a statutory charge. This franchise confers sole and exclusive market rights over a distance of 10.73 km.

Markets make up less than 1 per cent of total retail sales in the UK, but attract potential customers to the town area. The character of markets relies on variety, mix of traders, simplicity and liveliness.

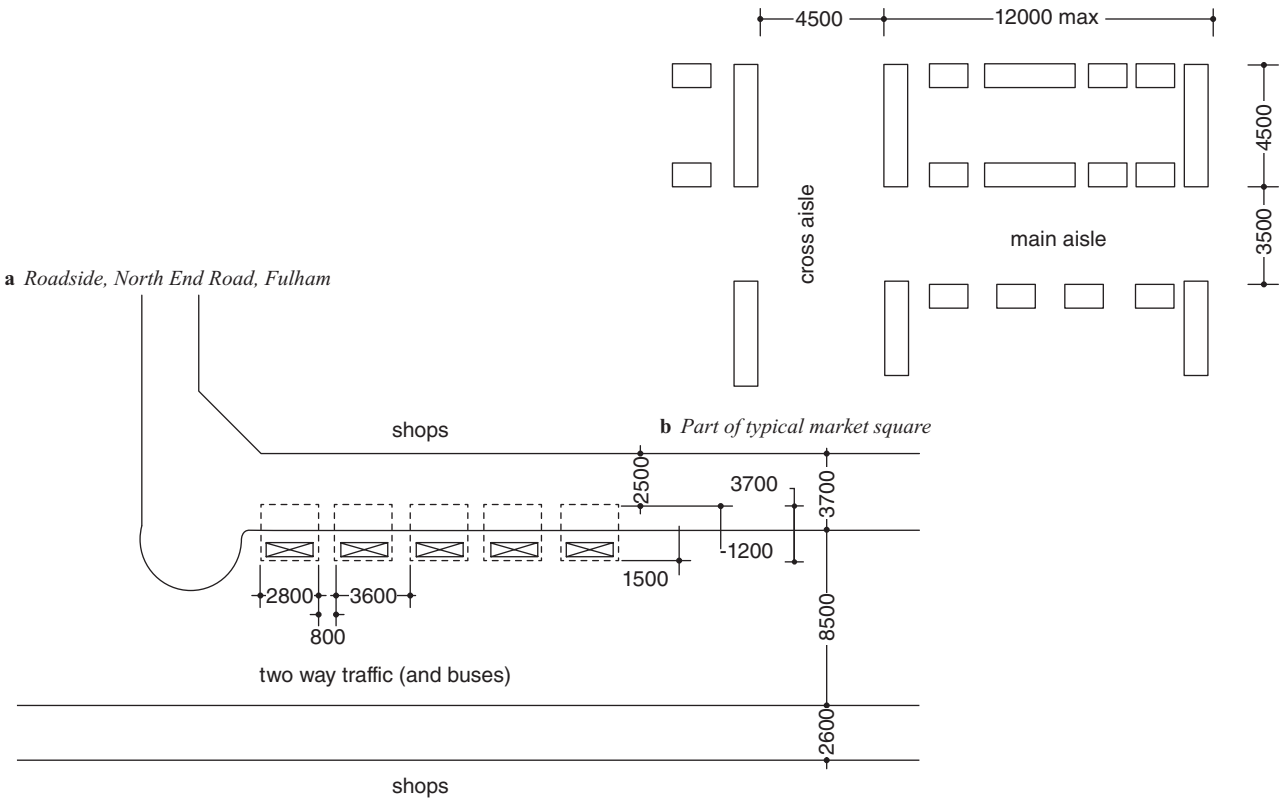
3.2 Open markets

Markets may be set up in streets, squares and open spaces, Figure 35.1. Stands comprise erected stalls and fitted-out vans and trailers set out in line along kerbs or back to back between aisles. Key considerations are:

- vehicle parking and loading (near stalls);
- traffic control;
- garbage storage and collection;
- washing facilities;
- protection of exposed food.

3.3 Covered markets

Permanent market stalls are sited in town centres and fringe areas (associated with auction rooms). New projects include craft markets (permanent or temporary) combined with workshops or forming part of shopping centres. Redevelopment of existing market halls often involves linkages with shopping centres and car parks.



35.1 *Markets*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

3.4 Planning

Halls are usually designed to give a large-span open space having natural roof lighting, good ventilation and service connections. One-floor trading is preferred. Any upper floor is usually limited to a perimeter balcony served by escalators, stairs, goods and disabled lifts. Perimeter stalls and other grouped layouts have service corridors. Fish, meat and food stalls are sited in zoned areas with more sophisticated ventilation, drainage and services.

Key considerations: Access and linkage to car parks, shopping areas, goods delivery and parking bays. Mix of traders. Risk of fire (incombustible materials, fire-resistant construction smoke evacuation) and means of escape.

4 SHOPS AND STORES

4.1 Locations

Main locations for retail development in the UK are:

- *High street*: inner cities and towns, including backland development of shopping centres, shopping malls and street frontages.
- *Urban fringes*: industrial wasteland, redevelopment areas (superstores, retail parks, discount stores).
- *Out-of-town*: near motorway/main road junctions, easy access to large population catchment (retail complexes, regional centres, discount warehouses).
- *Neighbourhood*: association with estate development, filling stations (convenience shops), nurseries (garden centres), tourist attractions (souvenir shops, cafes).

Out-of-town retail developments generally allow much lower rents, easier access and parking, economical purpose-built 'shed' designs with flexible large-span spaces. Retail parks and complexes also generate mutual benefit from association of stores and services. Planning guidelines in the UK have stiffened resistance to development on greenfield sites with policies directed towards town-centre shopping and sensitive integration of new frontages.

Key factors affecting location:

- *Trading Zone*: Population, demographics, socio-economic profiles.
- *Accessibility*: Journey times, footfalls, transport systems, parking.
- *Attractions*: Range of goods and services, associated benefits.
- *Deterrents*: Travel costs, development, lease conditions and cost.
- *Economic*: Market maturity, trade saturation, economic trends.

For store planning and location these factors are often expressed in comprehensive shopping models. Customer parking and goods supply arrangements requirements also require detailed analysis.

4.2 Range of shops and stores

Retail outlets can be broadly divided into small shops (less than 280 m^2 sales area) and large space users. The latter include supermarkets and stores which may specialise in food or non-food lines or sell a wide variety of products (composite shops, variety shops, departmental stores).

Distinctions between stores tend to become blurred with:

- *Retail polarisation*: trends towards both larger (one-stop shopping) and smaller retailers (speciality and convenience shops, financial, etc. services, franchised units, workshop-craft outlets).
- *Competition*: innovation, market penetration and development of new merchandise and selling methods, creaming of popular lines.
- *Acquisition*: merger of competing outlets, focusing of business and market positioning of company products, rationalisation of lines of goods and resources.
- *Image and service improvement*: extension of added value and high-profit value lines. Improved customer services and design environment.

4.3 Planning guidelines

Table I gives guidelines on planning shop space.

Table I Shop space

Structural models	Width (m)	Notes
Small shops	5.3 to 6.0	Mostly 5.4 m
Large-space users	7.3 to 9.2	Depending on beam depth. Single-storey buildings – larger spans
Clear ceiling	*Height(m)*	*To underside of beams*
Small shops	3.3 to 3.8	Sales area
	3.2 to 3.6	Non-sales area
Large-space users	3.6 minimum	With floor: floor spacing 4 to 5 m
Typical floor loading	*kN/m^2*	
Shop sales area	5	
Shop storage	10	Increase in loading docks
Car parking	*Car spaces per 100 m^2 gross retail area*	
Supermarkets, Superstores	10–12	
Shopping centres	4–5	
Goods and service docks	*m*	*Notes*
Typical provision for large-space user		
Two 15 m articulated lorries: width	10.7	Allowing 1.5 m each side
Minimum clearance height	4.7	Approach road – 5.00 m
Design load for service yard	20 kN/m^2	
(See also Chapter 3.)		
Deliveries may be controlled or random. Provision must be made for manoeuvring space and waiting bays, for separate refuse storage with compaction equipment, refrigerated garbage and collection skips.		
Staff facilities (general guide only)		
Staff numbers: net sales areas, 1:50 m^2 to 1:80 m^2		
Additions to the net sales area	*Net areas*	*Gross areas*
Staff facilities	10–15 per cent	25–30 per cent
Offices	5–8 per cent	
Staff facilities include: restaurant with kitchen and servery, coffee and recreation rooms, changing areas, toilets, personnel and training and reception/control area.		

4.4 Shop fittings

Shop fittings may be individual bespoke designs, fabricated or modular units. While the range and style vary widely, fittings must satisfy functional needs (including ergonomics) and be compatible with the design, versatile, durable, stable and safe in use.

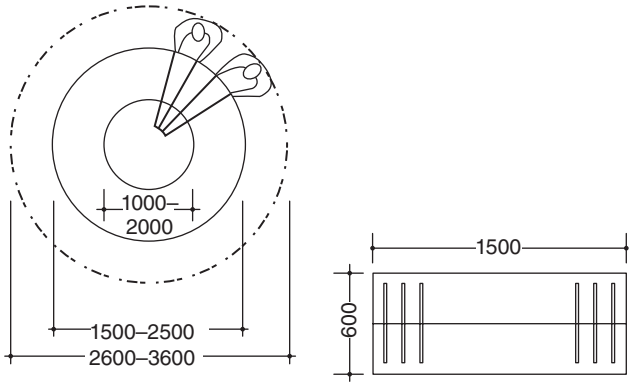
Display units can be broadly divided into wall-anchored fittings and free-standing units, the latter being designed for perimeter or central locations.

Figures 35.2 and 35.3 are examples of mobile display units, while Figures 35.4 to 35.6 show units suitable for supermarkets.

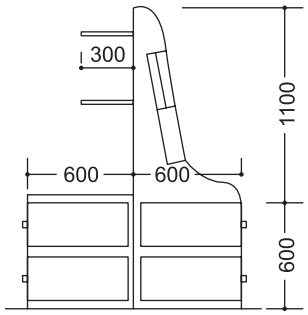
Examples include:

- wall systems (slotted panels, frames, suspensions)
- fitted furniture (cupboards, wardrobes, trays)
- free-standing racks and garment rails
- gondolas and island displays
- cases (counters, showcases, wall cases)
- cabinets (front or top access)
- shelving systems (modular, adjustable)
- forms, mannequins, displays (counter or free-standing)
- bins, tables, risers
- counters (cash and wrap, checkout, service).

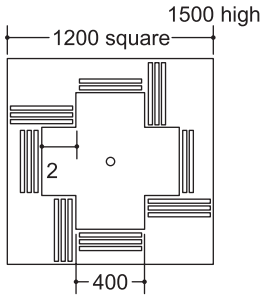
Construction materials include hardwoods, laminates (lipped) acrylics, toughened glass, polycarbonate, UPVC, chrome-plated and stainless steel, anodised aluminium.



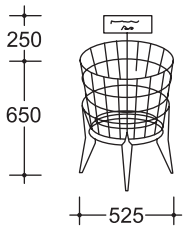
35.2 *Storage and display racks for clothing shops*



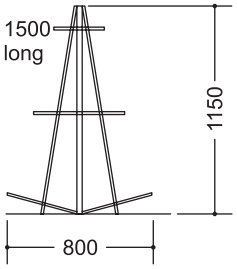
a *Greetings cards*



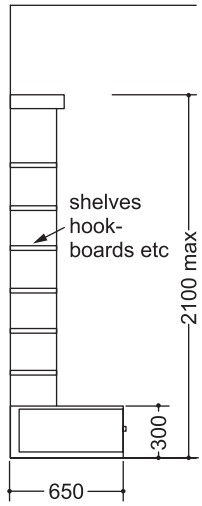
b *Paperback books*



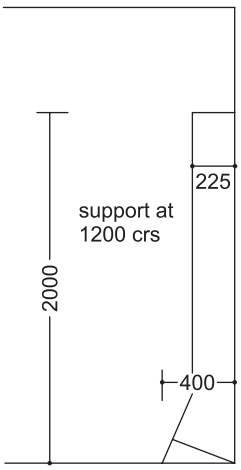
c *Bins, used everywhere*



d *Island display of books*

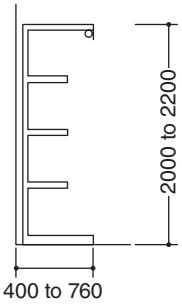


e *Wall units for stationery and books*

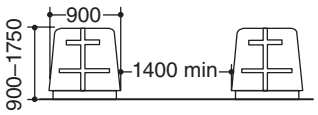


f *Wall units for books*

35.3 *Storage and display fittings for stationery and bookshops*



35.4 *Section through supermarket wall shelving*



35.5 *Section through supermarket shelving*

4.5 Lighting

Table II gives guidance for lighting.

Table II Lighting levels

Lighting	Standard service illuminances (lux)	Notes
Conventional shops	500	Concentrated over displays
Supermarkets	500	Usually increased to 700–800 lux with three levels of control: 100 per cent – sales, 50 per cent – stacking, 30 per cent – security
Covered shopping centres	100–200	Malls, arcades, precincts
Lifts, main circulation	150	
Staffrooms	150	
External covered ways	30	

Luminaires include low-voltage units (displays), colour-balanced fluorescent (sales areas), metal halide (high intensities).

4.6 Temperature

Table III gives recommended temperatures and ventilation for different sizes and types of shop.

Table IV gives temperatures for various food cabinets.

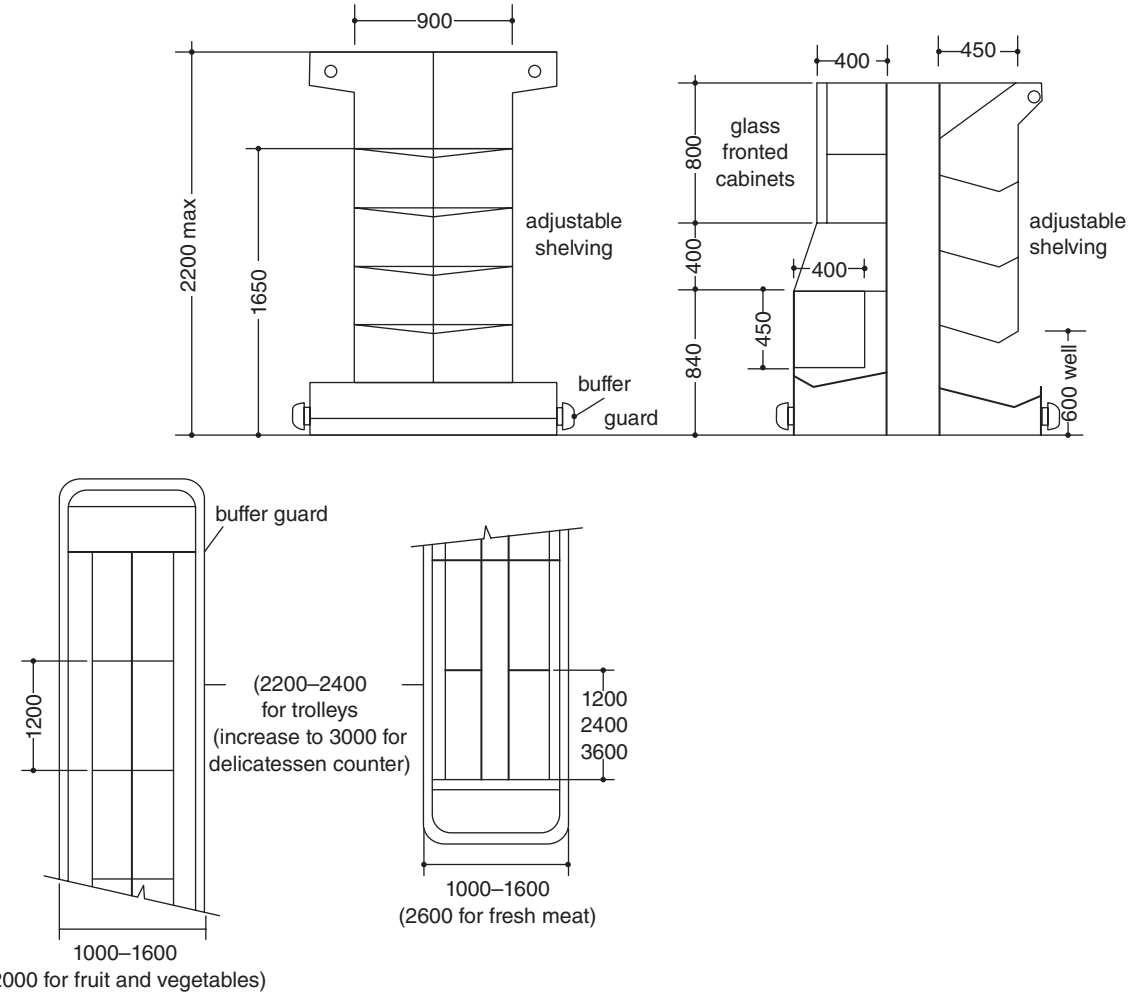
Table III Temperatures: design conditions

	Temperature (°C)	Air infiltration (Changes/hour)	Ventilation allowance (W/m³°C)
Small shops	18	1	0.33
Large shops	18	½	0.17
Department stores	18	¼	0.08
Fitting rooms	21	1½	0.50
Store rooms	15	½	0.17

Table IV Food cabinets

Display of food	Cabinets (°C)
Fresh products (chilled)	+8
Dairy products, cooked meats	+3
Fresh meats, poultry, fish	0
Frozen foods (subject to EU regulations)	–18

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



35.6 *Plan and section through supermarket display cabinets*

4.7 Air conditioning

The recommended outdoor supply rate for air conditioning spaces is 8 per person with a minimum of 5 per person, 3 per m^2 of floor area. In large stores, occupancies are on average 1 person per 5–6 m^2 and 1 person per 1.8 m^2 for peak areas.

Air conditioning is usually designed for 18–21°C at 50 per cent ± 5 per cent RH (below-risk of static) pressurised to + 5 per cent actual air volumes.

4.8 Energy management

Most multiple and large stores use energy management systems with remote station monitoring. Waste heat is recovered from refrigeration for hot water supplies and cool air recycled from refrigerated display areas. Refrigerants are changing to hcfcs (non-ozone reactive) with leakage-detection systems.

5 SMALL SHOPS

5.1 General

These are shops having a sales area less than 280 m^2 and not more than three stores, one of which may be a basement. Shops employing fewer than 20 people or 10 above the ground floor do not normally require a fire certificate.

5.2 Location

Convenience shops need to be near populated areas or stopping places (filling stations, airports, railway stations).

Speciality shops are best grouped with other shops and large space users to increase market exposure or in speciality areas associated with tourist attractions, etc.

Financial, etc. services: shop units usually combined with offices and ancillary rooms above.

5.3 Planning

Typical small shop plans are shown in Table V.

5.4 Servicing arrangements

Stock replenishment and waste removal is usually through a rear service road but in a shopping complex this may be accessed through a service corridor and goods lift. Some pedestrianised precincts allow vehicle access to front of shops outside restricted hours.

5.5 Design

The design of the shop frontage, graphics and window display is a major consideration. Multiple and franchised outlets usually reflect a uniform brand image. In environmentally sensitive areas, the scale and character of existing facades may need to be retained.

Interior layouts, fittings and design features depend on the nature and volume of goods sold.

Table V Small shop plans

	Typical	Minimum
Width of frontage	5.4 to 6.0 m	4.0 m
Depth	18.0 to 36.0 m	12.0 m
Height (depending on services)		3.0 m
Sales:ancillary areas	50:50	45:55
Staff facilities	1 wc plus 1 washbasin for each sex (minimum) Changing area with individual lockers Restroom with small food-preparation area	
Office	Files, safe, desk, terminals	

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Rental charges are mainly determined by location and width of frontage. The width:overall depth ratio is typically 1:4 or 5, the lower value rear areas being used for goods storage, processing and staff facilities.

6 DEPARTMENT STORES

6.1 General

Department stores are large complex shops, invariably extending over several floor levels, selling a wide variety of goods, particularly clothes. Sales areas are grouped into departments corresponding to different categories of shops but are flexible in size and position. Departments may be operated directly by the store or let to other traders and franchisees.

Main high street stores usually have more than 20 000 m^2 sales areas but 'Junior' department stores in new shopping centres are less than 10 000 m^2 over two floors. Sales:gross area ratios are relatively low, 45:55.

6.2 Planning

A frontage to more than one street or mall is preferred for extended window displays, customer entrances and emergency exits. Separate staff entrances and goods delivery and despatch areas (with customer collection bay) are essential.

Internal areas must be planned for maximum clear space to allow for changes in seasonal sales and tenancy arrangements. Exceptions are food areas (food halls, food-preparation kitchens) which require permanently fitted equipment and special services.

6.3 Fire requirements

Compartmentation: most regulations permit up to 2000 m^2 and 7000 m^3 or twice this size (4000 m^2) with automatic sprinkler system.

Smoke evacuation: reservoir space with exhaust ventilation and controlled airflows.

Construction: fire-resisting structures and limitations on surface flame spread of lining materials.

Isolation: sprinklers, water curtains and physical separation of escalators, lift shafts and voids.

Means of escape: travel distances to protected staircases and adequate exits to street.

6.4 Locations

Locations for departments are rationalised by floor levels of related goods but influenced by turnover values and unit selling times. The ground floor is used for quick sales or small items to attract customer interest.

Restaurants, toilets and customer services are usually accessed through selling areas.

Subsidiary accommodation is needed to service departments on each floor but main stock rooms, staff facilities and administration are located in lower-value areas (rear, basement or upper floor).

Escalators and lifts are usually centrally positioned to create a focus and draw customers through departments.

6.5 Trends

Department stores have relatively high staffing and operating costs. Life-cycle renovation may be used to remodel, divide and/or extend stores as shopping centres and shops within shops. Developments include Junior Departmental stores, Anchor stores in regional centres and airports. Flagship store designs stress customer focused ambience, distinctive lines, quality branded merchandise and range of customer services.

7 VARIETY STORES

7.1 General

These are large-space users selling a wide range of non-food goods, mainly by self-selection in an open sales area. In some stores part of the area is used for self-service food sales. Includes independent and multiple chain stores (Marks & Spencer, John Lewis etc.).

7.2 Size and location

Sales areas range from 500 to 15 000 m^2, most major stores being between 10 000 and 15 000 m^2 with sales:ancillary area ratios of 50:50.

Locations

- Prime high streets: serving sizeable catchment populations.
- Shopping centres: multi-level links to upper and lower floors.
- Regional shopping complexes and retail parks (space allowing introduction of wider ranges of goods).

Major stores require catchments of 80 000 to 100 000.

7.3 Planning

A rectangular plan with one-level trading is preferred with frontages on the high street and shopping mall. Sales floors in large stores are on two levels (sometimes three) with food areas having access to parking or collection points. Escalators, stairs and lifts for the disabled and goods distribution are kept to the perimeter to allow uninterrupted space for display and circulation planning.

7.4 Layout

Main aisles with distinctive flooring lead from entrances to assemblies of display fittings and cash and wrap points positioned for visibility and convenient access.

Displays include both perimeter and island fittings with related goods grouped together for easy location and comparison. Stores selling clothes and fashion goods must provide changing rooms and multiple mirror points. The self-service areas for food goods are planned on supermarket lines.

7.5 Facilities

Some stores provide a cafe or restaurant for customer use usually located on the upper floor to promote other impulse buying. Toilets and other customer services are in this vicinity.

Ancillary areas for staff and reserve stock are at the rear or on a higher floor, with separate staff entrance, reception and control leading to changing and associated facilities.

8 SUPERMARKETS

8.1 General

Supermarkets sell food and regular domestic necessities on self-service lines. The sales areas of large-space users range from 1000 to 2500 m^2 although many small grocers also use self-service.

8.2 Planning

Sales are invariably on one floor, planned to allow trolley circulation from car park through the store. Where required, upper floors are limited to non-food goods. A simple rectangular plan is preferred with 30 to 60 m frontage. (Minimum frontage (18 m) may require double-banked checkouts.)

The position and layout of the checkout points govern entrance, exit and circulation plans. Sales areas have large unobstructed spaces with structural grids of 9.0 m or more (to suit stand spacing) and 3.66 m clear ceiling heights. Supermarkets and store chains have their own evolving standards for aisle widths, till layouts, loading docks, etc.

8.3 Layout

A standard arrangement of parallel shelf racks and cabinets on each side of circulation aisles is invariably adopted. The main aisles are 2.2 to 2.5 m wide increasing to 2.8 to 3.2 m in front of delicatessen counters and fresh/frozen meat cabinets. 3.0m across aisles are

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

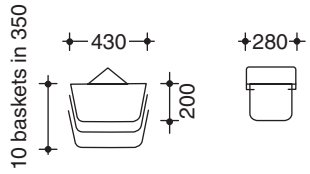
provided at the end of turns and a clear area 2.2 to 3.0m deep on each side of the checkout line.

Displays are grouped into food, non-food and off-licence sections. Delicatessen, bakery and perishables prepared on the premises need to be adjacent to the preparation areas, with easy access to stores (refrigerated).

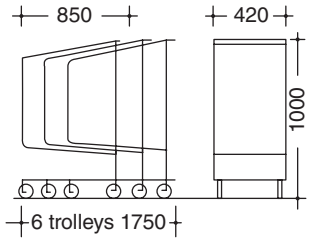
As a rule, refrigerated display cabinets are grouped together to facilitate service connections and airflow recovery.

Demand goods (vegetables, fruit) are usually placed near the entrance to initiate buying and promotional items displayed in bins and in racks at the end of rows and checkout stations.

Space has to be allocated for customers to collect and restore baskets and trolleys, Figures 35.7 and 35.8. Where virtually all customers arrive by car, trolley parks are normally situated within the car parking area, often in lightly covered kiosks; and few (if any) baskets are provided. In urban areas, substantial areas within the store curtilage have to be provided, and many customers will use baskets.



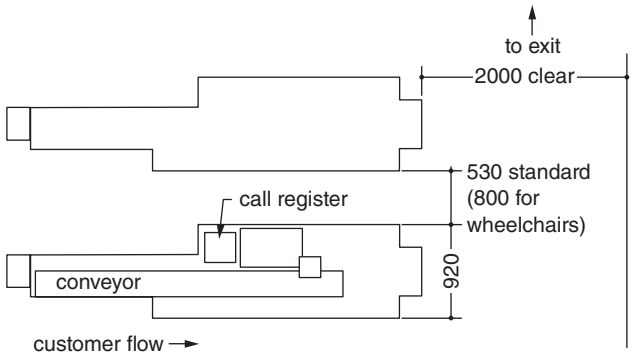
35.7 *Supermarket baskets*



35.8 *Supermarket trolleys*

In self-service shops, supermarkets and hypermarkets the customer pays for his or her purchases at a checkout. These vary greatly in design, depending on the type and quantities of merchandise, and the policies of the company concerned. Some contain automatic price-checking equipment and semi-automatic packing arrangements. Figure 35.9 shows a fairly standard basic design.

Separate shop units (newsagents, florist, chemist, cafe) may be sited independently of the checkout and direct access is required to public toilets, public telephones and management offices.



35.9 *Typical check-out*

8.4 Trends

The intensity of sales/m² is a critical consideration with trends towards increase of high added value (own-preparation bakery, butchery) and profit margins (delicatessen, wines, plant sales, made-up goods).

Technical equipment includes barcode scanning, EPOS monitoring and stock control, and the introduction of liquid display shelf edge/labelling, robot packing and self-checkout facilities.

With opposition to out-of-town location, some multiples are developing convenience stores in town centres selling a limited range of goods.

9 HYPERMARKETS AND SUPERSTORES

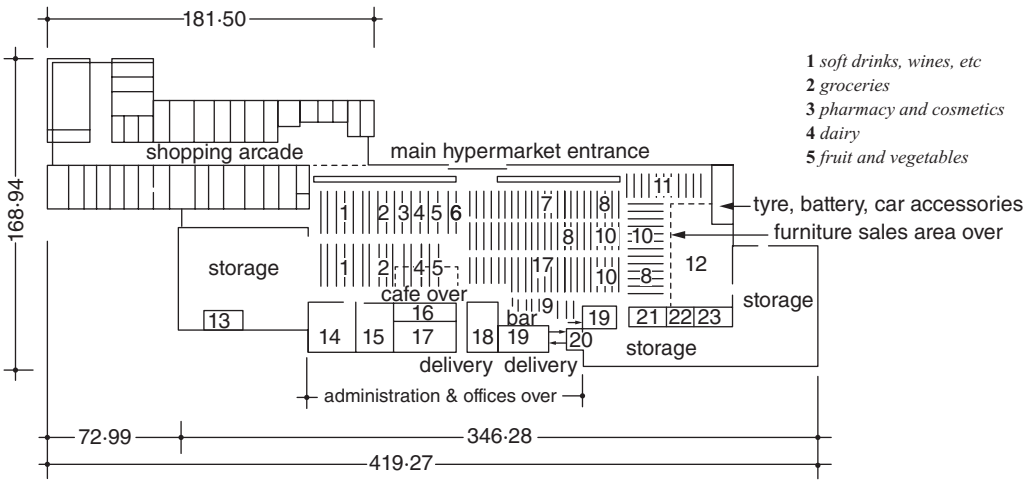
9.1 Hypermarkets

These are very large stores on supermarket lines but with at least 2500 m² sales floor such as Tesco Extra.

Compared with supermarkets the range of non-food lines is extended up to 50 per cent of the area. Hypermarkets tend to be built on derelict industrial land and urban fringes within large catchments, Figure 35.10.

Superstores are similar but tend to be larger with 5000–10000 m² of selling space. Located out of town, they occupy large sites, with extensive parking, a petrol-filling station and an associated square or arcade of small shops, Figure 35.11. The overall development often combines out-of-town shopping with community facilities such as a village hall, public house, sports ground or/and leisure centre.

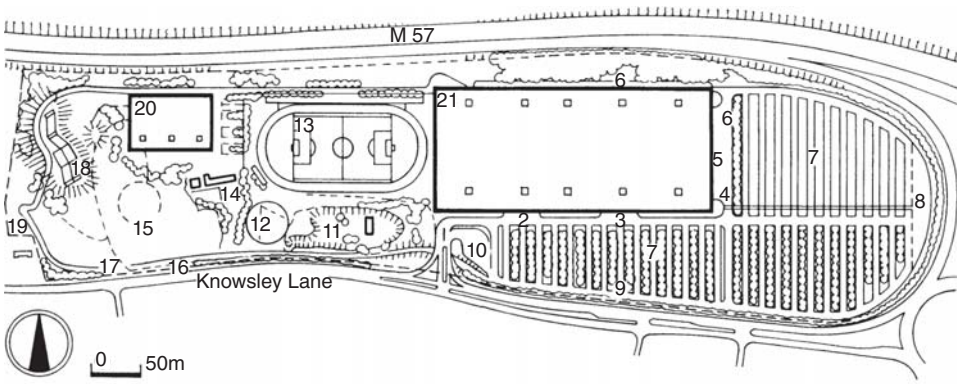
Discount stores and warehouse clubs concentrate on lower costs by limiting the range of goods (e.g. 650 compared to a supermarket's 3500 brand lines) and using simpler warehouse-style buildings and fittings.



1 *soft drinks, wines, etc*
2 *groceries*
3 *pharmacy and cosmetics*
4 *dairy*
5 *fruit and vegetables*
6 *children's clothing*
7 *clothing*
8 *household goods*
9 *fancy goods*
10 *shoes*
11 *electrical goods*
12 *furniture*
13 *fire-fighting and sprinkler installation*
14 *electricity sub-station*
15 *butchery preparation*
16 *cooked meats counter*
17 *fruit and vegetable preparation*
18 *baker's and pastry shop*
19 *changing rooms*
20 *lavatories*
21 *boutique*
22 *after sales service*
23 *furniture repair workshop*

35.10 *General layout of a major hypermarket*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



1 *site entrance*
2 *bus*
3 *taxi*
4 *service road*
5 *service bay*
6 *staff car park*
7 *car parking*
8 *coach parking*
9 *perimeter exit road*
10 *petrol service station*
11 *adventure playground*
12 *open play space*
13 *sports pitches and athletic track*
14 *horticultural centre*
15 *riding school field*
16 *bridle path*
17 *cycle training and racing track*
18 *dry ski and toboggan slopes*
19 *site boundary*
20 *riding school*
21 *pavilion containing superstore, leisure pool, sports hall, restaurants, library, cinema, exhibition gallery, etc.*

35.11 *Superstore at Knowsley, Lancashire: site plan Architects: Foster Associates*

9.2 Planning

Large stores are basically constructed as large rectangular boxes having large-span clearances to allow mainly one-level trading. If required, upper storeys are confined to part of the building and used for non-food sales, and ancillary services. The sales:ancillary ratio is high 60:40, with maximum goods on display and highly mechanised stock replenishment.

Compared with supermarkets, the stores use larger trolleys, wider and level circulation routes and easier transfer to car park areas (some with prepacking and mechanised conveyors).

10 SHOPPING CENTRES

10.1 Types

These are planned as a shopping complex under one central management which has a high degree of overall control, leasing units to individual retailers.

Shopping centres may be:

- *Open, in terraces*, squares, piazzas or village-style groupings.
- *Partially covered*, with canopies over frontages (3.6 m high for clearance) or setbacks creating arcades.
- *Fully covered*, single-level or multi-level shopping malls, converted warehouses, etc.

10.2 Locations

New centres:

- in new towns and expanding residential areas;
- out-of-town regional shopping centres.

Integrated centre:

- in existing high street areas;
- open up backland for commercial use;
- provide linkages with other developments, carparks, etc.;
- extend pedestrianised areas.

10.3 Planning

Centres should, where practicable, follow existing street patterns and be sensitively integrated into the existing street architecture.

Commercial and operational considerations

- Number, size and locations of large space users and other attractions (magnets) which will increase pedestrian flows.
- Distribution, number and size of small shop units, numbers of shopping levels.
- Servicing needs and access for goods vehicles.
- Entrances and links with parking, public transport and other shopping areas.
- Focuses and features to provide an identity and sense of place.
- Environmental control in the mall and individual shops.
- Fire regulations, safety and security requirements.

10.4 Plan forms

Shopping units are mainly one or two levels. Upper levels are usually required to join multi-storey variety and department stores and form galleries around a central square or atrium. Gross leasable areas vary, many infilling centres fall within 25 000 and 50 000 m^2 GLA providing 40 to 100 units. New regional centres may provide up to 100 000 m^2 GLA with 40 per cent allocated to large space users (magnets).

Magnets are sited near the ends of malls and branches to attract flows of shoppers past individual shops and have an effective range of 90 to 120 m. It is not practical to extend a mall more than 350 m and large developments call for more than one level with concentrated plan forms. L (Figure 35.12), T (Figure 35.13), C and Square plans are common but out-of-town centres may use cruciform (Figure 35.14), pinwheel (Figure 35.15) and figure-of-eight (Figure 35.16) layouts extending out from a central concourse. A common variant in new UK centres is the loop or racetrack such as at the Westfield, London.

10.5 Details

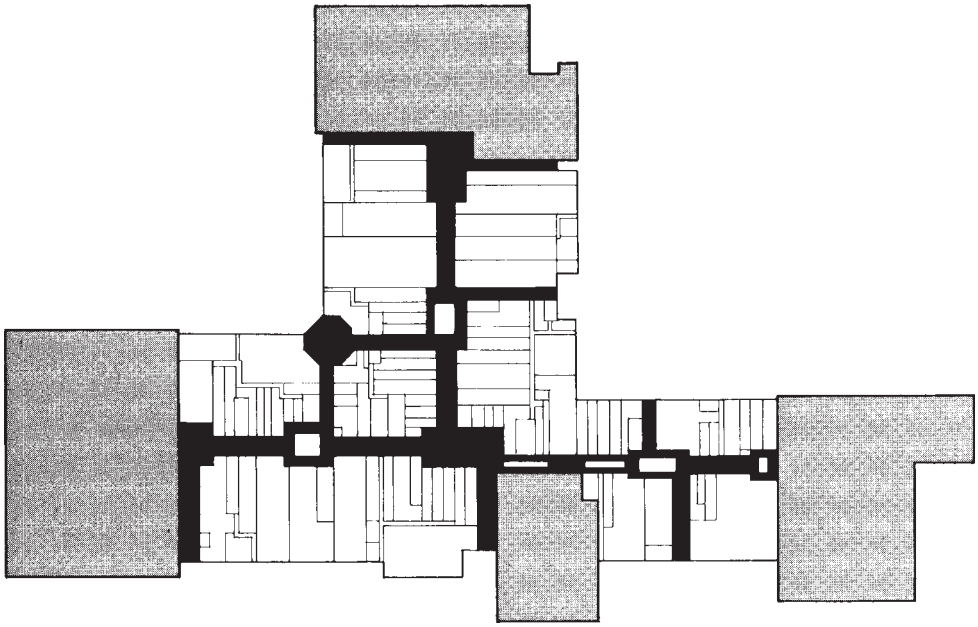
In the UK mall widths have progressively increased from 5.4 m to in excess of 8 m. The average French centre uses a 16 m mall while North American malls vary from 12 to 27 m. Galleries around central courts are often 4 m wide. The preferred frontage for small shops is 5.4 m to 7.3 m with a depth of 13 m to 39 m but smaller units (1.8 × 3.6m) are often required for service outlets and specialised trades. The centres of wide malls are often populated by retail merchandising units (RMUs) typically up to 2 m wide. 2500 mm is the minimum shop front height. The optimum floor to floor level of a new build is generally 6 m. Airconditioning arangements are commonly provided by a vertically mounted grill running above the shop fronts.

Glazed frontages are necessary when the mall remains open to the public at night but otherwise Continental (fully or partly open) frontages are more convenient with latticework shutters or fire barriers (if required) to secure the shop at night. The centres of wide malls are often populated by retail merchandising units

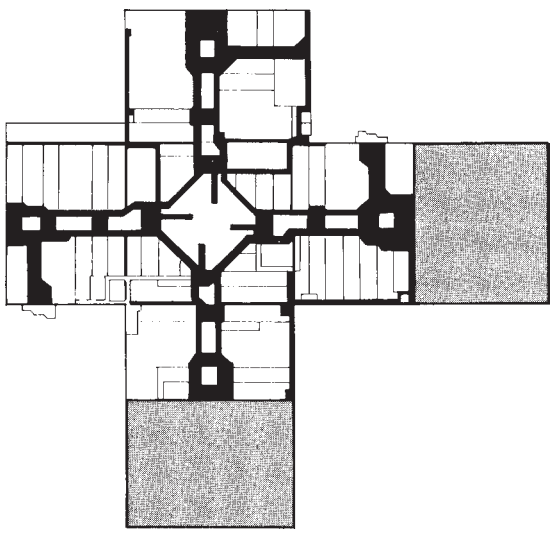
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



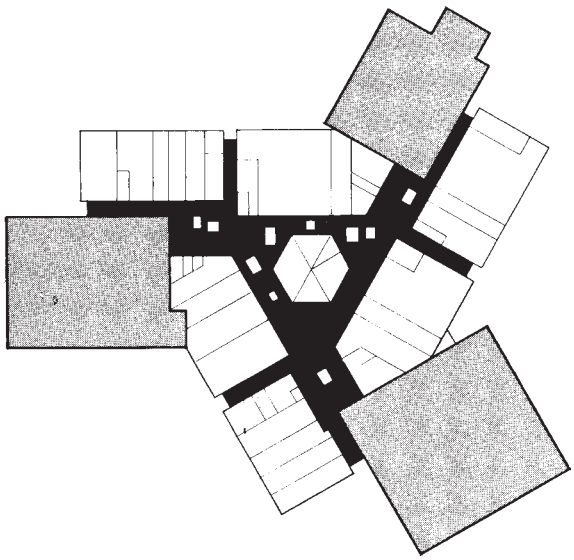
35.12 *L-shaped plan: Arndale Centre, Luton*



35.13 *T-shaped plan: Willowbrook Mall, New Jersey*

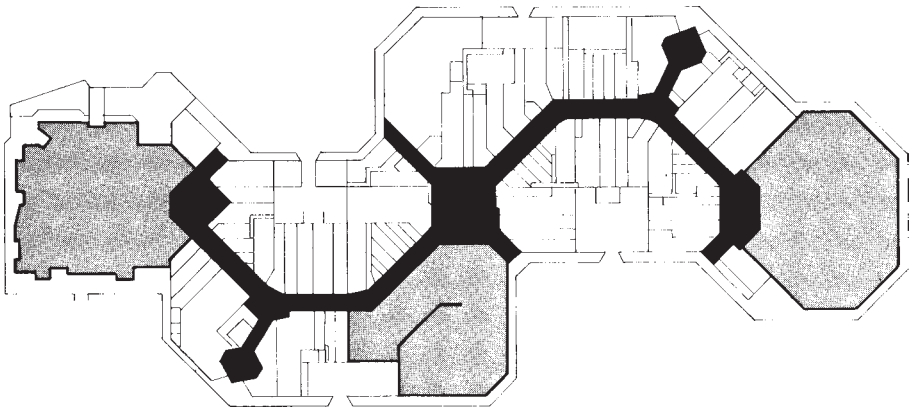


35.14 *Cruciform plan: La Puente, California*

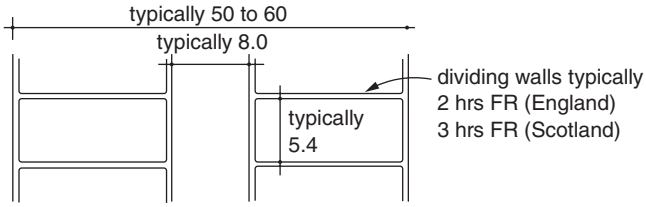


35.15 *Pinwheel plan: Randhurst, Illinois*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



35.16 *Figure-of-eight plan: Sherway gardens, Toronto*



35.17 *Plan of a mall showing fire separation between shop units*

(RMUs) typically up to 2 m wide (2500 mm is minimum shopfront height).

10.6 Food courts and focuses

Large atria and glazed courtyards provide activity spaces which are often landscaped and used as revenue-generating open restaurants or food courts. Features such as water fountains, kiosks, planted containers and children's play centres also create focuses for interest and direction.

10.7 Fire precautions

The design of shopping centres does not conform with conventional compartmentation arrangements and specific requirements will be stipulated by each fire authority.

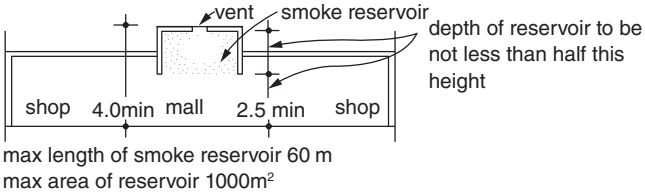
Fire control

Fire separation walls are required between shops in different tenancies, Figure 35.17. Malls must be of non-combustible construction, with incidental combustible material controlled, and have an automatic sprinkler system installed.

Specific requirements apply to adjoining or facing frontages of large space users (more than 2000 m^2).

Smoke control

Smoke reservoirs, Figure 35.18, are created by downstand beams on fascias at shop frontages and intervals along the mall. Smoke detectors activate exhaust fans in the reservoirs and lower fresh air supply fans to ensure clear escape routes. Further smoke ventilation and smoke control facilities are shown in Figures 35.19 to 35.20.



35.18 *Section showing smoke reservoir*

Escape routes

Maximum occupancy levels are estimated on the basis of:

- Shops, showrooms, supplementary areas – 7.0 m^2/person
- Supermarkets, department sales floors – 2.0 m^2/person

No more than 50 per cent of occupants should be assumed to escape through the rear of a shop, the rest using the mall. Escape routes from the mall must be provided at intervals with exits to open streets directly or via separated structures.

Controls

Automatic fire alarm and indication systems must be installed.

Access

Requirements of the fire authority for appliance access into the mall must be adopted together with positions for hydrants, hoses and extinguishers.

10.8 Circulations

Vertical circulation between storeys requires escalators, featured lifts and stairs designed to stimulate interest. These are usually located in a spacious central concourse or atrium, at junctions or corners and within the large space users.

Servicing shops

Vehicular access is required to loading docks and waiting bays directly accessible to each of the larger stores, with service roads, goods lifts and tunnels extending to the rear of shops. Service entry is usually at basement and street level but may be at an upper level on sloping sites.

10.9 Engineering services

The landlord is normally responsible for installing mains and providing the communal services of the mall including comfort cooling and heating or air-conditioning, lighting, cleaning, fire control and security systems. As a rule, individual tenants install their own services and equipment subject to agreement. Food-preparation areas, public toilets and plant areas require the installation of specific ventilation, drainage and electrical services.

Sections through a typical centre showing the complexity of structure and servicing are illustrated in Figures 35.19 to 35.21.

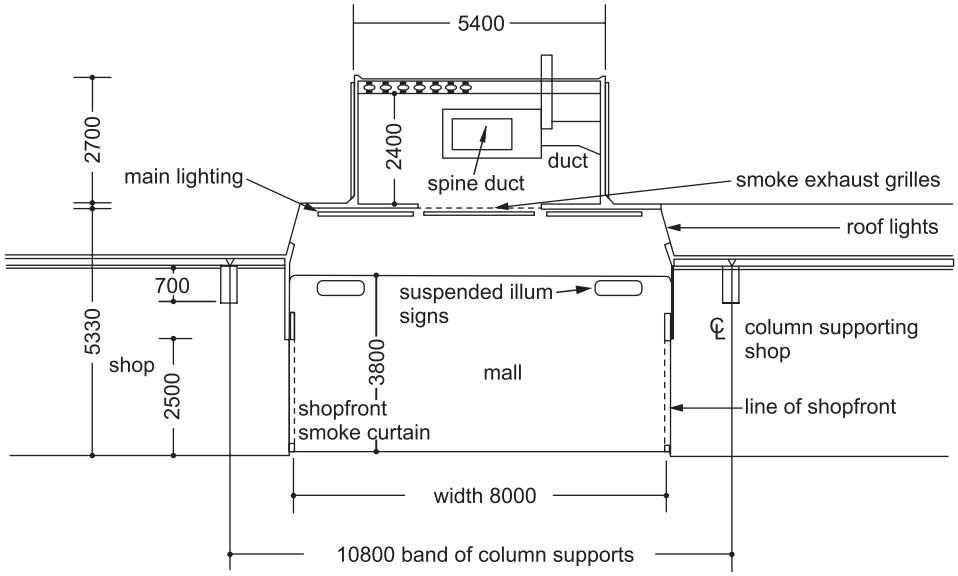
10.10 Other facilities

Public toilets including facilities for the disabled are installed and maintained by the landlord. Access to a public car park is often a primary consideration in letting units.

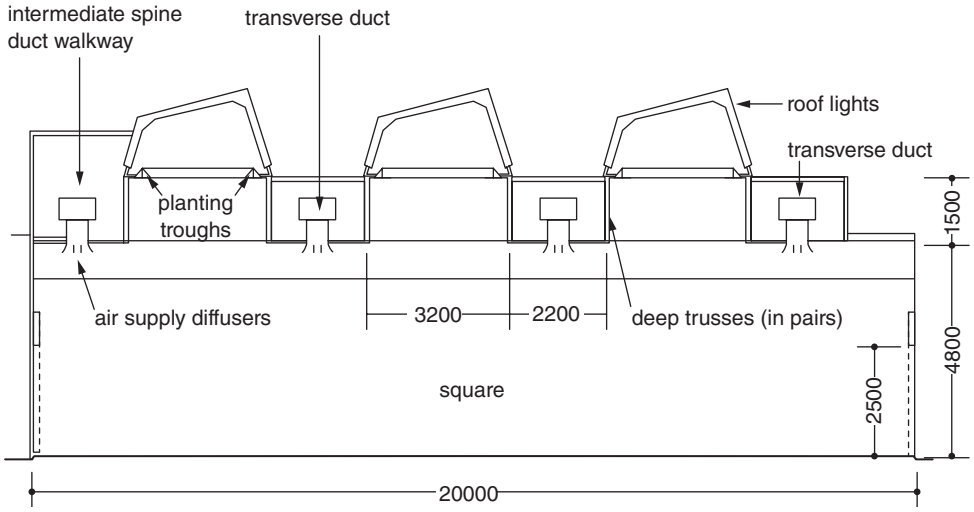
10.11 Town-centre shopping centres

Some examples of town-centre shopping centres are shown in Figures 35.22 and 35.23.

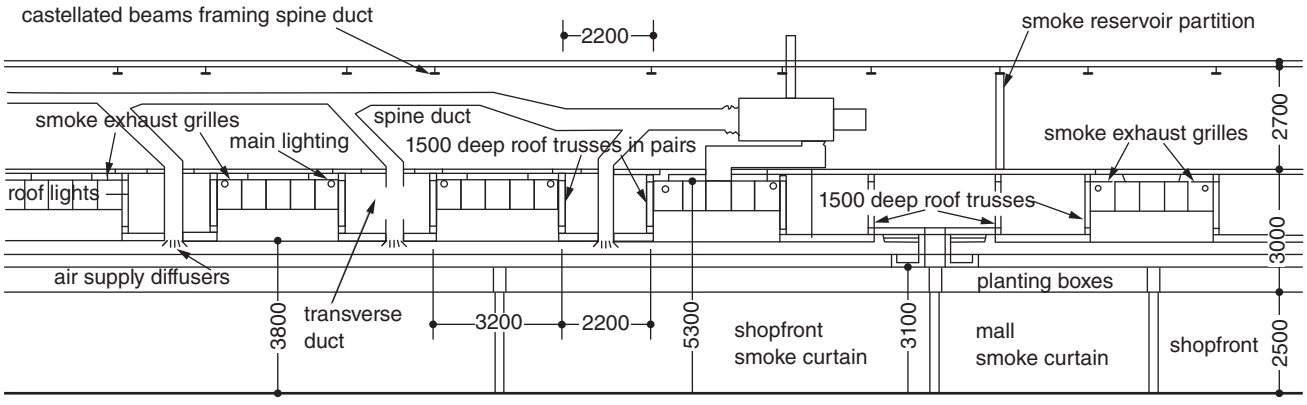
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



35.19 *Detail cross-section through a shopping mall*

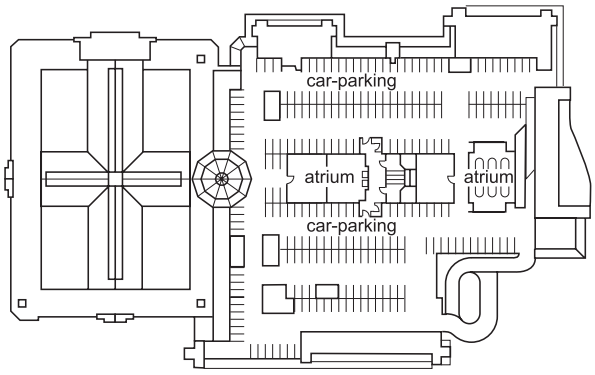


35.20 *Detail cross-section through central square. Note: 2500 mm is the minimum shopfront height. The optimum floor to floor level of a new build is generally 6m*

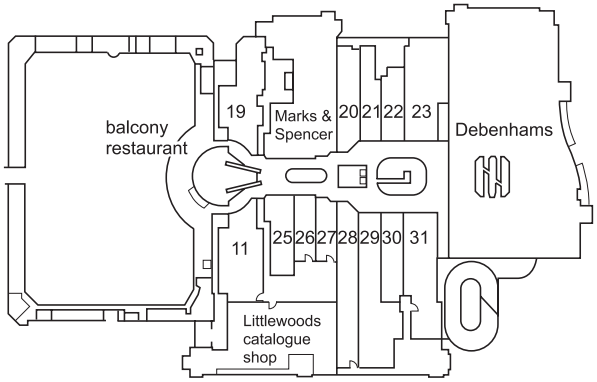


35.21 *Detail longitudinal section along mall. Note: Another, more common, arrangement is a vertically mounted grill running above the shopfronts*

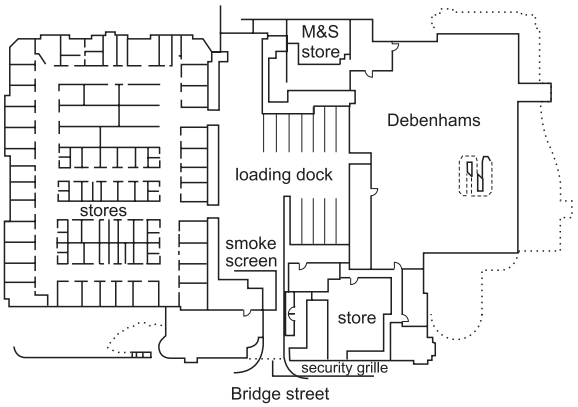
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



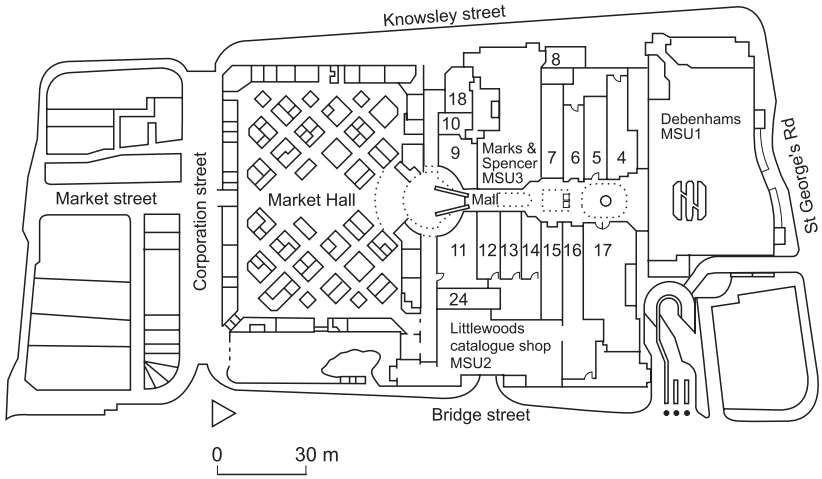
a *First-floor level*



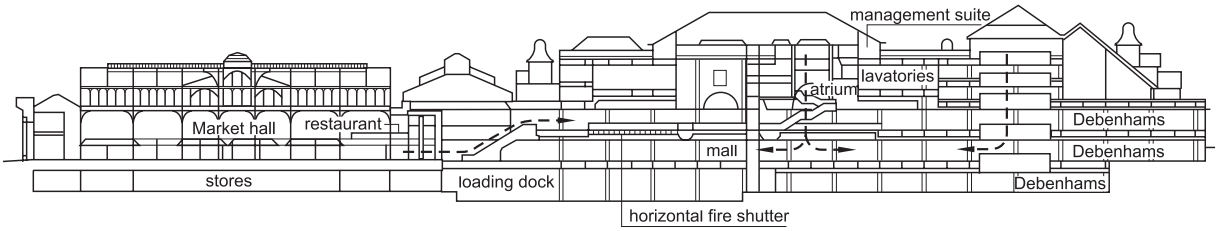
b *Upper ground-floor level*



c *Ground-floor level*



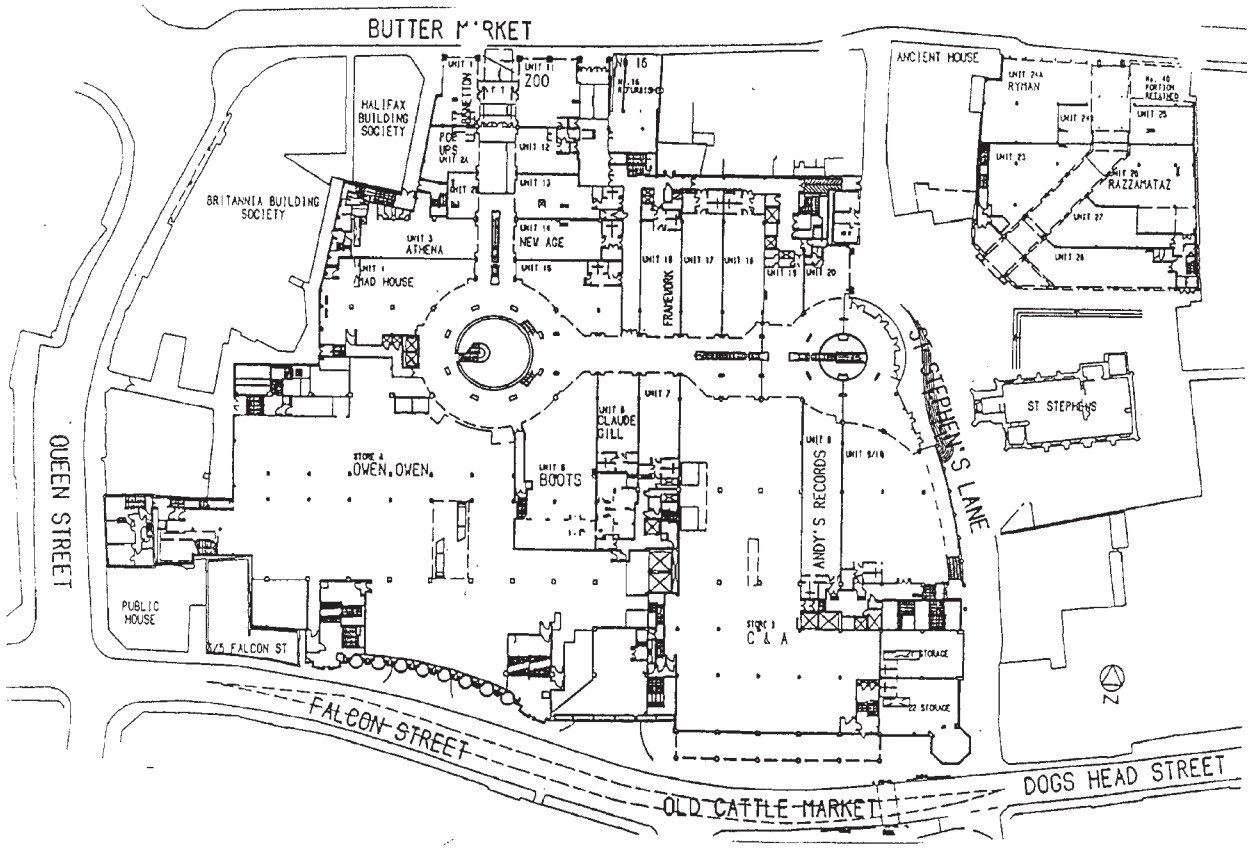
d *Lower ground-floor level*



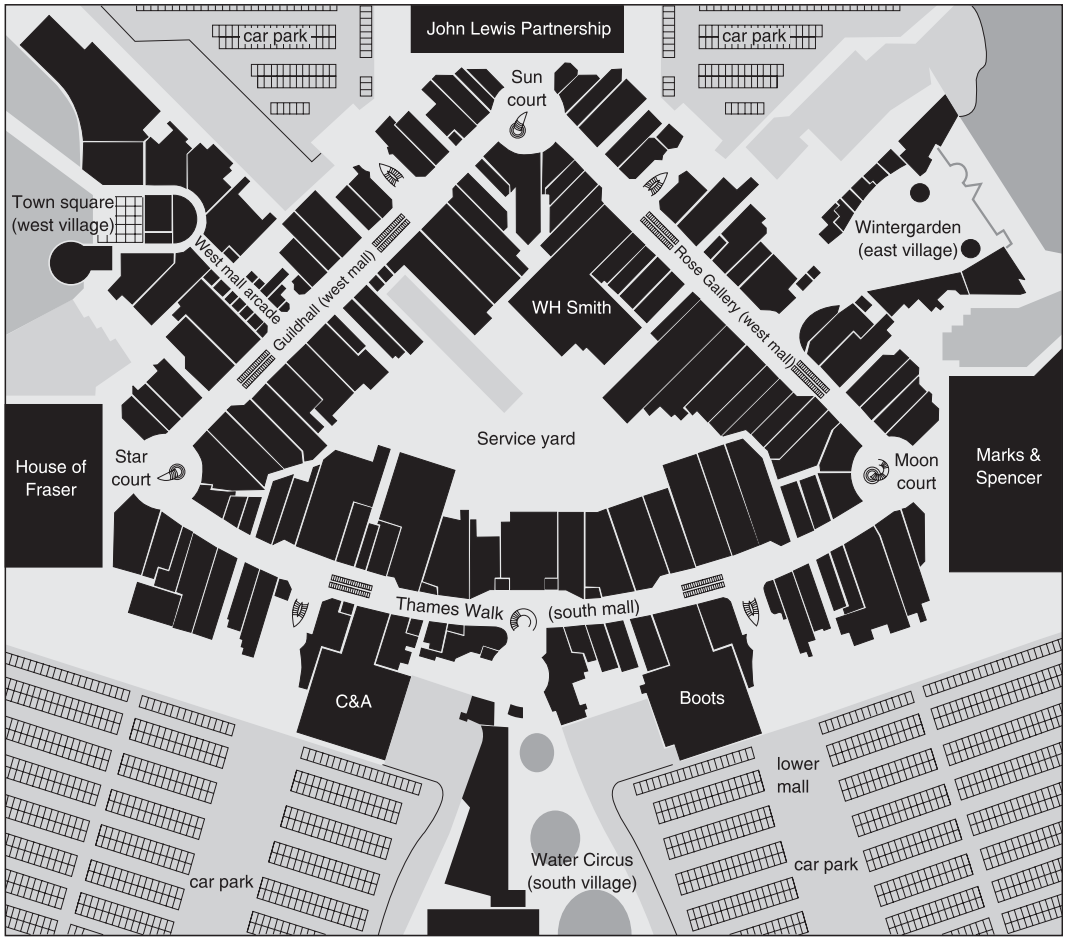
e *Section south–north*

35.22 *Bolton Market Place: a shopping centre on two levels linked to the refurbished existing Market Hall. Deliveries and storage are in the basement, and car parking on three upper floors. Total area is 49796 m² Architects: Chapman Taylor & Partners*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

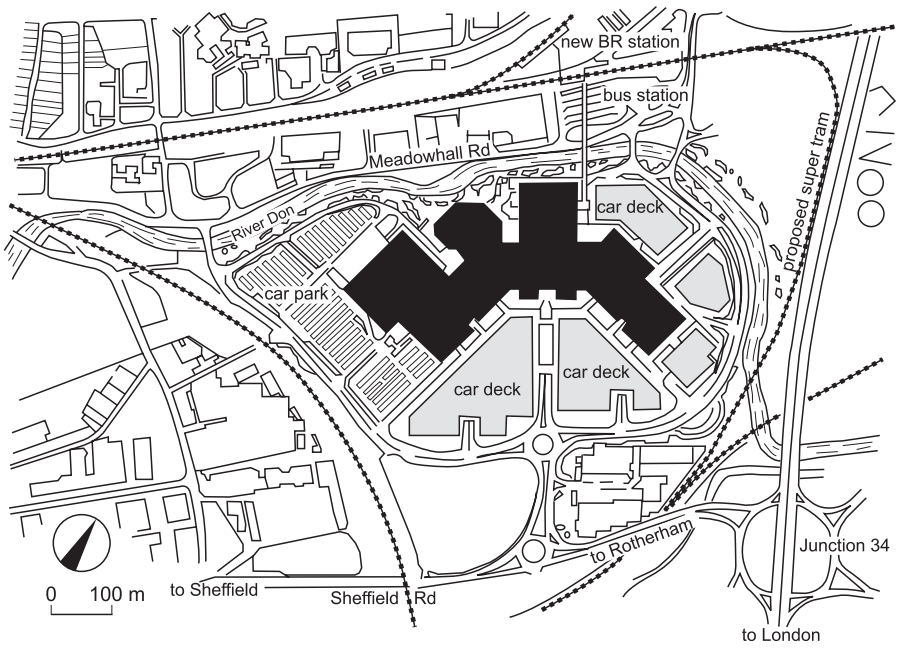


35.23 *Buttermarket, Ipswich. Development of a shopping centre in a sensitive historic area, incorporating a church restored as an amenity area, and two level basement parking. Completed in 1992 with 49 units. Built area 25083 m², cost £37 million Ground-floor plan Architects: Building Design Partnership*

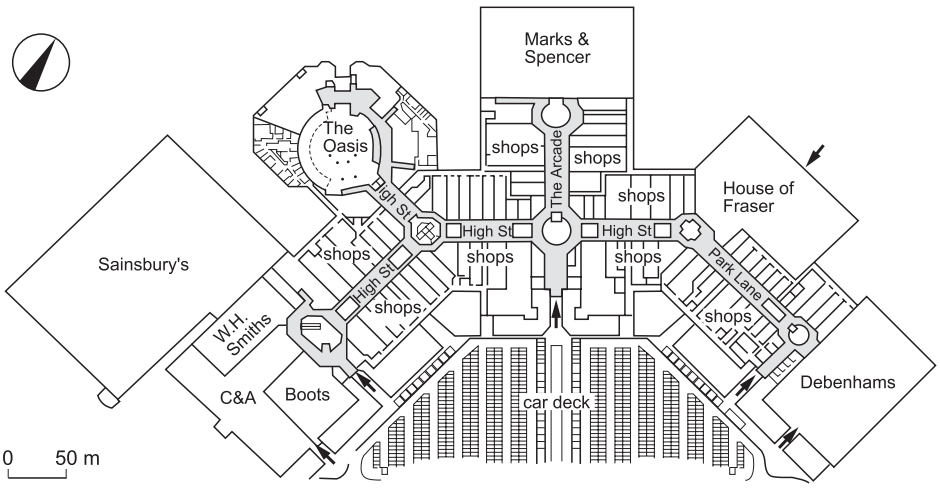


35.24 *Bluewater Park near Dartford, Kent. Europe's biggest retail centre to date. Architects: Eric Kuhne and Benoy*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



a *Site plan of the regional shopping centre*



b *First-floor level of the dome's shopping mall with shops on two levels*

35.25 *Meadowhall Centre, Sheffield*

11 RETAIL PARKS

These are centres of at least 4500 m^2 sited outside a town consisting of at least three single-storey units of 900 m^2. Retail parks cover non-food goods (DIY, furniture, furnishings, consumer durables, etc.). Buildings are generally of warehouse design and benefit from the combined attraction, shared infrastructure, parking and extra facilities (cafe/fast food outlets).

12 REGIONAL CENTRES

These are large multiple shopping complexes located near major highway junctions to serve a wide catchment area (see Figures 35.24 and 35.25). The larger centres provide both leisure and shopping attractions to extend market and family interest. Depending on scale, the amenities include crèches, children's play areas, multi-cinemas, live entertainment, fitness/health centres, waiting and lounge meeting areas and a wide choice of catering outlets.

In 2011 there were 19 regional shopping centres with a floor area exceeding 100 m^2 in the UK together offering almost 3.9 million m^2 of retail space. The largest are the Metrocentre, Gateshead (194,000 m^2 including retail park), Bluewater, Dartford (155,700 m^2) Westfield, Dudley (154,002 m^2) and Westfield, London (139,000 m^2).

Large comprehensive shopping developments provide a stimulus for employment and urban regeneration. Redevelopment sites include exhausted mineral workings landscaped as lakes, brownfield sites and discontinued industrial wasteland. The areas required for buildings, customer parking and goods distribution are extensive. Access, traffic movements and circulations must be modelled and planned in detail including means of escape and security control.

Extensive demands are made on technical infrastructures and conservation provisions include rainwater recycling, combined heat and power systems, energy balancing, airflow control, fabric insulation and shading, management control systems and planned maintenance.

The arrangement of shops, malls and halls and vertical circulations is largely determined by the locations of anchor stores and food-service outlets which attract customer movements. Staff facilities and central services are planned in association with tenant requirements.

13 BIBLIOGRAPHY

S. Appelby (ed.), *Shop Spec. Shopfitting Specification International*, Purple Media, 2006

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

N. Beddington, *Shopping Centres*, Butterworth Architecture, 1991

British Council of Shopping Centres, *A Briefing Guide for Shopping Centre Development*, BCSC, 2000

P. Bernman and J. Evans, *Retail Management – A Strategic Approach*, 10th Edn, Harlow, Pearson Prentice Hall, 2006

Chapman Taylor Partners, 'Trading architecture: The Bolton Market Place', *Architects' Journal*, 19 April 1989

P. Coleman, *Shopping Environments: Evolution, Planning and Design*, Architectural Press, 2006

Cox and Britain, *Retail Management*, MacDonald and Evans, 1993

A.C. Nielsen, *Retail Pocket Book 2006*, World Advertising Research Center, 2006

Q. Pickard (ed.), 'Shops and Retail', *The Architects Handbook*, Blackwell Science, 2002

J. Prior, *Sustainable Retail Premises, An Environmental Guide to Design, Refurbishment and Management of Retail Premises*, BRE Publications, 1999

This page intentionally left blank

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

36 Schools

Anthony Langan

Anthony Langan is sector lead for education at AHR Architects (formerly Aedas)

KEY POINTS:

- *This chapter brings together good practice and recent standards, but the Department for Education should be consulted for the very latest standards and guidelines*
- *The design of schools is a highly political, and constantly evolving, field of study*
- *The current emphasis is on efficient, compact forms that are easy to extend*
- *Schools should be designed as low-carbon environments with high quality natural lighting and should be naturally ventilated in all but the most exceptional circumstances*

Contents

1 Introduction
2 School types
3 Key design information and design standards
4 Environmental design, sustainability and low carbon design
5 School furniture and ergonomics
6 Security and fire safety
7 Early Years school design
8 Primary schools
9 Secondary schools
10 SEN provision
11 References

1 INTRODUCTION

This chapter specifically relates to the design of schools in England and Wales at the time of writing. In other parts of the UK, design standards and education delivery varies.

1.1 Sector changes

Over the past decade, school design development has increased significantly as development of curriculum and education delivery methods along with major programmes of school renewal, have driven the education design debate.

Education is at the fulcrum of social and economic renewal. Transforming education delivery and engaging students in new ways of learning is seen as the key to raising education standards and preparing young people to meet future challenges. Curriculum delivery has changed to develop a wider engagement in education, and greater emphasis is given to vocational subjects and student subject choice.

There have been several key recent changes. The DfE (Department for Education) is currently promoting capital programmes to deliver the development of new academies under the stewardship of Local Education Authorities in partnership with Academy sponsors. There is also the development of Free Schools offering alternative models to LEA provision, and the introduction of the Primary Capital programme for the redevelopment of Primary Schools to meet the demographic growth demand.

1.2 National Curriculum

The National Curriculum defines the core entitlement of pupils at all stages of their education. It is monitored by the Qualifications and Curriculum Authority (QCA).

The National Curriculum applies to pupils of compulsory school age in community and foundation schools, including community special schools and foundation special schools, and voluntary aided and voluntary controlled schools. It sets out a series of statutory requirements and is organised on the basis of four key stages:

1 Key Stage 1: Ages 5–7 (Years 1–2).
2 Key Stage 2: Ages 7–11 (Years 3–6).
3 Key Stage 3: Ages 11–14 (Years 7–9).
4 Key Stage 4: Ages 14–16 (Years 10–11).

Developed in a series of Key Stages, the Primary Curriculum KS1 and 2 is based upon a wide breadth of learning as well as developing key skills in literacy, numeracy and ICT. At these early stages of a child's development, emphasis is placed on social and emotional development along with key personal and thinking skills, while engaging children in learning through play and activity-based learning.

The Secondary Curriculum seeks to provide a cohesive structure for learning from the ages 11–19 years (KS3 and 4). These build on the experiences of children in primary school to help students achieve high standards and develop personal, learning and thinking skills (PLTS). More recently, the government has introduced the concept of the English Baccalaureate. This is a grouping of subject areas rather than a formal qualification in its own right.

1.3 Role of Ofsted

Ofsted is the Office for Standards in Education, Children's Services and Skills. Ofsted was set up under the Education and Inspections Act by the government to regulate and inspect and to help achieve excellence in the care of children and young people. As part of its role, Ofsted inspects schools and produces reports into its findings using a set framework of criteria on a range of subjects from the safety of the environment that the school provides to the quality of teaching and learning in individual lessons. Parents will often use the Ofsted reports when choosing a school for their child. See www.ofsted.gov.uk.

2 SCHOOL TYPES

Formal education is compulsory between the ages of 5 and 16 years. Typology of schools has increased in recent years with the introduction of Academies and Free Schools. The main different types are now as follows:

- State maintained. These are funded by the DfE through taxation at national and local level, often with contributions from local diocese and archdiocese organisations. Most maintained schools are comprehensive or non-selective of students. However there is a tradition of religious influence in schools through the Voluntary Controlled or Voluntary Aided system. These schools can develop an admissions policy which allows them to select a proportion of students. Students are also usually drawn from a much wider catchment than LEA schools. Some authorities still operate a grammar school selective system of selection at the age of 11. Some operate a middle school system where the upper years of primary school and the lower years of primary school are combined.

- Academies, where LEAs work with sponsors to organise a school. Sponsors are often from faith or commercial backgrounds and can influence the ethos of the school and curriculum that is delivered, Figure 36.1. Existing schools can also 'opt out' of local authority control to become Academies. Academies are allowed to select a small proportion of students based upon their specialism.
- Free schools, set up by groups interested in the promotion of education outside the control of local education authorities.
- Privately funded schools run by their owners or charitable foundations.

Many Academy and grant maintained schools adopt a specialism – a subject in which they excel. Schools must present evidence and apply to the DfE for specialist status from the number of subject areas approved by the department. See also the Specialist Schools and Academies Trust.

All through schools, which take students from early years to the age of 19, have increased in number recently and the exemplar design study by the DfE shows an example of how these may be organised.



36.1 *Oasis Academy, Enfield, a specialist maths, ICT and music school with a Christian ethos designed by John McAslan + Partners. (Photograph: Hufton + Crow)*

3 KEY DESIGN INFORMATION AND DESIGN STANDARDS

3.1 School design standards

There is a significant amount of design guidance, both formal and informal, and also best practice documents available for the design of schools.

3.2 Legislation

The legislative framework is based upon the School Premises Regulations 2012 and the adoption of the Building Regulations. The legislative aspects also apply to independent schools (see DfE website).

Often DfE non-statutory Building Bulletin publications are referred to in the approved documents.

3.3 Guidance

The DfE has published a significant number of Building Bulletins and best practice guidance in the form of design notes. This guidance includes:

- Baseline Designs introduced in 2012 (see Section 3.4).
- Area guidance briefing framework BB103 for secondary and primary schools.
- Inspirational designs for schools such as the Schools for the Future Exemplar Designs for Schools, 2003.
- Very detailed standards such as Environmental Design and Ventilation (BB87 and 101) and Acoustic Design in schools (BB93).

3.4 Baseline Designs

The Baseline Designs are a series of primary and secondary school designs developed by the Education Funding Agency (EFA) in 2012. The designs demonstrate how the standard output specification developed for the Private Finance 2 (PF2) procured schools can be met. This specification is also being adopted for other schools currently being procured by the EFA to ensure consistency across the new estate.

The Baseline Designs have been developed to Stage 2 of the RIBA Plan of Work. One of the key drivers of the designs is standardisation – in conceptual approach, detail design and specification. This is seen by the EFA as a way of reducing design and construction costs and also of producing an equality of provision across all schools countrywide.

The designs meet a standard curriculum in England and Wales, but provide flexibility in order to react to other organisations. The EFA have undertaken consultations with other user groups to help ensure that the designs meet the needs of certain types of extra-curricular provision.

Key features of the designs are:

- Simple organisational concepts, such as finger schemes, Figure 36.2, where linear classroom wings emanate from a core of common spaces, halls, dining, administration etc. and a 'superblock' concept, Figure 36.3, that places the core large spaces at the centre of the building and then wraps classroom spaces around,
- A plan organisation that provides for suites of subject-driven teaching accommodation. Emphasis is placed on how these suites are organised so that this may be repeated across multiple projects.
- Area standards that are different from the BB98 and 99 guidance notes with strict emphasis placed on the provision of teaching accommodation over non-teaching.
- For secondary schools, the overall area formula is: 1050 m² (+ 350 m² if there is a sixth form) + 6.3 m²/pupil place for 11- to 16-year-olds + 7 m²/pupil place for post-16s.
- For primary schools the overall area formula is: 350 m² + 4.1 m²/pupil place.
- Environmental strategies that have been worked up in some detail to ensure that the designs will conform to the environmental standards of the output specification but also provide longer term flexibility by providing robust and flexible environmental concepts that will stand up to the building footprint being adapted internally.
- Environmental strategies for teaching spaces that are designed to mitigate summertime maximum temperatures, reduce CO_2 levels and provide adequate natural daylight. Daylight is measured against how the design utilises available daylight, how even the spread of the daylight provided is and whether it is glare free. This approach has necessitated that the majority of classroom spaces are lit also from the back or corridor face of the room by clerestory glazing and top lighting to the corridor spaces.

3.5 Design Quality Indicators (DQI)

In 2005 the DCFS published a methodology of evaluating school design for LEAs and schools, known as DQI for Schools. This is a framework of design criteria which is tailored by the individuals involved in the project. This tool allows LEAs to represent their needs more succinctly to the designers involved in the project. See www.dqi.org.uk.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

3.6 Commission for Architecture and the Built Environment

The Commission for Architecture and the Built Environment (CABE) – now part of the Design Council – has developed a framework of design support for local authorities involved in the development of school buildings. In 2008, minimum design standards developed by CABE were adopted by the government for school projects and are still a useful guide to successful school design.

CABE's 10 criteria for successful school design are:

- Identity and context: making a school the students and community can be proud of.
- Site plan: making the best use of the site.
- School grounds: making assets of the outdoor spaces.
- Organisation: creating a clear diagram for the buildings.
- Buildings: making form, massing and appearance work together.
- Interiors: creating excellent spaces for learning and teaching.
- Resources: deploying convincing environmental strategies.
- Feeling safe: creating a secure and welcoming place.
- Long life, loose fit: creating a school that can adapt and evolve in the future.
- Successful whole: making a design that works in the round.

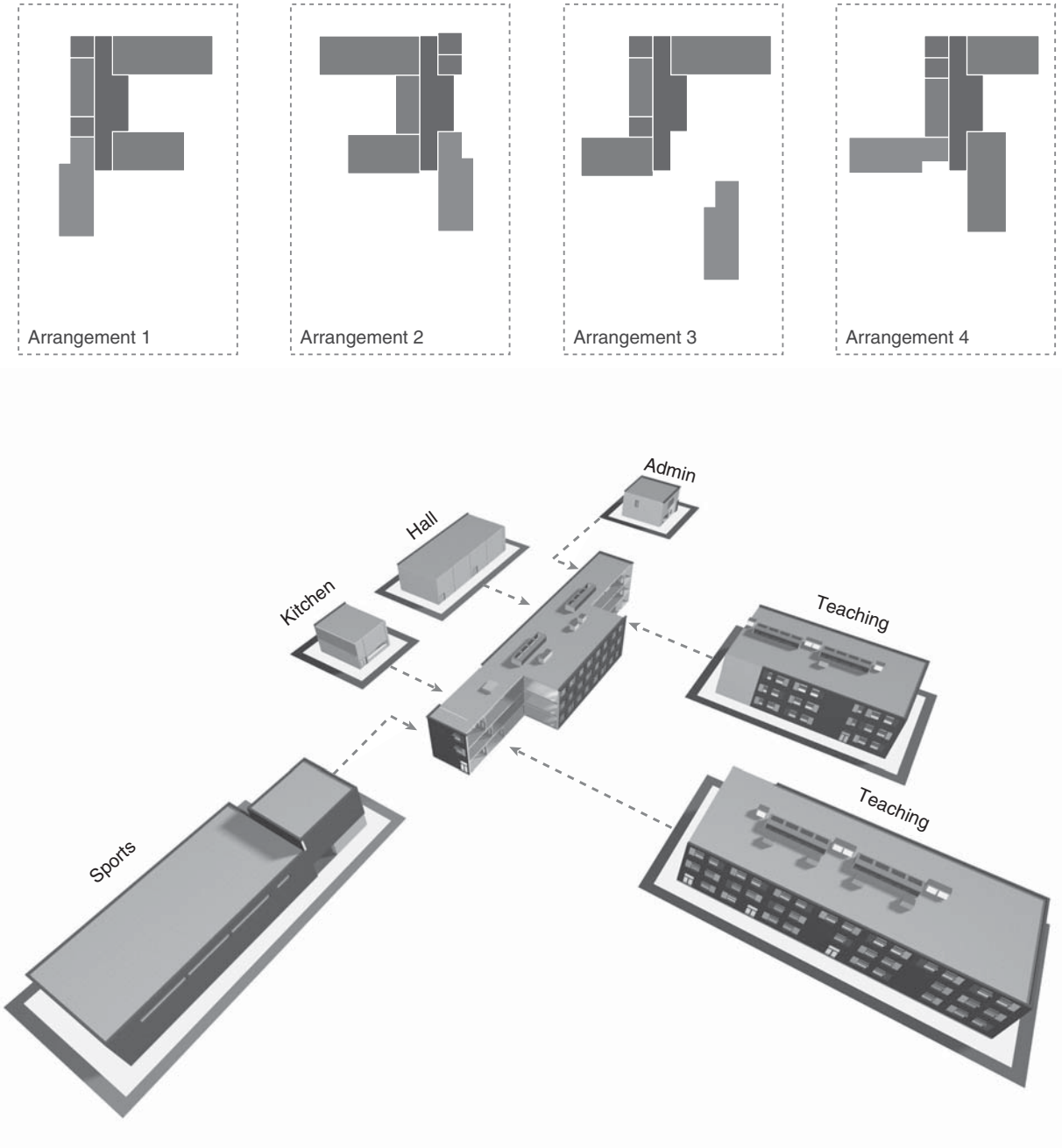
3.7 Design Share

International design websites such as the site Design Share help to promote an understanding of design standards and methodologies utilised in other parts of the world. The incorporation of international best practice into school design in the UK is becoming increasingly prevalent. Many authorities undertake international design study tours in the preparation for major projects, particularly to Scandinavia and Europe.

4 ENVIRONMENTAL DESIGN, SUSTAINABILITY AND LOW CARBON DESIGN

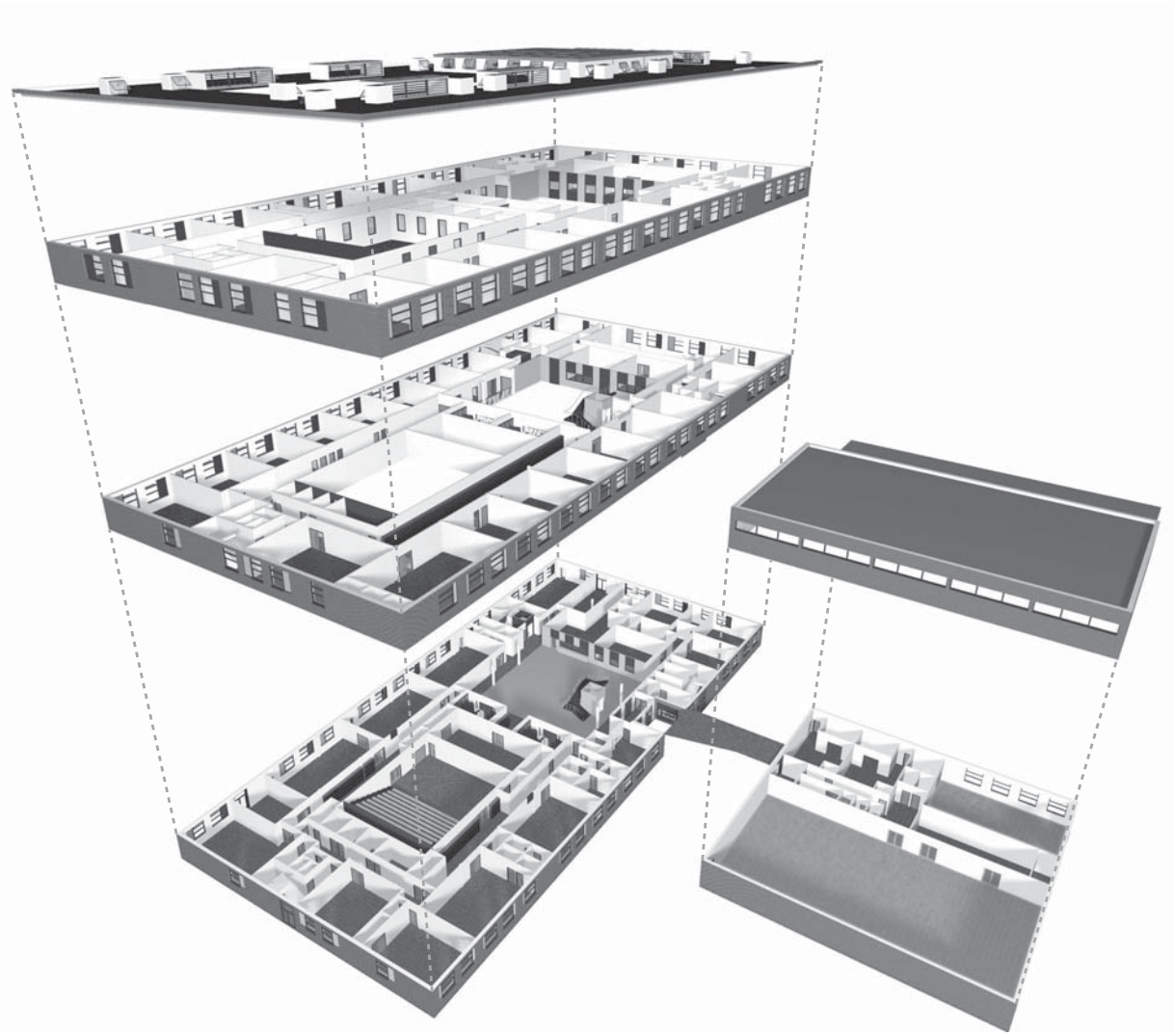
4.1 Background

In 2007 the government commissioned a report into the carbon emissions of schools by the Sustainable Development Commission. This developed a baseline target of a reduction of around 60 per



36.2 *Education Funding Agency Baseline Design for a 1200-place secondary school designed as a 'finger block' kit of parts (Type 1)*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



36.3 *Education Funding Agency Baseline Design for a 1200-place secondary school designed superblock (Type 2)*

cent based upon the 2002 Building Regulations. Development of the building regulations subsequently has incorporated a sizable proportion of these targets.

The DCFS developed the 'Carbon Calculator' as a design tool. This sets out the environmental and carbon reduction standards to be achieved in the design of school buildings and also provides a series of methods and energy efficiency measures for achieving the required targets. These include reviewing the fabric and form of the proposed building, including the U values, along with its orientation to maximise the passive measures in reducing energy consumption.

The guidance also describes the various technologies that can be adopted to reduce the carbon emissions in schools. According to the Sustainable Development Commission, almost 40 per cent of the carbon is spent in maintaining the environment of the school.

4.2 Ventilation

The guidance for the carbon calculator also confirms that air-conditioning is not within standard school construction costs and that in all but the most exceptional circumstances, natural ventilation of some form should be adopted to optimise both capital and recurrent costs.

Refer also to BB 101 'Ventilation of School Buildings' and the complementary calculation tools, 'Classcool and Classvent'. BB101 introduces ventilation performance standards and also criteria for the prevention of summertime overheating and classroom carbon dioxide levels. The maintenance of a suitable classroom environment, within suitable temperatures and carbon dioxide levels, is seen as key to maintaining concentration in students.

Potential natural ventilation strategies include:

- Night time cooling via exposed thermal mass. The UK has cooler summer temperatures at night. These may be exploited using thermal mass or thermal inertia, thereby smoothing daily temperature swings. By exposing heavy building fabric in the ceiling it absorbs heat during the day then cools during the night when exposed to cool night time air.
- Earth tubes. These are concrete or clay pipes in the ground through which the supply air is passed. They are able to supply pre-warmed air in the winter and cooled air in the summer as the ground itself does not vary much in temperature over the seasons. They still have an energy requirement for fans.
- Borehole cooling. If a school has access to ground water at a suitable depth and extract licences are granted, cool water at 12–15°C can be pumped though the pipes of an underfloor heating and cooling system to cool the rooms in the summer.
- Mixed mode cooling. A building designed to limit solar gain and equipment gains may only overheat for a small percentage of the time. If a reduced size of cooling system is provided for extreme conditions only, and natural ventilation is used for most of the time, it is termed mixed mode.

4.3 Day lighting

Natural day lighting is seen as the primary light source in school design and depends on the proportions of the room, amount and position of glazing, reflectivity of surfaces, and whereabouts in the

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

room it is being measured. The Baseline Designs give some simple practical guidance to achieve good day lighting.

The use of daylight as the main means of lighting is also recommended in BB87. Sometimes site constraints such as adjacent buildings or trees will mean electric lighting will be the main source, but the designer should strive to avoid this. Daylight provides a less stressful environment for pupils and teachers, and saves energy.

Uniformity or Daylight Autonomy is equally important. If a classroom was illuminated perfectly evenly throughout, then it would have a uniformity of one. The importance of uniformity in day lighting can be illustrated by the fact that lights can often be found on in classrooms even though average daylight is good. Again, the Baseline Designs show principles of good day lighting; providing daylight from two sides of the room significantly enhances uniformity.

As far as space planning is concerned, natural lighting and natural ventilation are in sympathy. The maximum depths of spaces for natural ventilation are comparable to the maximum depths for effective day lighting.

4.4 ICT

The exponential use of technology in the classroom places significant burden on the environmental design of individual spaces. However, as technology develops both PCs and laptop computers are becoming more energy efficient and therefore placing less burden per unit on the environmental conditions. This is denoted through the Energy Star standards on the units.

There are also a number of strategies for reducing the processing power of the computer itself, known as 'Thin Client'. Here, the processing is undertaken by a remote server rather than the individual computer, thus reducing the energy and heat load in the individual space. For details, refer to guidance by the government's ICT advisors BECTA.

4.5 Energy sources

Development of low carbon energy solutions is central to lowering the carbon footprint of the nation's schools and a number of technical solutions have been adopted over the past few years. The adoption of any one or combination of these measures needs careful consideration by the design team and client as they incur considerable capital cost and also recurrent cost over the life of the school.

The main options are:

- Biomass. This refers to an energy source derived from organic matter, including wood from forests, waste wood sources and factory waste. Over the past few years a number of local authorities have developed supply chain networks to ensure continuity of supply as more schools adopt this technology.

  Ideally, biomass should be used close to its source of supply to minimise the environmental impact of transportation. Chips require significant storage space below or above ground prior to being burned. Pellets are denser than chips and have greater calorific value but are more expensive.

  Biomass can potentially meet all of a school's heating needs, although it is usual to have some gas back up. It typically reduces carbon emissions by 20–30%, being 1/8th of the emissions of gas and 1/16th of that of electric heating.

- Combined heat and power (CHP). This is the production of electricity and useful heat in a single process. It can be up to 80% efficient, albeit the overall efficiency of the system depends on the ability to use the heat available. This is usually dependent on a constant heat requirement of, for instance, a swimming pool or possibly matching load to surrounding housing, where the school uses heat during the day and the excess heat is distributed later to local housing via a district heating system. Excess electricity can be put back into the national grid.
- Ground source heat pumps (GSHP). These use the constant temperature of the ground to provide heating or possibly cooling, which is extracted through boreholes or loops under the ground. It then produces heat in the school through underfloor heating systems. These systems are not carbon zero as they use electricity in their operation, but have a coefficient of production of usually 3 or 4 to 1, thus for every 1kw that is used, 3 or 4kws are produced in heat.
- Photovoltaic cells (PV). These convert energy from the sun into electricity through semiconductor cells. They are often applied to facades or roofs of buildings. However they are expensive and have a simple payback period of circa 70 years.
- Solar thermal. Solar hot water systems use energy from the sun to heat hot water. Fluid is heated in the panels and then water in a cistern is heated through a simple heat exchanger. There are two types of systems: flat plate and evacuated tube systems. Solar thermal hot water can work in the less clement months of the year to pre-heat water that is boosted by an alternative system.
- Wind generation. Wind turbines are one of the most cost effective renewable energy options with a simple pay back period of around 25 years. Modern free standing turbines of 6–20kw are suitable for suburban areas, subject to consultation with local planning authorities and their use is becoming more accepted.

5 SCHOOL FURNITURE AND ERGONOMICS

5.1 Suitability

Students come in all shapes and sizes and the furniture that is provided for them must respond to this. The provision of inappropriately sized furniture can lead to problems with posture in later life and can also affect the ability of the individual student to concentrate on the task in hand, reducing their ability to learn effectively.

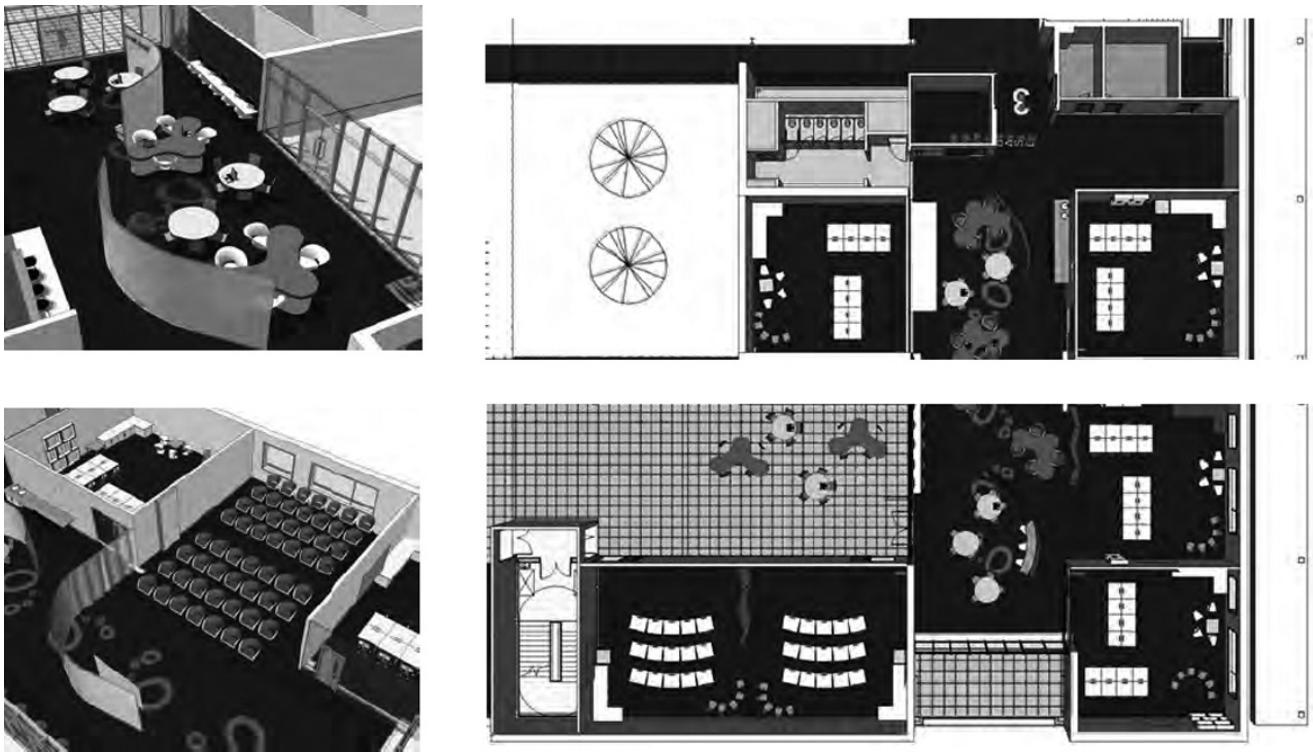
Over the past decade, the market for the provision of furniture to schools has increased, as have the design solutions that the companies involved now provide. Often project teams will have a consultant who will take the lead on the selection and design of the Fixed Furniture and Equipment (FFE) to be installed. In major projects it is the FFE designer's responsibility to ensure that the selection of FFE meets the relevant British and European standards (BS EN 1729 part 1 and 2 of 2007) and also to ensure the furniture has a suitable life span and durability. The FFE designer will consult with the client team, educationalist and architect to ensure that the FFE to be provided is fully coordinated with, and flexible enough to respond to, the various learning styles to be adopted.

Key design considerations for the architect include ensuring:

- That the FFE provided is suitably flexible to adapt with the building to the likely pedagogical styles.
- That the FFE should also be suitably flexible to accommodate the physical needs of individual students and adapt to their size and shape if required, and also be suitable to accommodate less able students.
- That the selection of FFE is in concert with the proposed concept for flexibility and adaptability within the building layout and structure and services, so that the FFE used does not inhibit future flexibility.

5.2 Flexibility of FFE layouts

The ability for spaces to flex on a daily basis is a key design driver in education design and is essential to the delivery of education in varied modes to meet the learning styles of students, Figure 36.4. Therefore the ability for spaces to be able to encompass more activities is very important. Often, general teaching spaces may need to be adapted from time to time to provide light practical work space. This can easily be done through FFE but can be enhanced by simply providing a single sink. Specialist spaces such as science need to maintain flexibility and the trend is therefore for services such



36.4 *Flexible FFE layouts by AHR Architects*

as hardwire ICT and water, gas, electrical supplies to be provided to the perimeter of the spaces, leaving the centre of the room unencumbered to increase flexibility.

6 SECURITY AND FIRE SAFETY

The design of a safe environment for students, staff and the wider community is a paramount concern in the design of any school. Ofsted pays particular attention to a school's ability to provide a safe environment for students, particularly from the viewpoint of deterring intruders. Simple yet effective measures involving single entrance points and secure perimeters should be incorporated into each school design.

The local planning authorities will expect that the local Police Architectural Design Liaison Officer has been consulted in the development of the design and that the principles of Secured by Design have been incorporated into the design of the new facilities. Secured by Design's 2010 Schools Guidance provides a range of advice on the design of site strategies, the security of the shell of the building, internal layout and design through to the management of the facilities.

School insurers such as Zurich Municipal produce their own design guidance for architects. Often local authorities are keen to ensure this guidance is followed to ensure the building will be insurable.

Published by the DFE, BB100 provides design guidance on design for fire safety in schools. Design against the risk of fire in schools is regulated under the Building Regulations and BB100 demonstrates design principles for meeting the standards set in the Building Regulations Approved Documents. The Baseline Designs have developed a fire strategy that has been informed by the BS 9999 Code of practice for fire safety in the design, management and use of buildings, and is based on the risk profile of the building's occupants.

The fire strategy provides for flexibility in the spatial arrangements and internal layouts. A life safety sprinkler system has been included in the secondary school. The simpler primary school design does not require a system for life safety.

Larger projects have become increasingly sophisticated in their design over the last decade, for instance many schools incorporate atria spaces. Therefore the design for fire prevention often involves fire engineering design. This is undertaken by a Fire Engineer to ensure that the design meets the design standards of the Approved Documents. The role of the architect is to agree the fire strategy with the client and design team and to see that the strategy works with the overall design concept for the new facilities.

7 EARLY YEARS SCHOOL DESIGN

7.1 Provision

Early Years Foundation Stage (EYFS) education serves children to the age of 5 including the reception class of compulsory education. In terms of compulsory education, a child must start school at the beginning of the next school term following their fifth birthday and would at this time enter reception class. However most children start earlier than this at a nursery class as provision has been expanded to provide a part time place for all 3 and 4 year olds.

To help meet this commitment, many other forms of early years provision has been developed including Sure Start Children's Centres, which are often but not always attached to primary schools.

All registered providers of Early Years care are required to use the EYFS statutory framework. The framework is set around a number of key themes: the development of a unique child; the ability for the child to develop positive relationships with others; the creation of an environment which supports the role of learning; and the recognition that children learn in different ways and at different rates.

Schools often provide an extended schools provision for students from the age of 4 to 14 providing childcare, breakfast and homework clubs for pupils to allow parents flexibility in their work arrangements and bring community services into schools. (See the DfE publication *Designing Schools for Extended Services 2006*).

7.2 Design principles

The design of the environment should respond to these EYFS framework issues and the architect should be aware of the ways in which early years pupils learn. CABE in association with the DfE has produced a design guide on Sure Start Centres, the principles of which are applicable to all environments for early years learning.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Some of the key design principles for Early Years design are:

- Development of a rich and varied space to encourage all learning styles and independence.
- Natural light and ventilation.
- Sense of scale that relates to the individual.
- Creation of an indoor/outdoor environment with instant accessibility to both.
- Innovative and challenging landscape.
- Involvement of the whole community in a building that is welcoming and friendly.

7.3 Area standards

Area standards for Early Years provision are set out in the EYFS statutory framework and give statutory requirements for various ages of children (see also BB103):

- 0–2 years 3.5m^2 per child.
- 2–3 years 2.5m^2 per child.
- 3–5 years 2.3m^2 per child.

As a guide, 9m^2 per pupil should be provided for outdoor areas. These should provide a diverse, fun and challenging environment in which children can learn and grow. Directly outside of learning spaces, a covered area should be provided where learning can be taken outside in inclement weather. This can, through use of shutters, also act as a large storage area for play equipment out of hours. Storage is a key requirement both externally and internally since equipment and toys are often bulky.

7.4 Other design considerations

There are several other design considerations:

- WCs and hand basins should be provided at a ratio of 1 for every 10 children over the age of 2.
- Provision of a relaxation and sleep area for children who wish to rest.
- Provision of a kitchen to provide healthy meals and snacks.
- Facilities for the preparation of babies' feeds.
- Suitable hygienic changing facilities.
- Staff welfare facilities.
- Suitable office space for the secure keeping of records and meetings with parents.

8 PRIMARY SCHOOLS (INCLUDING INFANT, JUNIOR AND FIRST SCHOOLS)

8.1 Background

Many primary schools incorporate nurseries and many share sites with Sure Start Centres, to provide a full EYFS provision. The first

ADS Code	Zone	Area Data Sheet (ADS) name and description	Size used in SoA tool
PRI03	D	**Nursery playroom:** For a range of FF&E layout options and activities for 3 to 4 year olds	55m^2 for 26
PRI13	D	**Reception classroom:** For a range of FF&E layout options and activities for reception pupils	62m^2 for 30
PRI23	D	**Infant classroom (extensive):** For a full range of FF&E layout options and activities for Key Stage 1 pupils	62m^2 for 30
PRI33	C	**Junior classroom:** For a range of FF&E layout options and activities for Key Stage 2 pupils	55m^2 for 30
PRI22	B	**Classbase with sink:** For limited primary activities including water-based, typically for infant (Key Stage 1), with easy access to a shared teaching area without sink	50m^2 for 30
PRI26	C	**Shared teaching without sink:** Open plan teaching area shared by adjacent classbases with sinks to enhance the range of activities, typically infant (Key Stage 1)	varies
PRI32	B	**Classbase without sink:** For limited primary activities, typically for junior (Key Stage 2), with easy access to a shared teaching area with sink	50m^2 for 30
PRI36	C	**Shared teaching with sink:** Open plan teaching area shared by adjacent classbases without sinks to enhance the range of activities, typically junior (Key Stage 2)	varies
PRA01	D	**ICT rich practical room** Classroom used for fixed ICT devices for all workplaces with limited layout options	62m^2 for 30
PRA11	D	**Food bay/ practical resources:** For primary food preparation with a small group and pupil access to practical resources	13m^2 for 4
PRA12	D	**Food/ science/ DT area:** Specialist space for primary food preparation, science, art and Design Technology activities	34m^2 for 15 62m^2 for 30
RES00	B	**Large group room:** Room for assistance with individuals and groups	27m^2 for 15

36.5 *Key area formulae from Building Bulletin 103*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

year of statutory school provision is the reception class. This takes children from 4 to 5 years of age.

Primary schools deliver Key Stages 1 & 2 of the National Curriculum as set out by the Qualifications and Curriculum Agency (QCA).

Primary schools are usually organised in Forms of Entry (FE) e.g. 1FE, 2FE, 3FE with notionally circa 30 children per class. Therefore a 1FE school would have a capacity of circa 210 children and so on.

8.2 Design guidance

Guidance including sample schedules of accommodation can be found in BB103. This superseded BB99, which still proves useful for adjacencies and school organisation. A primary school designed to these standards is shown in Figure 36.6.

According to the Baseline Designs developed by the Education Funding Agency (see Section 3.4) the overall area formula for primary schools should be: 350m² + 4.1m²/pupil place. Examples of designs for 2FE schools of different sizes are shown in Figures 36.7 and 36.8. All Baseline Designs and BB103 are shown on the DfE website www.gov.uk/government/organisations/department-for-education.

8.3 Key Stage 1 & 2 curriculum organisation

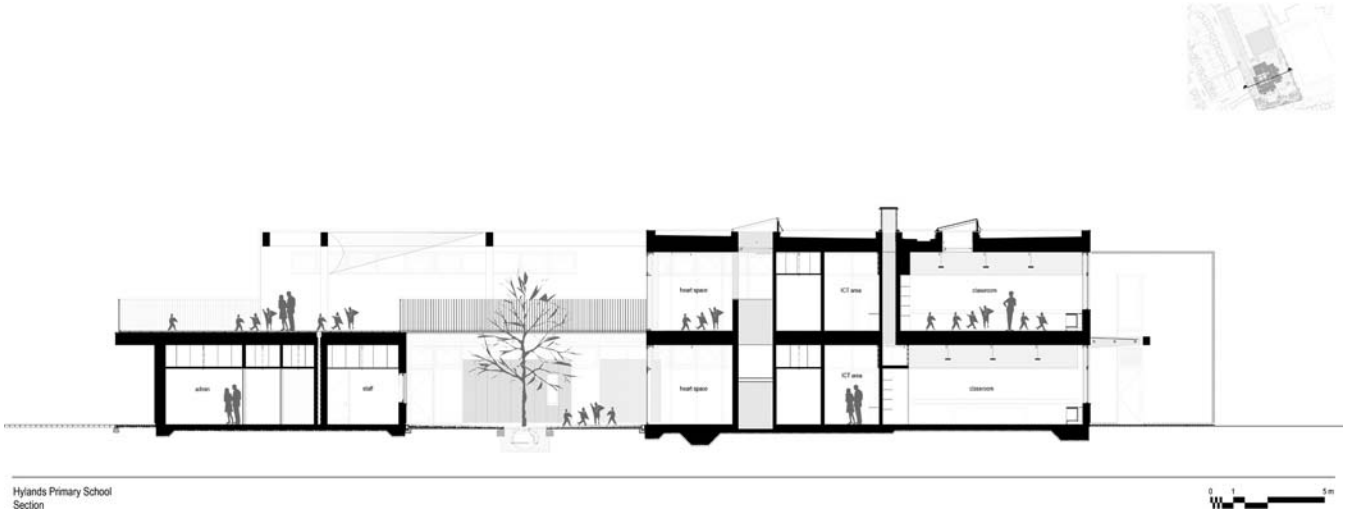
At Key Stages 1 & 2, the statutory subjects that all pupils must study are art and design, design and technology, English, geography, history, information and communication technology, mathematics, music, physical education and science. Religious education must also be provided at Key Stages 1 & 2.

Children are organised in classes of approximately 30 and are sedentary in that the majority of activities are undertaken in the classroom. Therefore the classroom should provide a varied environment, particularly in the early years organisations/department-for-education in the upper years of KS2; the teaching and learning experience becomes more formal and the learning setting responds to this.

Classrooms should have direct access to external areas to take teaching and learning outside. This needs to be an immediate relationship to give the greatest opportunity to enhance the learning experience.



36.6a *Hylands Primary School in Hornchurch, Essex was designed by Walters and Cohen for the London Borough of Havering and conforms to BB99. This ground floor plan shows classrooms and hall on the perimetre with a central courtyard and inner 'heart' space*



36.6b *Section of Hylands Primary School, designed by Walters and Cohen, showing the central courtyard.*

Specialist activities, such as music, drama and PE, usually take place in the school hall or in the case of music, small support spaces. Occasionally schools will increase the amount of specialist space by enhancing a classroom in KS2 to undertake light practical work in science and technology for the older students.

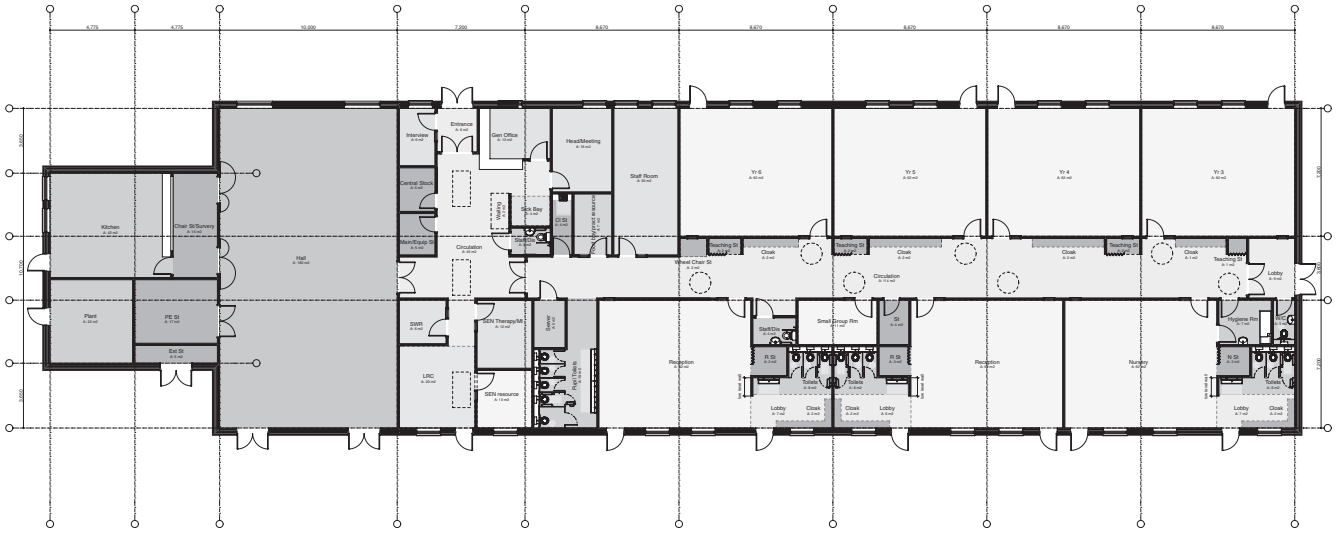
8.4 ICT

ICT plays an ever-increasing part in the delivery of learning. In primary schools, significant ICT provision is usually confined to an ICT suite or room, often located adjacent to or within the library or Learning Resource Centre area. However, each classroom from the Early Years onward will contain up to approximately three computers for use during the various class settings utilised throughout the day.

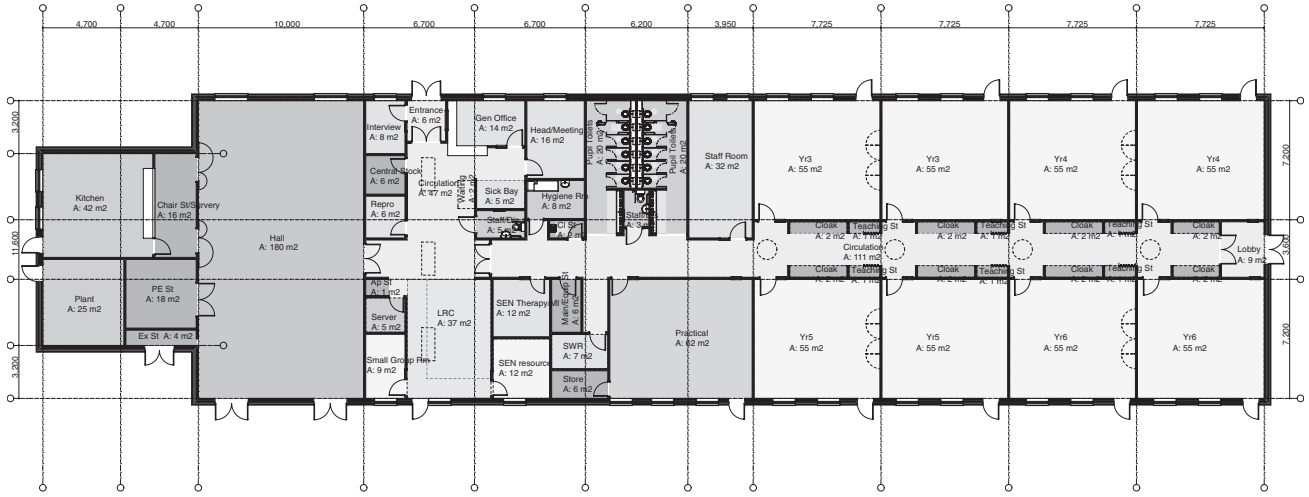
8.5 Site organisation

Since primary schools serve a very close catchment area, it is likely that a significant proportion of the children will walk to school. There are a number of initiatives to encourage this and many authorities encourage 'walking buses' by providing equipment such as highly visual jackets, for parents to organise themselves.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



36.7 *Education Funding Agency Baseline Design for a 2FE, 180-place primary school*



36.8 *Education Funding Agency Baseline Design for a 2FE, 240-place junior school*

Therefore in all schools, design to separate vehicular traffic and pedestrians will be a key concern of planning and highways authorities when assessing the scheme. This is particularly important at times of access and egress when the site is very busy. However car drop off and pick up by parents in many instances is inevitable, and the design needs to manage this well to avoid congestion, providing turning and waiting areas. There will also be the need to accommodate bus use either for occasional trips or in more rural circumstances the drop off and pick up of students from outlying areas.

Provision of staff parking is usually restricted by local planning regulations and must be considered as part of an overall transport policy by the school and the LEA together in a 'Green Travel Plan'. Many schools have adopted the Eco School standard which aims to make children and their parents aware of the carbon footprint of the schools and their own personal activities including how they get to school.

Security of the site is also a key consideration and the building form and site organisation should create clear areas of public and private domain to ensure the security of the children and teachers.

Often children will access the school through their individual classrooms via the playground. This needs to be a managed progression from the public areas of the site.

8.6 Community use

Community use of school buildings is increasing, with buildings seen as a resource for the whole community. This can range from:

- Use of the school for breakfast and after school clubs.
- Community drop-in facilities for the local authority to give advice, community policing or even community health services.
- Community library facilities which are shared by the school.
- Often community support facilities will be linked to a Sure Start Children's Centre.

8.7 Building form

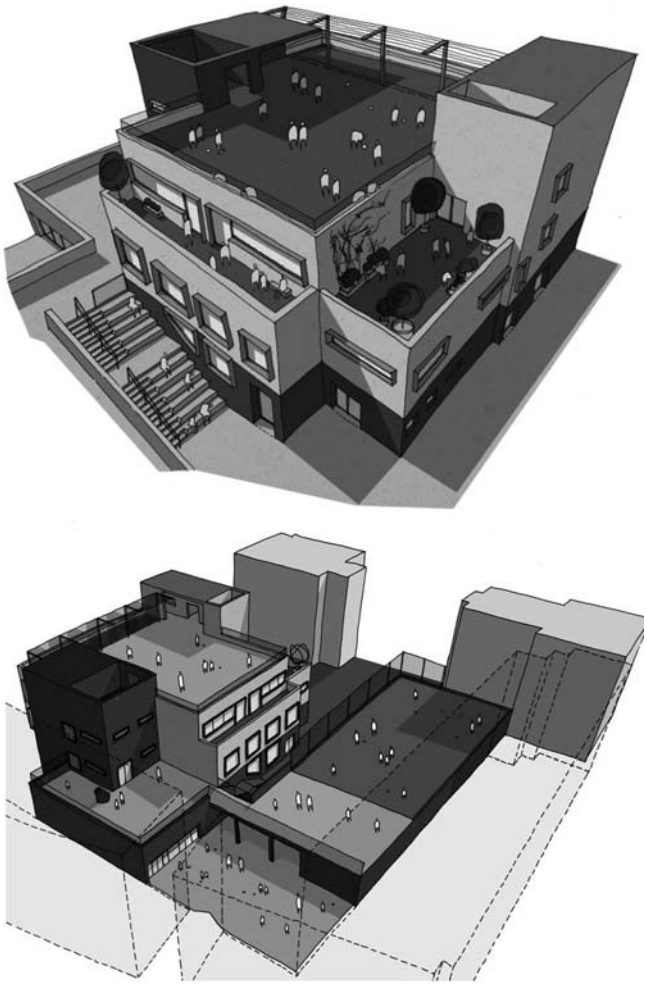
Over the past few decades primary schools have usually been single storey buildings, which have related to a particular context and construction methodology. In recent years however several notable projects have challenged this conception as site areas have become more constrained and resources more scarce. Hampton Gurney School in London by BDP and St Johns School in Blackpool by AHR Architects (Figure 36.9) are examples of this, and maintain the crucial relationships between indoor and outdoor spaces through the provision of play decks.

8.8 Organisation

There are several core spaces common to all schools:

- Reception. This is the arrival point for parents and visitors during the day. The space should be bright and welcoming and give a view of school activity to demonstrate that the building is a place of learning. It should also be able to display the work of the school. Around the reception will be administration spaces, often

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



36.9 *St Johns' CE Primary school by AHR Architects*

including the office of the head, and a parent or visitor room for meetings with parents, or use by peripatetic health visitors and others.

- The Hall. This will be used for numerous activities including PE, Music, Drama, assemblies, social events and dining. Most children will stay in school for school dinners or will eat their packed lunch in the hall so the kitchen needs to be adjacent but also have safe access and egress for deliveries.
- Classrooms. These spaces must provide a varied environment, and be supported by flexible spaces between classes for breakout or the withdrawal of students for personalised tuition. Storage is also critical to the successful operation of a school to store both resources and work in progress.
- Toilets. These should be provided at a minimum standard of 1 for every 20 children, often at a rate of 2 per class. It is often associated with cloakrooms en route to the play areas, and provides a wet lobby area. Often schools operate an indoor shoe policy where children change shoes on entering. Separate sex WCs need to be provided for children over the age of 8. Disabled WCs should be provided for staff and children and many authorities do not allow these to be doubled up.
- Staff facilities. These should provide a relaxing environment, but equally often provide a small work area for preparation of lesson material. Staff WCs are positioned close by. The Deputy Head's room often doubles as a visitors' interview room.
- Caretaker's facilities. These include storage and maintenance equipment, usually with easy access to the service areas of the school.

8.9 Landscape and recreation

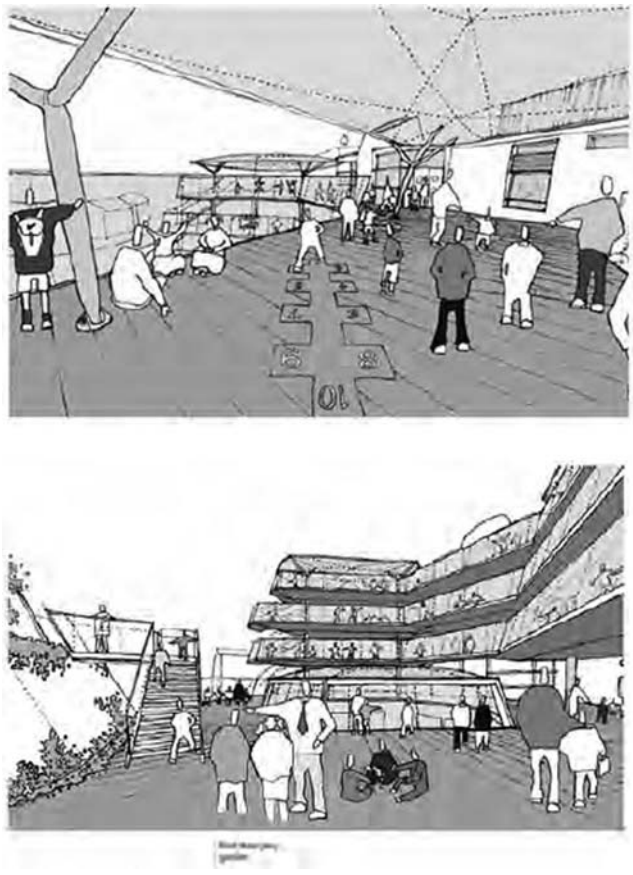
The relationship between indoor and outdoor spaces has become increasingly important to the education environment in recent years as educationalists strive to create a diverse number of learning settings. This is to ensure that children are able to learn according to their individual needs.

BB103 shows the overall areas to be provided, but environmental diversity is critically important to the creation of a successful school.

Spaces close to the building need to provide shelter from the wind and cover from the rain, particularly for the earliest years.

Orientation of teaching and learning spaces is critical in achieving a successful balance, and this must be considered at the earliest stages of site planning. Provision of protected spaces will allow the teachers to take children outside to demonstrate the principles of the subject being learnt (Figure 36.10).

There should be a progression and hierarchy in the spaces as they move away from the building form to give harder play areas and also spaces that allow children to read and socialise. Hard areas usually double as court spaces for outdoor PE. Playing fields are usually positioned furthest away from the building but with direct access from hard areas to give a natural progression in the warmer months of the years and an open feel to the site's periphery.



36.10 *Outdoor Classroom by BDP from Exemplar Designs for Schools by DfE*

9 SECONDARY SCHOOLS

9.1 Background

Students move to secondary school at the age of 11 and study the secondary national curriculum through KS3 and 4 to the age of 16. Full details of the secondary national curriculum can be obtained from the Qualifications and Curriculum Authority website. The studies are directed towards formal qualifications obtained at the age of 16. From secondary education, many students stay on in education, either by attending a sixth form in the school or another school or by moving to local FE colleges which provide a range of vocational and academic courses as a stepping stone to university, further training or employment.

Secondary schools take many forms. The majority are comprehensive schools in that they do not choose their student intake on

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

academic ability. However specialist schools and academies can apply some methods of selection based upon the specialism of the particular school.

9.2 Size and structure

Schools vary greatly in size, from the smallest secondary at 450 pupils to the largest at over 2000. However there has been a move in recent years to have a minimum size of 750 students and a maximum at 1500 students, rising to circa 1800 if the school includes a sixth form. The optimum sizes and the most common in recent school design are 900, 1050, 1200 and 1500 students.

The larger the school, the greater the need to break the size of the school down into manageable pastoral groups where students and staff can relate to each other in a positive way. Schools are responsible for the wellbeing of the whole student, not just academic achievement, and pastoral management of students is a crucial issue. Therefore, the creation of pastoral groups around houses or year groups is common in schools. House groups involve a vertical structure, which brings a number of students from each year group together into a house. The advantages of this are that the older students help to peer mentor younger students. A negative may be that the group are likely only to be together for pastoral times in the timetable.

Alternatively, pastoral groups may be based on year or half year groups. This does not have the positives of bringing together older and younger students, but other than for streaming of certain subjects, the students will spend the majority of time together.

Year 7, the first year in secondary school, is often separated out from the other years. This is to avoid any dip in performance during the Year 7 transition between primary and secondary schools. Often Year 7 will have separate social and play areas and will gradually integrate themselves into the wider social life of the school.

9.3 Guidance

Details of standard schedules of accommodation can be found in BB103 Area Guidelines for Mainstream Schools which replaces BB98 by the DFE, Figure 36.11.

According to the Baseline Designs developed by the Education Funding Agency (Section 3.4), the overall area formula for secondary schools should be: 1050m² (+ 350m² if there is a sixth form) + 6.3m²/pupil place for 11- to 16-year-olds + 7m²/pupil place for post-16s. Baseline Designs are shown in full on the DfE website. A design for an 1850-pupil secondary school is shown as Figure 36.12

9.4 Educational organisation

Traditionally schools have followed a subject based curriculum organisation, bringing together all general teaching spaces which would cater for subjects such as English, maths and humanities, and separating out specialist spaces for science and technology. Spaces for ICT would traditionally be located as a central resource and music and drama space with the hall for performances and also as a potential community facility. Sports would also be located with proximity to playing fields and MUGA (Multi Use Games Area) spaces, but also close to car parking for ease of community use.

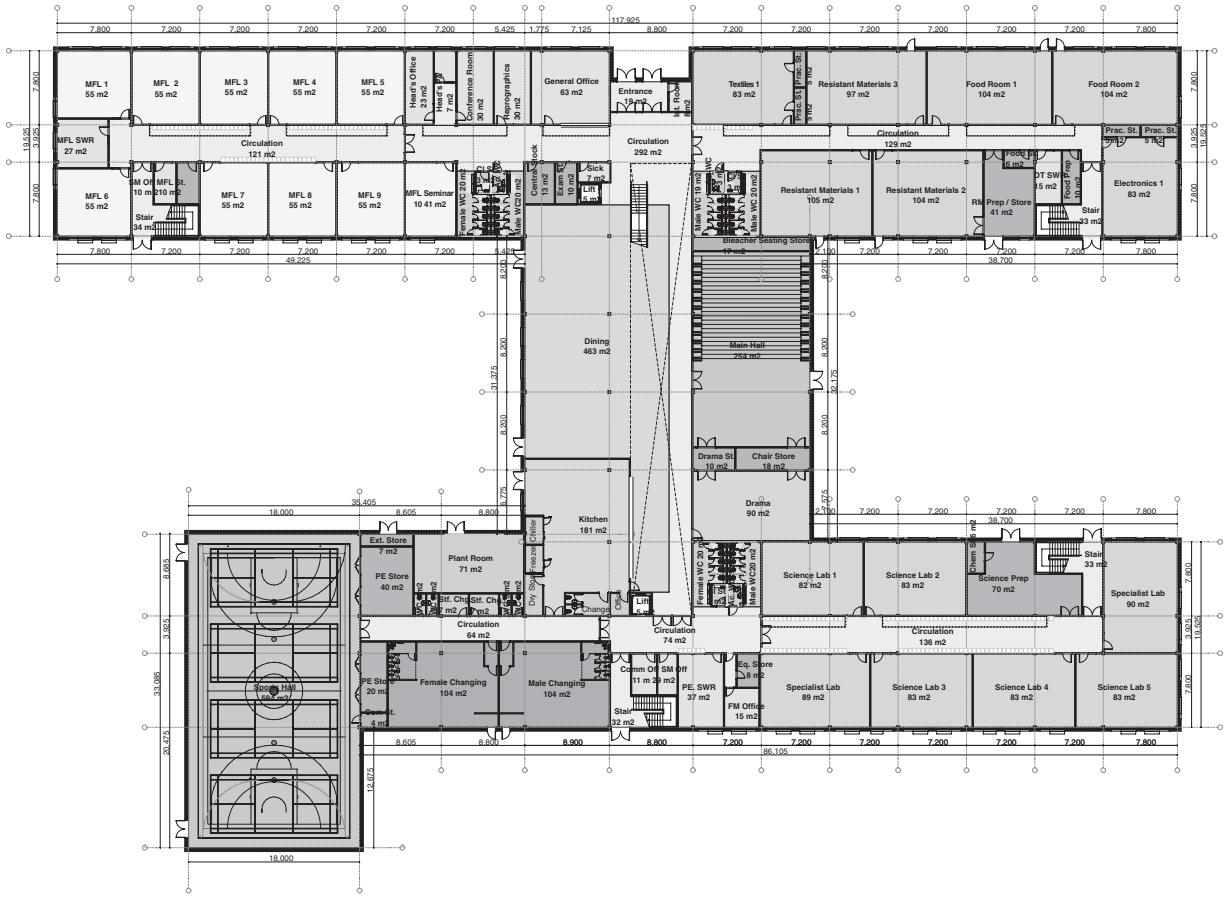
This organisation is still relevant and with good design can be made into a very flexible, educationally driven solution. However education theory and practice often moves architects to consider other ways of organising schools.

At one end of the spectrum is the *'schools within schools'* model, which brings a series of spaces together to cater for the needs of a particular cohort, of, say 150 students. They would be provided with the majority of facilities required to enable the group to remain in this area for the majority of the time, only moving away to access very specialist facilities or to participate in sports. Typically, the group would have a series of general classrooms,

ADS Code	Zone	Area Data Sheet (ADS) name and description	Size used in SoA tool
CLA02	C	**Seminar room:** For smaller 14-19 groups with a range of FF&E layout options and activities	41m² for 30
CLA12	C	**General classroom:** For a range of FF&E layout options and activities	55m² for 30
CLA13	D	**Extensive classroom:** Suitable for all classroom FF&E layout options and activities	62m² for 30
CLA32	D	**ICT-rich classroom:** With fixed ICT devices for all workplaces and a range of FF&E layout options	62m² for 30
CLA35	D	**ICT-rich learning area:** Semi-open plan area with fixed ICT devices for all workplaces and range of FF&E layout options	62m² for 30
CLA41	D	**ICT/business studies room:** Classroom with fixed ICT devices for half of the workplaces with business environment	62m² for 30
DAT02	F	**General art room:** For a range of FF&E layout options and activities suitable for general 2D art	83m² for 30
DAT03	G	**3D art room:** for general and 3D art including clay work	97m² for 30
DAT05	G	**3D art room (textiles):** For general artwork and printing techniques and 3D art	104m² for 32
DAT12	H	**Hair and beauty salon:** for hair styling and beauty therapy	69m² for 16
DAT22	G	**Graphic products:** For graphics and light, small scale product design	83m² for 25
DAT25	G	**Constructional textiles:** For working with textiles	83m² for 25
DAT28	G	**Electronics and control systems:** For electronics, pneumatics and light, small scale product design	83m² for 25
DAT32	F	**Food studio:** for demonstrations of food preparation	69m² for 24
DAT35	H	**Food room:** For non-vocational practical cookery activities by pupils in pairs	104m² for 24 if 1 space, 97m² if 2
DAT43	H	**Resistant materials workshop:** for working with resistant materials and electronics	104m² for 24 if 1 space, 97m² if 2
DAT46	I	**RM workshop with heat bay:** For working with a range of resistant materials, including wood, metal and plastics	111m² for 24
DAT49	J	**Construction workshop:** workshop for vocational construction courses	97m² for 16
PER01	D	**Music classroom:** for performance, composing and theory	62m² for 30
PER02	E	**Extensive music classroom:** for performance, composing and theory, with option of keyboards for all pupils	69m² for 30
PER04	F	**Music recital/drama studio:** studio space for drama and large music recital room combined	83m² for 30
PER05	F	**Drama studio:** studio space for drama	90m² for 30
SCI02	E	**Science studio:** For demonstration and light experiments	69m² for 30
SCI05	F	**General science laboratory:** For demonstration and a wide range of 'hands on' experiments	83m² for 30
SCI11	F	**Specialist science laboratory:** For demonstration for all types of experiments, up to A-level	90m² for 30

36.11 *Key area formulae from BB103 by DfE*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



36.12 *Education Funding Agency Baseline Design (ground floor) for an 1850-pupil Type 1 secondary school*

breakout facilities and small group rooms, and also a number of specialist facilities to provide technology and science facilities. The group would have direct access to a varied landscape. Dining could be communal or taken in the breakout space of the school dependent upon the philosophy.

This model brings together the positive mentor relationships between a small group of students and staff who would essentially deliver all teaching and learning to the group all of the time. The model is particularly adaptable to project-based learning where cross subject teaching is implemented. Often the school would be designed so that each school could be adjusted to create larger or smaller groups as the circumstances dictated.

A similar but less radical model is the creation of '*home base'* spaces within a school, with group teaching spaces around them. These can be designed to accommodate a year or house group rather than necessarily being purely subject based. Specialist spaces can be positioned remotely from the home base for efficiency of use. Again, the organisation principle is that the student would spend the majority of time relating directly to the group in cross-subject teaching relating directly to a smaller number of teachers and mentors.

9.5 Site organisation

The key principles of organising a school site are to:

- Create a positive public domain, which welcomes the community onto the site.
- Create distinct public and private domains that create a safe working environment for all.
- Create a clear separation of vehicular traffic and pedestrians and organisation of drop off and pick up.
- Create a diverse landscape that enhances the curriculum.
- Optimise the orientation of buildings and indoor and outdoor space to make the most of the climatic conditions and help create a sustainable solution. This needs to be considered in the earliest stages of design.

Schools are major buildings in their local communities. New school buildings create a sense of local pride and the architecture and design should respond positively to these issues. Creating a positive public domain is critical to the way in which the school announces itself to its local community and many school designs incorporate plaza type spaces for the community to inhabit. Car parking and accessibility for bus drop off and pick up is a major logistical issue on any school site, and must be designed logically and to enhance safely.

9.6 Landscape and recreation areas

BB103 Annex B provides guidance on the provision of the net site area and playing field provision. Often the planning authorities will ask for the views of Sport England to be considered during the planning process. Provision includes:

- Sports pitches.
- Games courts (MUGA).
- Soft informal and social areas.
- Hard informal and social areas.
- Habitat areas.

The diversity of the landscape and the learning environment that it provides is key to creating a successful school environment. The Faraday Project, a research project into the teaching of science by the DfE, places a significant importance on the development of a creative landscape for learning.

The development of successful social spaces is also critical to the development of social skills in young people and the relationship between dining and external areas as overspill space is an important consideration.

On more confined sites, the creative development of sports facilities, including mountain bike tracks and trim trails, are often incorporated to encourage the maximum use of sporting facilities and also encourage students who dislike team sports to become

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

active. All weather facilities allow much more intensive use and synthetic pitches can be a significant community resource, particularly when used with floodlighting, and so can be counted as double in the space provision in BB98.

9.7 Community use

Secondary schools are seen as major community resources and as such are often open for many more hours beyond the school day for:

- Serving the extended schools agenda and also encouraging students to remain in school to undertake homework, use ICT facilities or participate in group activities.
- Accommodating other local authority services, community police, and health facilities.
- Crèche services for students and the wider community.
- Significant community facilities such as libraries with associated cafe. It may be part of the ethos of the school to allow the community to access such facilities during the school day. Clear lines of security and separation are needed to ensure that this is done elegantly.

The design of a new school should be zoned in both security and environmental terms to accommodate community use. A clear and simple zoning strategy will allow the building to be operated out of hours at minimal cost by minimising attendance and heating and lighting use.

9.8 Reception and social spaces

It is common practice provide a single point of entry for all users of the building, students, staff and visitors alike. Therefore a key requirement is to be able to receive high volumes of people efficiently and effectively while providing a pleasant environment that will engage visitors in the work and ethos of the school. This involves detailed design of reception spaces, and the ability for the reception to have a direct connection with other parts of the school.

Administration facilities are positioned adjacent to the reception. These are an extensive facility dealing with school finances and the administration of student records etc.

Social spaces for students are important. They can act as break out spaces for teaching and learning when not in use, but also help to give the students a sense of ownership, as well as providing space where lockers, if required, can be easily accessed. Often these are provided for each year group. They can also form home base spaces for student groups.

9.9 General teaching spaces

BB103 provides sizes of teaching spaces and associated storage based upon the group sizes. General teaching spaces need to provide a flexible environment and are often grouped in curriculum areas. Furniture needs to be flexible and easily moved and stored to enable the room to accommodate various teaching and learning settings. These settings may need to be changed quickly.

All services will be to the periphery of the room. These will consist of power and data facilities. ICT will often be wireless and connected through lap top computers as non-specialist activities use less memory.

Within each group of general classrooms it is useful to have a flexible dividing screen between two rooms to provide a larger space for activities, lectures or small examinations. Flexible screens are expensive and are compromised in terms of acoustics, however when used judiciously they can add great flexibility to a working environment.

9.10 Science

The development of science teaching environments has been greatly influenced by the Project Faraday publication by the DfE, Figure 36.13. This is an exemplar study into the range of spaces required to deliver the teaching of science in the new century. Many of the studies suggest a mix of spaces, moving away from purely using the traditional science laboratory to the development of science studio spaces. These spaces are usually central to a suite of laboratories but are lightly serviced spaces that can flex to become a large demonstration space for experiments, a space where results are collated using ICT, or a flexible breakout space from the surrounding laboratories. Preparation facilities are often centralised in the department to provide a facility for the preparation of materials for lessons and the storage of equipment.

Laboratories are also now more lightly serviced and flexible, with servicing, water, gas and electricity, to the periphery of the room. This gives flexibility to the centre of the space. Rooms within the department are often more open with the use of glazed screens creating visual links between spaces and creating a more professional world of work environment.

Science is also taken out of the classroom into the whole school site using the built and natural environment as the backdrop for the exploration of science, creating, for example, living recycling systems.

9.11 Technology

Technology is the subject that most naturally replicates the world of industry, and incorporates subjects that design an object or product, then creates the product and markets it through graphics and media. Technology studies are also expanding to include vocational subjects such as land-based studies, food and catering and construction as part of the expanding 14–19 agenda.

A typical technology department will have a series of specialist spaces in enclosed areas around a central space that will be ICT based, possibly a design subject. The whole department will often be open with glazed screens between rooms. Often spaces of a similar type, for instance resistant materials, will be joined to give an open studio feel. This also ensures access to equipment so that expensive machinery is not doubled up.

Guidance on areas for each subject area is given in BB98, Figure 36.11, the spaces are much larger than general teaching spaces, usually between 90 and 130 m^2 depending on the subject. The storage and preparation facilities for the materials, equipment and tools associated with these areas are also large. In addition, secure storage for students' work is essential – both work in progress and completed work awaiting final assessment.

ICT is usually hard-wired fixed machines which can use high memory capacity for design and graphics programmes. This usually increases the cooling load on the spaces.

9.12 Art and design

Often associated with technology, these spaces can create an open studio feel. When possible, spaces should be higher than standard floor-to-floor height. This can help the display and storage of work. 2D art rooms can often be used with textiles, whilst 3D art rooms are often self-contained. Ceramics is dusty and the need to provide a separate kiln space often precludes pairing ceramics with other art subjects.

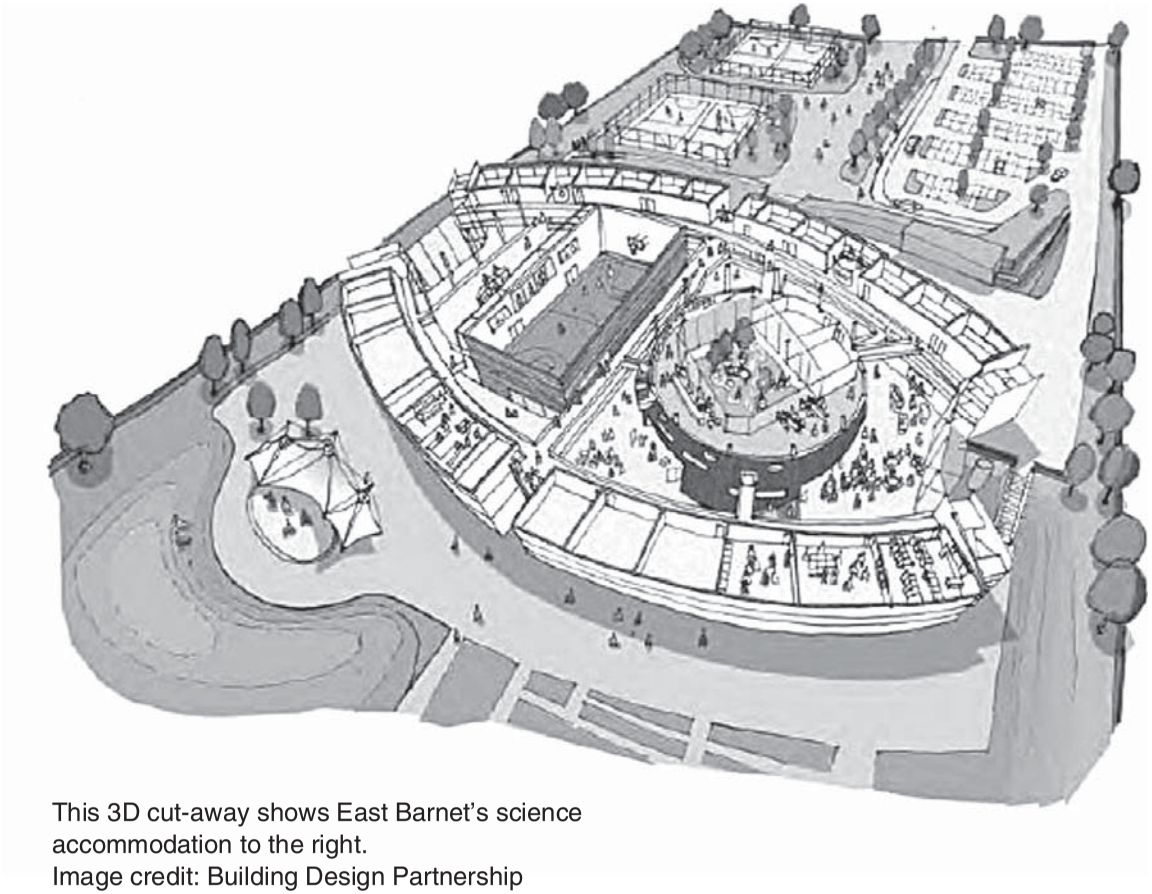
9.13 LRC (Learning Resource Centre)

With the increasing use of ICT throughout schools, the LRC is no longer the hub of technology and the trend is for the spaces to revert to the written form. Often a LRC will have a series of areas from informal lounge area to formal teaching area that can be used for lessons when needed. Community use of these spaces for internet access is high and some schools encourage this during the school day and provide refreshment facilities. In these circumstances, the operation and security arrangements need to be very carefully considered.

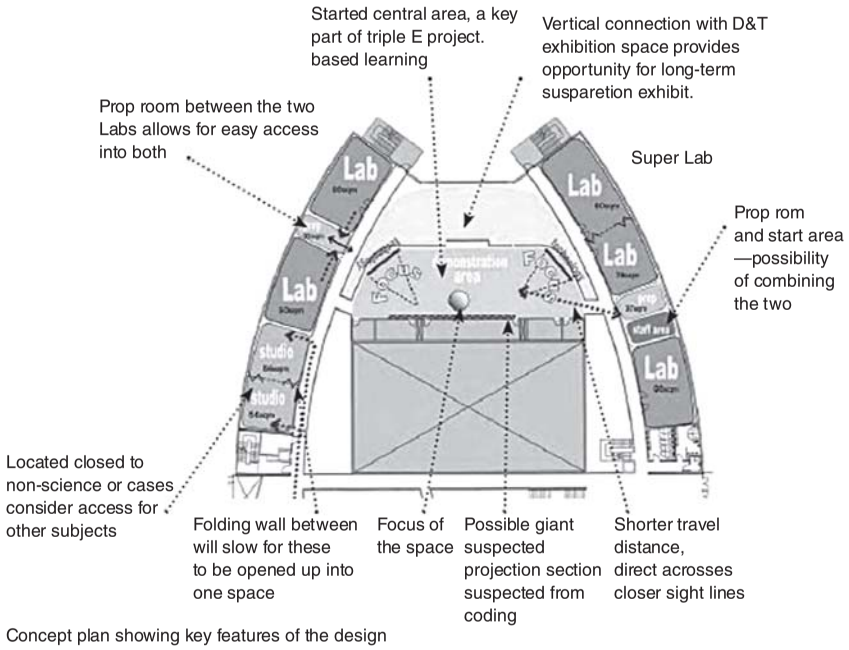
The environment should be bright and stimulating and given the high degree of community access, schools often display the work of the students and their outreach work to the community.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



This 3D cut-away shows East Barnet's science accommodation to the right.
Image credit: Building Design Partnership



Concept plan showing key features of the design

36.13 *Project Faraday design by DEGW and BDP*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

9.14 Music and drama

Often grouped together, the larger dance spaces may also double up as activity studios with the sports department. Music other than group performances in the hall or other small performance spaces takes place in smaller group or ensemble rooms, with one or two larger rooms for teaching. The acoustic qualities of these spaces are a key consideration, as is the provision of secure storage since instruments are often large and expensive. Storage is often used as an acoustic buffer between spaces.

Dance spaces need extra height and the use of sprung flooring with a series of curtains and mirrors. Drama spaces often benefit from extra height for lighting for rehearsals. Neither space is elaborate.

9.15 Hall spaces

Hall spaces need to be flexible and offer themselves to as many uses as possible such as performances, parents' evenings and assemblies (but not of the whole school as the space is seldom big enough). As sports halls are often used for examinations they need to have some acoustic isolation, although the trend is away from this as examination pressure can often be taken up in other ways.

9.16 Dining

Dining is often seen as a social experience that is part of the development of the whole child. Staff are also encouraged to use the facilities to help create positive relationships. Therefore dining periods are being extended to make the experience more pleasurable and more detail is being placed on the design and operation of the facilities, particularly the installation of FFE and the provision of outdoor dining.

Often dining is divided into several offers ranging from a full service incorporating hot meals, salads and jacket potatoes, to a sandwich take away often located away from the main dining areas.

Kitchens are designed by specialist catering designers in order to ensure that hygiene regulations are met and also that the throughput of pupils to be served in the time allowed is met. The architect should see that the kitchen design is coordinated into the design concept for dining.

9.17 Staff facilities

A welfare room with associated toilets is provided for staff. This will vary in size and capacity dependent upon the ethos of the school and the function that is to be met. WCs should also be provided at strategic locations throughout the school, within regulation distances. Staff should not share WCs with students. Staff offices and workspaces should be located strategically throughout the school in order to maximise passive supervision.

10 SPECIAL EDUCATIONAL NEEDS PROVISION

10.1 Strategy

The government's strategy for students with Special Educational Needs (SEN) is set out in the DfE document *Removing Barriers to Education*. This sets out the policy framework for local authorities and schools to follow and is aimed at assessing the needs of pupils quickly and developing a personalised plan for learning. This can be set within mainstream or more traditional special school settings dependent upon the abilities of the pupil.

Following on from this document there has been a move toward accommodating pupils with fewer difficulties in mainstream schools and also to co-locating special needs provision with mainstream. This is either on the same campus or within the same building and creates a design challenge to integrate students while protecting the most vulnerable.

The landscape of special needs provision has changed significantly in recent years and the design guidance has been updated in the form of Building Bulletin 102: Designing for Pupils with Special Educational Needs. This replaced Building Bulletins 77, 91 and 94.

10.2 Provision within mainstream schools

Accessibility legislation in recent new build schools ensures a certain level of accessibility for students with mobility, sight and hearing issues. However, to accommodate pupils with more complex issues, schools may have to be adapted to the particular needs of an individual student.

Often schools will encompass a unit to address particular issues, for instance autism, or hearing or sight impairment. These are located within the school but the design of the learning environment will be tailored to the special need that the space addresses. This has become increasingly common as authorities seek to accommodate students with less complex needs in mainstream education. This is to ensure the entitlement of the individual pupil to a full and fulfilling education.

10.3 Special school provision

The move toward personalisation of education and the emphasis on the uniqueness of the individual has removed a significant amount of generic terminology in special school design. No longer are schools for Moderate Learning Difficulties (MLD) or Profound and Multiple Learning Difficulties (PMLD) students, schools must have the ability to react to the needs of all students. Often schools will accommodate students with completely varying ranges of abilities across the whole spectrum of special needs. BB102, Figure 36.14, neatly summarises within Annex F the key definitions and issues relating to the various difficulties that pupils may have. Schools may also be of all-through age ranges.

10.4 Areas and space

BB102 provides a series of schedules and design examples for the provision of special school facilities. These provide areas per pupil ranging between 40 and 45 m^2 per pupil – significantly higher than mainstream schools. A classroom of 65 m^2 usually accommodates 8 to 10 pupils dependent upon their abilities and age. Schools will have a mix of general teaching and specialist spaces; specialist spaces for art, food technology and ICT are most common.

Particular areas to consider when designing for SEN include:

- A significant area for the equipment to support the pupils in the teaching space and to create a series of learning environments within the room.
- A direct and level link to a covered and secure outdoor space is essential. Often schemes are centred around an external court with raised beds and sensory gardens.
- Significant areas should be given to non-teaching space, for instance large hygiene facilities adjacent to general classrooms often with hoists to assist the less able students.
- Large areas for the storage of equipment. Often pupils will have more than one wheelchair and will change from one to another on entering the building.
- Medical facilities for visiting peripatetic clinicians.
- Hydrotherapy pool for physiotherapy with associated changing facilities.
- A sensory environment with soft furnishings, lighting equipment and music.
- A central hall that is easily accessible. This is important because it is common practice for pupils to gather morning and evening for arrival and departure via mini buses and taxis. The hall is often multi use for sport and dining dependent upon the size of the school.
- External spaces need to be secured and sheltered from the elements and have a variety of surfaces. Planting is often raised in order for pupils to be able to access the plants.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Children's need	Typical support	Design issues	Space needed in classroom for…
Cognition and learning			
Specific learning difficulty SpLD	3D learning aids; occupational and/or physiotherapy; learning, behaviour/speech & language (SpLg) support	Good acoustics for SpLg therapy; storage for learning aids; SEN resource base	Learning aids, ICT; practical work; flexible layouts for movement work; appropriate positioning of child in class
Moderate learning difficulty MLD	SpLg therapy; learning & behaviour support; social skills training	Good visibility for supervision; good acoustics for SpLg; H&S risk assessments; storage for resources and learning aids; SEN resource & specialist bases	Learning aids, ICT; practical work; flexible use of FF&E; appropriate positioning of child in class
Severe learning difficulty SLD	3D learning aids; multi-sensory work; adapted ICT; social skills & independence training; SpLg therapy; learning & behaviour support; physio-, occupational & hydrotherapy	Good visibility for supervision; wayfinding to aid independence; good acoustics for SpLg therapy; specialist SEN support; H&S risk assessments; storage & use of mobility/learning aids	Multi-sensory and practical activities; learning aids, ICT; flexible use of FF&E; movement and circulation (some mobility aids); additional support staff
Profound & multiple learning difficulty PMLD	3D learning aids; multi-sensory work; sensory impairment support; SpLg therapy; occupational, physio- and/or hydrotherapy; medical & personal care; soft play	As SLD but more space for greater support, storage and concentration of needs; higher accessibility standards; intensive use of mobility aids & hoists; H&S risk assessments: manual handling, infection control; storage and use of mobility & learning aids	Multi-sensory, practical & therapy work; adapted ICT & access technology; additional staff; flexible use of FF&E; movement and circulation (bulky mobility aids)
Behaviour, emotional and social development			
Behaviour, emotional and social difficulty BESD	Behavioural, cognitive, social skills support; learning mentors; social workers, educational psychologists, mental health service (CAMHS)	Good sightlines, balance between privacy and ease of overseeing children; secure storage; robust materials, tamper proof FF&E & concealed services; H&S risk assessments; large spaces for social and outdoor activities	Avoiding distraction and conflict; varying layout (e.g. separated or grouped tables); supervision; developing social skills; quiet/informal corner
Communication and interaction			
Speech, language & communication needs SLCN	Social skills support; learning & communication aids, synthetic speech production equipment, assistive technology; SpLg therapy; learning and behaviour support	Easily understood whole school layout with clear signage; good lighting, room acoustics and sound insulation; sound-field systems, extra ICT and associated services	Position of child in class; use of signs, symbols, communication aids and synthetic speech production equipment; SpLg therapy
Autistic spectrum disorder ASD	Learning & behaviour support; social skills programmes in class and by withdrawal; specialist ASD teaching approaches; specialist ASD resource base	Simple layout: calm, ordered, low stimulus spaces, no confusing large spaces; indirect lighting, no glare, subdued colours; good acoustics, avoiding sudden/background noise; robust materials, tamper-proof elements and concealed services; possibly H&S risk assessments; safe indoor and outdoor places for withdrawal and to calm down	Varying approaches; structured activities using ICT and FF&E; position of child in class; screened workstations; safe quiet place to calm down
Sensory and/or physical			
Hearing impairment HI	Use of CCTV; HI teaching strategies; oral signing; HI learning & communication support; Splg therapy & social skills training; audiology & HI assessment	Avoid distraction: low sensory stimulus & subdued colours; good quality low glare lighting, avoiding shadows & silhouetting; good quality acoustics, low background noise; visual alarms, sound-field systems, hearing loops; storage & maintenance of technical aids	Signing, communication worker; U-shaped or other layout for good visibility; visual aids/ICT/TV/CCTV; radio aids
Visual impairment VI	VI specialist aids e.g. tactile and visual aids, Braille, CCTV viewers, ICT text magnification, speech & sound output; VI teaching strategies; VI support by mobility training officer	Good quality ambient & task lighting & controls; visual contrast, cues, symbols, tactile trails & maps; good acoustics, low background noise, speech & audio aids; sounder alarms, H&S warnings; VI resource room; storage and maintenance of technical aids	Clear, safe uncluttered layout; specialist (e.g. tactile and visual) aids; adapted ICT
Multi-sensory impairment MSI	Visual, tactile, mobility, communication aids and multi-sensory work; varied support as needed; MSI assessment, 1-1 learning and behaviour work; soft play room	As for HI and VI: clear, simple layout for sensory wayfinding with visual, audio & tactile cues; good quality non-glare lighting; good quality room acoustics, no background noise; greater use of mobility aids, hoists & hydrotherapy (see PD); large store	Individual or small groups, with HI, VI, MSI workers; practical learning aids; multi-sensory work; adapted ICT & access technology; flexible use of FF&E
Physical disability PD	Learning and mobility aids, scribe, adapted ICT, communication aids, assistive technology; use of hoists, mobility aids; occupational, physio- & hydrotherapy; personal carers, nurse, medical and/or health care support	Higher accessibility standards; much bulky mobility equipment (independent or assisted use), equipment store, storage bays off corridors; H&S risk assessments: manual handling; shallow pitch stairs, rest places; hygiene & infection control; assisted emergency escape, evacuation lifts & safe refuges; space for carers & equipment storage; place for rest & respite; large equipment storage spaces	Learning & communication aids, adapted ICT, assistive technology; scribe, assistant, carers, occupational therapist; specialist adjustable height FF&E; equipment storage; movement & circulation (some bulky mobility aids)

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

10.5 Schools for students with behavioural, emotional and social difficulties

Behavioural, emotional and social difficulties (BESD) pupils often follow a curriculum the same or near to that of mainstream schools, albeit with a vocational emphasis. The emphasis is on re-engagement of the student with education and behavioural modification. The buildings and external environment are often secure to ensure that the pupils stay in place. The subjects taught will include, for instance, car maintenance at the upper years and are aimed at the need to provide the pupils with a transferable skill. Subjects such as this are also used to engage the pupils with education.

Buildings are often arranged around a court. Internal spaces are usually smaller than mainstream schools and accommodate fewer pupils. A series of chill out spaces are provided to give space to the individual as and when required. Sport and outdoor activity will often play a big part in the curriculum, through the provision of 5-a-side courts and indoor sports facilities.

Pupils often arrive alone or in small groups by taxi or mini bus. Drop off facilities very close to the secure main entrance are essential.

11 REFERENCES

The DfE publish a significant number of design guidance documents, which are available from The Stationery Office (TSO), formerly HMSO.

11.1 DfE regulatory guidance

School Premises (England) Regulations 2012
Assessing the Net Capacity of Schools DfES, 2001

11.2 DfE Building Bulletins

BB103 – Area Guidelines for Mainstream Schools
BB102 – Designing for Disabled Children and Children with Special Educational Needs
BB101 – Ventilation of School Buildings
BB100 – Design for Fire Safety in Schools
BB99 – Briefing Framework for Primary School Projects
BB98 – Briefing Framework for Secondary School Projects
BB96 – Meeting the Educational Needs of Children and Young People in Hospital
BB94 – Inclusive School Design
BB93 – Acoustic Design of Schools
BB92 – Modern Foreign Languages Accommodation: A Design Guide
BB91 – Access for Disabled People to School Buildings: Management and Design Guide
BB90 – Lighting Design for Schools
BB89 – Art Accommodation in Secondary Schools
BB88 – Fume Cupboards in Schools
BB87 – Guidelines for Environmental Design
BB86 – Music Accommodation in Secondary Schools
BB85 – School Grounds: A Guide to Good Practice
BB84 – School Boarding Accommodation: A Design Guide
BB83 – Schools' Environmental Assessment Method (SEAM)
BB82 – Area Guidelines for Schools – revised 2002
BB81 – Design and Technology Accommodation in Schools: A Design Guide
BB80 – Science Accommodation in Secondary Schools: A Design Guide
BB79 – Passive Solar Schools: A Design Guide
BB78 – Security Lighting Crime Prevention on Schools Series
BB77 – Designing for Pupils with Special Educational Needs: Special Schools
BB76 – Maintenance of Electrical Services Maintenance and Renewal in Educational Buildings Series
BB75 – Closed Circuit TV Surveillance Systems in Educational Buildings Crime Prevention in Schools Series
BB73 – A Guide to Energy Efficient Refurbishment Maintenance and Renewal in Educational Buildings Series
BB72 – Educational Design Initiatives in City Technology Colleges
BB71 – The Outdoor Classroom Second Edition
BB70 – Maintenance of Mechanical Services Maintenance and Renewal in Educational Buildings Series
BB69 – Crime Prevention in Schools: Specification, Installation and Maintenance of Intruder Alarm Systems
BB67 – Crime Prevention in Schools: Practical Guidance
BB95 – Schools for the Future: Designs for Learning Communities, DCFS, 2002

11.3 Other publications

Asset Management Plans Guidance, DCSF
Better Buildings, Better Design, Better Education, DCSF, 2007
Building for Sure Start: A Design Guide, Department for Education, 2005.
Bursars' Guide to Sustainable School Operation, DFES, 2006
City Academies2, DCSF
City Learning Centres: design guide, DfEE, 2000
Classrooms of the Future, DCSF, 2003
Client Guide to Developing School Buildings, RIBA Policy & International Relations, 2007
Community Use of School Facilities Guidance, Sport England, updated 2009
Design of sustainable schools – Case Studies, DfES, 2006
Designing schools for extended services, DCSF, 2006
Designing Space for Sports and Arts, DfEE/Sport England, 2000
Designing School Grounds, Schools for the Future, DfES, 2006
Exemplar Designs: concepts and ideas, DCSF, 2004
Energy and water management: A guide for schools, DfES, 2002
Equalities impact assessment: building schools for the future, DfE, 2012
Every Child Matters, DfE, 2003
Inspirational Design for Kitchen & Dining Spaces, DCSF, 2007
How to Combat Arson in Schools, Arson Preventions Bureau, 2004
Inspirational Design for PE & Sport Spaces Department for Education, DFES, 2005
Managing Schools Facilities guides (www.education.gov.uk)
Primary ideas: projects to enhance primary school environments, Department for Education and Skills, 2006
Project Faraday – Exemplar designs for science, DCSF, 2007
Sustainable Water Management in Schools, CIRIA, 2006
Standard Specification, Layouts and Dimensions Guidance, DCSF, 2007/8
Transforming Schools: an inspirational guide to remodelling secondary schools, DCSF, 2004
21st Century Schools Learning Environments, OECD, 2006
Year of Action – Top Ten Tips for Saving energy and water and reducing waste in schools, DfE, 2012

11.4 Useful websites

BECTA www.becta.org.uk
BREEAM www.breeam.org
CABE www.designcouncil.org.uk/our-work/cabe
Department for Education www.education.gov.uk
Design Share www.designshare.com
Design Quality Indicators www.dqi.org.uk
Ofsted www.ofsted.gov.uk
Qualifications and Curriculum Authority (QCA) www.qca.org.uk
Specialist Schools and Academies Trust www.ssatuk.co.uk

This page intentionally left blank

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

37 Security and counter-terrorism

Mark Whyte and Chris Johnson

Director, Security Consulting and Explosion Effects, TPS
Managing Principal, Gensler

KEY POINTS:

- *In the contemporary society, with an increasingly crowded urban environment, 'resilience' is the critical term: resilient not just against natural hazards but against all forms of criminality, terrorist attacks and the deadly threats*
- *The level of security provision should be such that would-be attackers – criminal, terrorist or simply anti-social – are dissuaded from targeting the completed scheme. Bluntly, their activities are either halted or displaced to an alternative, less well-protected site*

Contents

1 Introduction
2 Security design principles
3 Designing a system
4 Counter terrorism concepts and standards
5 References
6 Sources of advice
7 Appendix 1 Security risk register example
8 Appendix 2 Physical security concepts and standards

1 INTRODUCTION

Security has not traditionally been at the forefront of concerns when architects, planners and designers consider the central requirements of a new-build project. Aesthetics, accessibility, functionality and cost will trump security in most cases, save perhaps for specific high profile, military or secure facility projects. However, it is increasingly recognised that designers have a responsibility to consider security requirements. In the contemporary risk society, with an increasingly crowded urban environment, 'resilience' is perhaps the critical term: resilient not just against natural geo- and hydro-meteorological hazards (such as earthquakes and floods), but against all forms of criminality, terrorist attacks and the deadly threat of a VBIED (vehicle-borne improvised explosive device) detonation or CBRN (chemical, biological, radiological or nuclear) attack. This chapter covers the incorporation of security measures into projects to help address such threats and risks.

1.1 Definitions

For purposes of clarity and to ensure a common understanding some common security terms are explained

- Security: can be used to describe either:
  - The condition where our people, assets and interests are protected from harm or loss from criminality and terrorism.

or

  - The identification of threats and risks from criminality and terrorism and the measures taken to mitigate them.
- Physical security: these are hard measures put in place to help deliver security. It can include electronic systems (CCTV, access control, intruder detection) fences, gates, door sets, glazing systems, barriers and bollards.
- Counter terrorism measures: physical measures taken to eliminate or limit the impact of a terrorist incident on buildings and their occupants and on infrastructure.
- Hostile vehicle mitigation: the deployment of appropriately rated and designed barriers, blockers and bollards to constrain or prevent the movement of vehicles being used for terrorist or criminal purposes,
- Threat: threats are potential events or activities that have the potential to cause harm or loss and can be expressed as Threat = Capability × Intent.
- Risk: risk is a way of expressing the potential for a threat to cause loss or harm expressed in terms of probability and impact. This can be shown as Risk = Probability (of an occurrence) × Impact (of an event or threat).
- Risk treatment: these are the measures taken to reduce the impact and probability of an event and can include avoidance, transfer, mitigation or acceptance.
- Residual risk: this is the level of risk remaining once mitigation measures have been applied.

2 SECURITY DESIGN PRINCIPLES

In designing security measures for a project, the following principles should be considered:

- Deterrence
- Detection
- Delay
- Response
- Pursuit
- Reassurance

2.1 Deterrence

The level of security provision should be such that would-be attackers – criminal, terrorist or simply anti-social – are dissuaded from targeting the completed scheme. Bluntly, their activities are either halted or displaced to an alternative, less well-protected site. Deterrence can be achieved by measures that may include:

- Adherence to concepts such as 'defensible space' and security through environmental design.
- Visible security features including perimeter fences, CCTV and lighting. For those who have been granted legitimate access to a location, physical measures such as security turnstiles, internal CCTV and intruder detection will provide a strong visual deterrent. A determined attacker carrying out a hostile reconnaissance will identify these measures as well as less overt ones such as fence line Perimeter Intrusion Detection System (PIDS) and infra red lighting on fully functional Pan Tilt Zoom (PTZ) CCTV.
- The provision of vehicle access control measures.
- The deployment of a well trained and motivated guard force.
- Internal CCTV coverage within reception areas and loading docks.

2.2 Detection

Should someone wish to target a particular site, there should be a high probability that they will be detected. This may be during a

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

reconnaissance/planning stage by a determined criminal, or while in the process of committing a crime. Detection can be achieved through measures that include:

- A PIDS system on a perimeter fence that will detect cutting and climbing attacks.
- CCTV linked to PIDS to provide verification of the cause of an alarm.
- Fully functional PTZ cameras with a day and night capability to track attackers attempting to breach a fence line or building envelope.
- Detection system on external doors, access hatches and glazed services
- CCTV slaved to detection to provide verification of the cause of an alarm on any of these detectors.
- Access control and intruder detection on designated doors and rooms within buildings.
- Facilities for the screening of visitors.

2.3 Delay

Measures should be in place that are sufficient to slow an attacker down and to prevent an attack succeeding prior to a response being mounted by the security personnel or police. It therefore follows that speed of response must be linked to the delay that can be imposed through the use, for example, of appropriate external door and window sets.

2.4 Response

There must be a capability to respond to incidents or potential incidents rapidly. This may be by security or FM personnel or by the police, and can be achieved through:

- well-understood internal reporting systems for staff;
- local security control rooms;
- automatic response generated from remote monitoring centres.

2.5 Pursuit

In the event of incident in or around a site, sufficient information must be retrievable from electronic systems and manned security personnel to support investigation and, if required, prosecution. This is achieved through:

- the deployment of CCTV cameras specified to achieve 10%, 25%, 50% and 100% screen heights (images of subjects) matched to their location and role;
- the permanent recording and archiving of CCTV images;
- the recording and archiving of access control and intruder detection systems event records;
- the recording of reports by security and other personnel

2.6 Reassurance

Security provision must provide building occupants and visitors with the confidence that they are properly protected without creating an oppressive feel and should also instil confidence in all stakeholders. Measures can include:

- appropriate lighting levels and clear lines of site;
- the use of high reliability access control systems and other security devices with high availability and minimum false alarms;
- deployment of security hardware such as turnstiles and car park access control systems;
- procedures at staff and visitors access points that are efficient and professionally executed.

3 DESIGNING A SYSTEM

3.1 Integration

Security must be considered as a whole to achieve the vision and objectives of a given scheme. Integrated technical, physical and procedural measures, within the context of a threat and risk assessment, should be applied. No one item should be considered in isolation. The physical performance of a fence for example is considered in the context of the threat and risk; the capability of detection and surveillance systems; the ability of security guards to respond; and the policies and procedures that will hold the elements together.

3.2 Security planning

Security requirements should be considered as early as possible within the design process. The earlier it is considered, the more economic and operationally effective the solution. A suggested design process flow chart is shown in Figure 37.1.

3.3 Physical and technical security

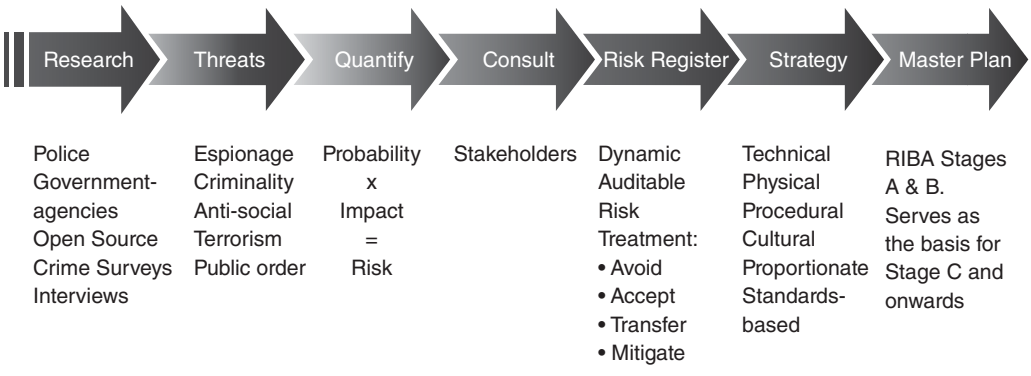
The following security measures fall into the category of physical provision. Professional advice should be sought regarding the application and design of such measures which are covered by a myriad of standards and which are discussed in more detail later.

- fences;
- perimeter intruder detection and surveillance;
- electronic access control;
- turnstiles;
- door and window sets;
- internal detection and surveillance;
- fixed and fully functional pan-tilt-zoom cameras;
- fixed cameras viewing points of entry.

The application of these measures will help deliver the following.

3.4 Surveillance and detection

A surveillance and detection plan should be considered for any scheme and will involve the deployment of technology alongside the concepts of natural surveillance and manned security. Surveillance can provide advance warning of an incident; support the management of an ongoing incident; provide a deterrent and



37.1 *An incremental approach to security design*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

support investigations. Importantly, CCTV can also be used to provide verification of detection system alarms.

3.5 Secure sites/building envelope

The integrity of buildings should be capable of being maintained 24 hours per day and can be achieved through measures that include:

- Robust construction.
- Electronic and physical access control arrangements.
- The surveillance of the building envelope by CCTV linked to detection technologies.
- The positioning of intruder detection on exterior doors and glazing.

3.6 Maintaining internal integrity of buildings

Ensuring that security threats can be kept outside of the building envelope, or within reception zones, is an important principle. The integrity of buildings can be maintained through the screening of visitors at reception areas, electronic access control systems or other local access control arrangements. It can be useful to consider a scheme in terms of security zones, each with their own security levels and standards. Typically zones would be:

- public areas such as building approaches and car parks;
- reception areas;
- operations areas where business is carried out;
- security areas such as data centres.

3.7 Procedural security

General

Technology and physical measures alone will not provide the levels of security required and there will always be a procedural and human element that will tie these measures together. Procedural security is also among the most visible of the elements of security provision and can be stepped up and down very quickly to respond to changing threats.

Scalability

Macro and micro security threat levels can rise and fall and the security posture within a location may need to be capable of being raised and lowered accordingly. Changing security postures can also act as a deterrent by creating uncertainty in the minds of would be aggressors and can serve to keep security personnel focused and motivated.

3.8 Manned security

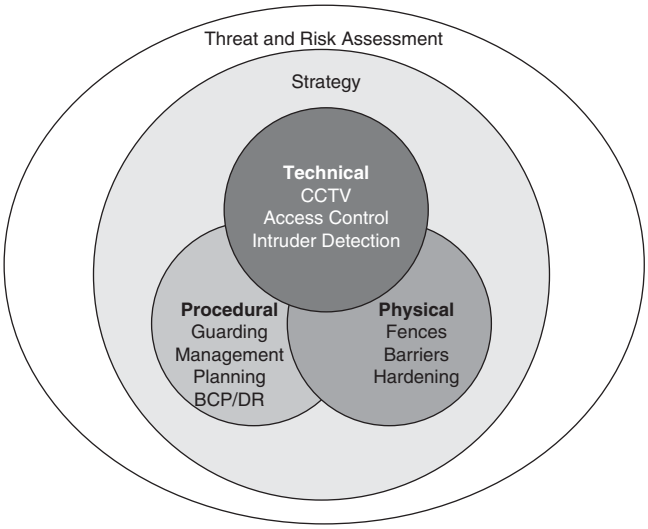
For certain sites and office locations manned security provision may be appropriate. Manned security can provide a uniformed, visual presence at designated points as a deterrent to criminality and terrorism and to provide reassurance to staff. Typical roles include:

- Operation of security control rooms, surveillance and detection equipment.
- Supervision and control of access control gate lines.
- Patrol of designated areas to detect and deter criminal activity and to provide reassurance.
- Reaction capability to respond to emergencies.

The relationships between the elements of an integrated security system are illustrated in Figure 37.2.

3.9 Standards and compliance

All technical, physical and procedural security should be designed and operated in accordance with the appropriate legislation, regulation and standards (e.g. Data Protection Act (1998), ISO, BS/EN). Where clients such as the MoD or insurers impose particular requirements, these must also be met. There is a wealth of freely available information on security planning, standards, tested products and their application which include:



37.2 *Elements of an integrated security system*

- Home Office Protecting Crowded Places Suite of Documents (2010)
  - Crowded Places: The Planning System and Counter-Terrorism
  - Protecting Crowded Places; Design and Technical Issues
- National Counter Terrorism Security Office Suite of Guidance Documents
- Secured by Design guides
- Private sector physical security standards:
  - Loss Prevention Certification Board (LPC) List of Approved Fire and Security Products and Services – The 'Red Book'
- Public Sector Standards:
  - Security Equipment Approvals Panel (SEAP) Catalogue of Security Equipment
- BS/EN and ISO

Applicable standards are covered in Appendix 2.

4 COUNTER TERRORISM CONCEPTS AND STANDARDS

Terrorism is the systematic use of terror especially as a means of coercion. An abiding characteristic is the indiscriminate use of violence against non-combatants for the purpose of gaining publicity for a group, cause or individual. The groups and individuals that practise terrorism in any one region will vary over time. Different groups and individuals will have different capabilities and resources, different objectives and different practices, and those of any one group and individual will develop over time. Although risk assessments at any one time can and should be based on current knowledge, a longer term view should also be taken into account when assessing the desirable levels of protection against terrorism for a new building.

The objective of counter-terrorism measures in buildings is to limit damage to the building fabric and injury to the occupants when an explosive device is detonated, and to limit the effectiveness of other forms of terrorist attack on the building and its occupants. They can serve either to reduce the probability of a successful attack or to reduce the consequences of an attack.

4.1 Types of attack and levels of protection

The major terrorist activity that impacts on the built environment is the use of improvised explosives devices (IED) in or near buildings

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

that will cause damage to buildings and injury, possibly fatal injury, to occupants of the buildings and their surroundings.

A wide range of IEDs have been used by terrorists. These include:

- lorry bombs
- van or truck bombs
- car bombs
- suitcase bombs
- pedestrian suicide bombs as waistcoats or rucksacks
- fire bombs
- parcel bombs
- letter bombs.

These show three basic forms of delivery:

- vehicle borne improvised explosives devices (VBIED);
- carried into place, generally inside a building, by a terrorist;
- through third party delivery services such as mail and courier services.

The counter terrorist measures appropriate to reduce the hazard from these different forms of delivery are generally different, and combinations of measures are generally required to protect against all IED threats.

At different locations and different times the relative risk of the different forms of attack will vary, depending on the capability of the currently active terrorist organisations. In locations such as the UK where bulk explosives materials are not easily obtained and access to key ingredients in bulk quantities is controlled, terrorist organisations require high logistical expertise to create large VBIEDs. This is not so critical in locations where explosive materials are readily available.

Subject to these relative risks, VBIEDs present the largest terrorist hazard to buildings and their occupants, as they are capable of causing extensive damage and risk to occupants across whole buildings and multiple buildings, and are capable of causing major damage and extreme risk to a building in close proximity. Counter terrorist measures to mitigate the consequences of VBIEDS may include:

- Hostile vehicle mitigation including barrier systems to keep vehicle bombs at a distance from the building.
- Location of delivery bays and visitor car parks to keep uncontrolled vehicles as far as possible from the building, and particularly out of basements.
- Access control, moving blockers and search facilities for vehicles allowed to approach or enter.
- Avoidance of features in the building at exposed positions that will enhance the blast loading from an explosion, e.g. re-entrant corners.
- Avoidance of features in the building at exposed positions that will reduce the strength, e.g. transfer structures at first floor with widely spaced ground floor columns.
- Enhancement of the building structure, particularly at ground and first floor level, to limit structural damage and prevent disproportionate or progressive structural collapse.
- Choice of facade design to reduce glazing area on exposed facades.
- Enhancement of glazed facades to reduce the risk of hazardous glazing fragments in the building, and to reduce any blast pressures entering the building.
- Choice of layout within the building to place low occupancy spaces at the exposed perimeter as a buffer area to the high occupancy spaces.
- Preparation of shelter areas within the building into which occupants can be evacuated in the event of a warning of immanent threat, in conjunction with suitable means of warning.

Smaller IEDs need to be closer to the building to cause a similar level of damage and hazard, and the damage will be more localised. Terrorists may try to detonate the IEDs inside the building, so visitor access control becomes critical. Counter terrorist measures to mitigate the consequences of carried or worn IEDs may include:

- Staff entrance separate from visitor entrance with pass and PIN entry control to reduce numbers at risk from visitors.
- Visitor reception and inspection in a dedicated satellite block separate from, but linked, to the main building.
- Baggage and visitor search and scan facilities on entry.
- Multiple search and entry lanes with protection between to reduce numbers at risk.
- Design of satellite block to vent internal package explosion.
- Security guards and suitable procedures and training.
- Blast and fragment protection to guard and reception positions when not directly interacting with visitors.
- Pedestrian access with external approach channelled perpendicular to facades rather than against the facades.
- Avoid locations where packages can be concealed close to or against the ground floor facade.
- Avoid deep and/or flat external windowsills at ground floor level where packages can be left placed against glazing.

Parcel or letter bombs may be delivered by innocent postmen or couriers mixed up with innocent deliveries. Bulk scanning of mail and other deliveries and inspection of deliveries too large for the scanner is required if such devices are to be excluded from the building. Counter terrorist measures to mitigate the consequences of delivered devices may include:

- Mail and delivery scanner located in the building.
- Scanner room on an external or courtyard face to vent internal blast outwards.
- Blast resistant container provided for suspect packages.
- Low occupancy buffer areas in rooms around the scanner room.
- Enhanced floor, walls, ceiling and door of the scanner room to avoid venting into the building.
- Mail and delivery scanning in a remote facility. This facility could serve more than one building. All deliveries to be made to the facility, and items to be transferred to the building after scanning in controlled vehicles only.

Other common forms of attack include the use of IEDs against public transport such as planes, trains and buses or against private motor vehicles and the use of firearms or other weapons against people, whether in the street, in vehicles or in buildings. These may affect buildings as collateral damage, even though they were not targeted at the building or its occupants. In general these are likely to be of less significance to the building design than a deliberate attack on the building, except for buildings that form part of the transport system such as airport terminals and railway stations. However, transportation threats may set a lower threshold for otherwise low risk buildings. For example, in the light of the London attacks in July 2007 it may be desirable to consider a pedestrian suicide bomb in the street as the minimum threat to be considered for any building on a bus route.

Less common but not unknown are chemical, biological, radiological or nuclear (CBRN) terrorist attacks. These are attacks on people using a vector carried usually in the air, but possibly also in the water supply. The building fabric will not be directly affected, but if the ventilation or water system has been used as a means of dispersion or distribution the contamination of the building may be a major problem.

Military level CBRN protection uses special charcoal filters for incoming air and positive pressurisation, or complete closedown with oxygen supply and carbon dioxide scrubbers. Entry and exit is very restricted requiring airlock and decontamination facilities and special clothing.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

This is very expensive and disruptive, and is limited to a few specialist buildings. For most buildings in the public or private sector, full CBRN protection is not warranted. However, some precautions in the design of ventilation systems can reduce the vulnerability of a building without ensuring complete protection. These may include:

- Separate ventilation system for visitor reception.
- Separate ventilation system for mail scanner room.
- Dual air intakes at high and low level that can be closed from the security control room depending on CBRN attack vector – aircraft or ground released.
- Ventilation mode to pressurise building by increasing input fan and recirculation and reducing exhaust fan – to be implemented from security control room.

The alternative choices, combinations and levels of counter terrorist measures considered suitable for any particular building will depend on the risk assessment, the dual purpose measures that will be implemented anyway for other reasons, the available budget and the acceptability of the residual risks. It is not expected that all terrorist risks can be eliminated, but by prioritising the appropriate protective measures the overall residual risks can be minimised.

Many protective measures will have little or no financial cost if they are incorporated from the start in the site masterplan and the building layout, but would be very expensive to implement at a later stage, either as a change in construction or a retrofit. Some active measures such as body and baggage search can be adjusted to match the current threat level, but only if provision for them has been made in the design, in the form of space and power supplies at the appropriate location in the visitor reception.

Early consideration of counter terrorism needs and the constraints that they may impose on other aspects of design is desirable to produce a building with an appropriate and flexible level of protection.

4.2 Blast loading on structures and facades

Blast waves are shock waves in air initially travelling away from the source, and are caused by a sudden release of energy, for example by the detonation of a chemical explosive. The blast wave takes the form of an abrupt rise from atmospheric pressure to a peak pressure, and then a rapid but gradual reduction in pressure back to atmospheric pressure (the positive phase), followed by a longer period of reduced pressure that eventually returns to atmospheric pressure (the negative phase). The positive and negative impulses are the areas under the overpressure-time curve over the positive and negative phases respectively.

The parameters of a blast wave depend on the quantity of blast energy, that is the mass of explosives, and the distance from the source. The parameters can be related to a unit charge using a scaling factor equal to the cube root of the explosives weight, and evaluated for a given scaled range, that is the range divided by the scaling factor. For example, a charge eight times as big at twice the range will produce the same peak pressure over twice the time and hence produce twice the impulse.

Different explosives materials release different energy, and so will produce different blast levels. These are often related to trinitrotoluene (TNT) as a 'standard' explosive. Many military explosives are more powerful than TNT, but many home made explosives (HME) used in IEDs are sensitive to variations in manufacture, and can vary from failure to detonate at all to power greater than TNT. In many cases a TNT equivalent of IEDs has been assessed from the extent of damage caused.

As a shock wave expands from a detonation it interacts with obstructions, reflecting off exposed faces and refracting around corners to load non-exposed faces. A blast wave moving parallel to a face is not modified, but exerts a transient load equal to the pressure history on the face. Reflection of a blast wave from near perpendicular faces amplifies the pressures in the air against the face, and hence the loading on the face. For intense shocks the positive pressures can be amplified by reflection factors up to 8, but for weak shocks the reflection factor will be just over 2, and the reflection factor of the negative phase will be less than 2.

For simple geometries of an air burst with no interaction before reaching the building, or a ground burst with interaction only with the ground, blast parameters can be interpolated by experienced blast engineers from accumulated blast trial data, using charts or simple computer programs. More complex streetscapes may include multiple and oblique reflections, refraction and clearing of reflected waves. Blast loading can be calculated numerically by an analyst modelling blast wave propagation in three dimensional models using Hydrocode or advanced Computational Fluid Dynamics (CFD) software.

For counter terrorist design, IED threats are commonly identified as a TNT equivalent charge size at a given stand-off range. However a common alternative approach is to specify a peak positive pressure and impulse. For a simple geometry, including for blast trials of cladding, these will have a one-to-one correspondence with a ground burst charge size and stand-off range from a building. For analysis the blast loadings are often simplified to a triangular pressure-time distribution and the negative phase ignored, although this may be conservative for some types of analysis and cannot assess rebound reactions.

For high risk buildings that are likely to be a direct target, a security risk analysis should identify specific locations where different charges might be placed taking account of different security measures such as access control and hostile vehicle mitigation, and the building structure and facade can then be designed to provide an appropriate level of protection from these site specific blast threats. For lower risk buildings where the probability of direct attack is small, some risks such as a lorry VBIED may not be designed against at the closest approach. Instead, design may be based on a generic threat level, say a car VBIED at 30m, and the possibility of a larger charge at this range or this charge at a closer range can be accepted as a residual risk.

The blast tests specified in BS EN ISO 16933 for arena blast testing of glass are increasingly being specified as generic threat levels, such as EXV25, with a peak pressure of 80 kPa and an impulse of 380 kPa.ms. This allows products that have been successfully tested to that level already to be offered for inclusion in the building without further blast testing.

Typical reflected blast loading on large facades from ground bursts that might be specified for design of blast resistant facades are given in Table I.

Threats would have to be significantly closer for these charges to be likely to cause failures of modern framed structures. Table II

Table I Typical blast threats requiring enhanced facade glazing

Threat	Charge size kg TNT	Stand-off range m	Scaled range m.kg$^{-1/3}$	Peak positive pressure kPa	Positive impulse kPa.ms
Lorry VBIED	1000	100	10	31.5	593
Car VBIED	100	25	5.39	87.1	537
Suitcase IED	25	10	3.42	236	564
Package IED	5	5	2.92	354	486

Table II Typical blast threats at the threshold of damage to conventional framed structures

Threat	Charge size kg TNT	Stand-off range m	Scaled range m.kg$^{-1/3}$	Peak positive pressure kPa	Positive impulse kPa.ms
Lorry VBIED	1000	40	4	162	1612
Car VBIED	100	10	2.15	846	1543
Suitcase IED	25	4	1.37	3334	1713
Package IED	5	1.5	0.88	11480	1808

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

shows the order of threats likely to cause limited damage to modern structural frames not designed for blast resistance. Significant damage could be expected in non-framed buildings subject to this level of loading.

Blast loading can be taken to fall into three types:

- Relatively small charges close in have total loading times much shorter than the response times of the target structures and facades. These loadings are called impulsive, and the degree of damage is likely to be related to the net impulse. For small scaled ranges the negative phase impulse will be substantially smaller than the positive phase impulse, and the net impulse will be a substantial proportion of the positive impulse. However, a larger charge at the same scaled range will cause the same degree of damage over a larger area which will cause a greater extent of damage.
- Very large charges at long ranges with positive phases much longer than the response time produce quasi-static loading where the damage is controlled by the peak pressure. However, this is more typical of petrochemical or distant nuclear explosions than IEDs.
- Between these extreme cases are dynamic loadings where both the impulse and the peak pressure will influence the response and a dynamic analysis is required to determine the response. The negative loading may have a significant effect.

In addition to the shock wave, a chemical explosion will produce an increase in air pressure due to the conversion of the explosives to gas and the heating of the air by the total energy of combustion, which is normally the combined energy of the shock wave and the afterburn that produces a fireball. In the open this residual gas pressure dissipates rapidly and does not increase the loading on structures. However, if the explosion is confined, the residual gas pressure will vent slowly and will produce a quasi-static loading on the confining surfaces in addition to the blast loading, which in itself will be amplified by multiple reflections. Even with moderate opening areas to vent the gas the gas impulse may overcome the negative phase of the blast and produce a positive impulse several times the enhanced blast impulse. Open venting area equal to one full side of a cubic volume, that is, $\text{Volume}^{2/3}$ is required for the gas pressure to dissipate as fast as the blast.

This gas pressure, combined with the multiple blast reflections, can result in much increased structural damage from a charge that explodes internally compared to the same charge outside the building. This is the reason that uncontrolled vehicle entry into basements for parking or delivery should be avoided, and why visitor entry control and delivery scanners should be external, or on an external face to allow rapid venting.

Design of a panel to resist external blast loading and yet to vent rapidly after an internal explosion is a careful balance using lightweight materials, and such a panel is likely to be substantially different from the normal building facade. Incorporating visitor entry or scanner rooms into the main structure will often require structural strengthening and compromises of appearance to maintain safety.

4.3 Structural robustness and disproportionate collapse

Large charges close to a conventional building will overwhelm the closest facades, generally on the lowest floor or two, and will cause local damage to the structure, most commonly to one or more ground floor columns at the perimeter. The structural design of the building will determine whether the immediate blast damage is the total damage, or whether the loss of structural support will cause further structural failures in the building, resulting in a progressive collapse of part or all of the building that may be completely disproportionate to the original blast damage.

Even large VBIEDS close outside modern multi-storey framed buildings will not normally cause immediate collapse due to blast loading. The loads are of very short duration and arrival times are staggered up the building. The mass of multiple floors is very large and will result in very limited overall response, often smaller than the sway expected in high rise buildings from a 3 second gust wind loading. In general, bracing systems for substantial buildings do not need to be considered for blast, and even in lightweight buildings with steel bracing the requirements are normally for stronger fixings rather than increased member strength. The large mass of the soil around foundations results in negligible blast response at ground level, and the effect of blast on foundations can be ignored provided the fixings of directly loaded members such as perimeter columns are adequate.

In extreme cases an internal detonation can demolish a substantial building, as was the case for the US Marine Barracks in Beirut in October 1983, where a 5.4 tonne TNT equivalent VBIED entered the building before detonating, causing complete collapse and 241 fatalities. However, this can best be prevented by Hostile Vehicle Mitigation to keep vehicles at a distance, designing out basement delivery bays and car parks close to loadbearing structure and entry control and inspection of vehicles that are allowed past the perimeter. Structural design to resist a major internal explosion is not likely to be an economic solution.

Disproportionate collapse of all or part of a building risks a major increase in fatalities and serious injuries, above those caused directly by the blast, and so is unacceptable. There are three main routes to avoid progressive collapse, often applied in combination:

- Prevent local failure of the structure, for example by increasing standoff from explosions or designing the ground floor columns to resist the blast loading without failure (although not necessarily without damage).
- Provide alternative load paths in the structure that can support the upper structure even if one or several adjacent ground floor columns are removed by analysing the structure with columns removed.
- Use prescriptive rules in structural Codes of Practice that are intended to provide alternative load paths in a damaged structure, that is, tying rules.

The robustness of a building is its insensitivity to local failure, which is provided by the second and third routes above. The standards for robustness in British buildings were set following the collapse of a full height corner of the 22-storey Ronan Point in May 1968 following a domestic gas explosion on the eighteenth floor, with four fatalities. These standards are incorporated into UK Building Regulations, and means of satisfying these standards have been incorporated into structural Codes of Practice. They are aimed at general robustness rather than specifically at bomb blast loading. Similar rules have been adopted in many other countries.

Loadbearing masonry buildings without vertical ties are inherently less robust because breach of the weakest parts of the facade (i.e. doors and windows) and blast entry causes uplift of the floors and roof, which removes lateral support to the loadbearing walls, allowing them to displace so that they cannot support the floors and roof against gravity afterwards. This is illustrated by the complete collapse of St Ethelbura's church 70 m from a 1 tonne bomb in Bishopsgate, London in April 1993, while framed buildings nearer to the detonation remained standing, even with column damage, and were reparable. Loadbearing masonry construction should be avoided for high risk buildings.

Because attack by VBIEDs will normally only occur at street level, some additional measures can be applied to enhance robustness of framed buildings under bomb blast loading. These are:

- Design the first floor slab and beams for reversal of gravity floor loading due to blast entering the ground floor and lifting the floor.
- Provide enhanced shear reinforcement at closer centres in perimeter ground floor columns to make the columns more ductile and less likely to fail catastrophically by shear.

- Provide main bracing systems for the building distributed in plan so that only part of the bracing system in any direction can be damaged by close proximity to a VBIED.

With the exception of increasing the standoff, most of this is the work of the structural engineer or a specialist blast engineer. However, these requirements should inform the architect's design, which should not work against them. For example, the use of a transfer structure at first floor level and fewer ground floor columns in the Alfred Murrah Building in Oklahoma reduced the alternative load paths, without the remaining columns being capable to resist blast loading. Failure of two or three adjacent ground floor columns on one face of the building under bomb blast in April 1995 resulted in a substantial part of the building collapsing with 168 fatalities.

4.4 Blast resistance of facades

The primary concern for blast resistance of facades is to prevent fragments of glass entering the building and injuring people. Monolithic annealed window glass is the weakest part of any building facade, breaks easily into jagged fragments and is ubiquitous in the built environment. As a result, glass fragments are the greatest source of injury in a blast in a built-up area. Glazing injuries can occur for hundreds of metres around a VBIED explosion, while other incidents may cause structural damage and direct blast injuries occur only within tens of metres of the explosion.

There are two possible solutions to the risk of glass fragments caused by blast. The first is to design the glazing not to break. However, for IED explosions this can result in very thick glazing that causes very high reaction forces on the window frame, which requires very strong structural supports back to the building frame. This may result in uneconomic facades that are not a realistic option for most buildings. This approach is normally required for quasi-static blast loads such as petrochemical explosions, but the low peak pressures make this design economic.

In-plane reactions from uncracked glass are small, so gasket, silicone and glazing tape bonding are all suitable, but the inwards and rebound reactions are very high, so the frames have to be very strong. One way spanning glass is less stiff and deflects further before cracking, and so may be beneficial for an uncracked design.

Bolted laminated glass systems have little strength at the concentrated supports after cracking, so bolted systems should be designed to remain uncracked under blast loading. However, bolted glazing systems will be substantially weaker than edge supported glazing, and are generally not recommended for blast resistant glazing.

The alternative solution is to design glazing that retains the glass fragments after the glass cracks. For new construction, this can best be provided by using a PVB laminated glass inner leaf in the glazing system, adequately anchored to the frame. Under blast-loading the inner leaf cracks and the PVB interlayer stretches, adsorbing energy and catching the fragments of the outer leaf if double glazing is used. This results in a lower reaction over a longer period that is easier for the frame and supports to resist, together with an in-plane reaction that tries to pull the glazing from the frame, so anchorage of the glazing into the frame is important to generate the full resistance of the laminated glass.

A similar behaviour is possible with application of anti-shatter film on the inside of existing glazing, but the limited possibilities for anchorage of the film and the limited strength of frames not designed to resist the reactions tends to limit the performance to the lower levels of blast protection. Unanchored anti-shatter film has frequently been applied to existing glazing and affords a limited enhancement in protection, mostly by bringing the velocity of glass fragments down to the mean velocity and reducing the exposure of sharp points and edges. The acrylic adhesives are degraded by ultra-violet light, so modern anti-shatter film has a useful life of about 10 to 15 years depending on exposure.

The outer leaf of a double glazed unit can be annealed, heat strengthened or toughened glass. The choice may have some effect on blast resistance, but will not be critical provided the inner leaf is laminated, as debris from a failed outer leaf can ride on the inner leaf and be expelled when the inner leaf rebounds. The choice of glass type is likely to be driven by other considerations like impact resistance, thermal shock or security against intrusion. Laminated glass can also be used in the outer leaf, but the performance of the PVB interlayers against blast may be reduced by high temperatures in the outer leaf, particularly if the glazing included thermal coatings.

Blast resistance is not fully standardised, so design threats tend to be site or client specific. Minimum standard threat levels for low risk UK government buildings are covered by recipe designs, with 6 mm toughened outer glazing and 6.8 mm thick laminated glass in conventionally designed metal frames. For more severe blast levels, blast testing or dynamic analysis informed by blast testing is the norm, using laminated glass with at least a 1.5 mm thick PVB interlayer and solid gaskets at least 30 mm deep or structural silicone at least 20 mm deep to anchor the glass in the frame. Fragility curves for a range of glass construction have been created by the Home Office for panes supported along all four edges. Derived from extensive testing, these are based on only two sizes of window pane, but provide an initial idea of performance. Glass is expected to crack, but the vast majority of fragments are expected to remain bonded to the interlayer. The interlayer will stretch as it deflects, adsorbing energy and slowing the response. Laminated glass has been demonstrated to deflect up to 32 per cent of the shorter span under blast loading without failure.

Gasket systems hold cracked laminated glass in position by framing and/or cover plates on both faces while a compression ring forms in the cracked glass to resist the tension in the PVB interlayer. This is only possible with support on all four edges of a glass pane. For windows of about 2 m^2 in size and aspect ratios up to about 1.5, blast tests have shown that stiff gaskets 30 mm deep will always provide adequate support and some systems with 25 mm deep gaskets may also be adequate. However, deeper gaskets and frame bites may be required for larger panes or higher aspect ratios. Gasket support of cracked glass is not amenable to calculation, and so needs to be demonstrated by blast testing.

Some structural silicones have been subjected to high strain rate laboratory testing that allows the strength of silicone anchorages to be calculated. Suitable silicone depths start from about 20 mm. Silicone supports are not sensitive to the size or aspect ratio of the glass, but are sensitive to the total thickness of PVB in the glazing make-up. Silicone can be used to provide single sided support against blast loading, but the silicone will also have to be designed for long-term support of the glass weight.

Blast trials of silicone attached curtain walling underpin the design approach, but new tests are not necessarily required for different cases.

Structural silicone can be used to support cracked one-way spanning laminated glass against blast loading on two opposite edges. However, slender glass plies must be avoided as they can cause failure of the silicone before the last ply cracks. Some modern glazing tapes at 25 mm width have been successfully tested to support glazing against moderate blast levels, but this is still under development and designs will currently need to be verified by testing.

For single windows piercing a stronger facade (e.g. masonry), frame enhancement only requires an increased bite to anchor the glazing and adequate fixings to resist the reaction and the in-plane tension in the PVB interlayer. For multi-panel windows or curtain walling, the transoms and mullions that span between supports will also require either to be designed dynamically for reaction from the glazing or proven by blast trials, but plastic deformation is permitted. Loadbearing structural supports of multi-bay glazing, such as columns that support the facade and roof, may also require to be designed dynamically for glazing reaction or blast loading, but should remain elastic.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Multi-bay glazing may be supported by a non-loadbearing secondary structure back to the main structure. When this works purely in bending it can be designed by dynamic analysis and allowed to undergo plastic yielding. However, some structures are designed to work as a truss with axially loaded members, or as a mixed system with both axial and bending forces on the members. These must be designed to remain elastic under the blast loading, and buckling of compressive members will need to be considered. Static buckling capacity limits are conservative but can be applied to linear dynamic analysis. Dynamic buckling assessment will require a nonlinear transient analysis which is very onerous. Specialist blast design advice should be sought as early as possible.

Where vulnerable supports such as glass fins or external fins prone to lateral-torsional buckling are used to support blast resistant glazing against normal loading, it may be necessary to incorporate secondary support systems such as cables to provide an alternative support path under blast loading. These in turn may impose large concentrated reactions on the building structure locally. Specialist blast design advice should be sought as early as possible.

Blast glazing design and materials are still developing rapidly, and various alternative solutions such as polycarbonate or glass clad polycarbonate glazing, ionoplast interlayers and cast plastic glazing materials are at different levels of development, experience and acceptability. Most of these are significantly more expensive than PVB laminated glass, and have additional issues such as deeper bites or larger reaction forces that need to be resolved. Specialist blast design advice should be sought before any of these alternatives are proposed.

Masonry facades are less vulnerable to blast than most glazing, but tend to resist blast primarily by inertia rather than strength. For a pressure high enough to crack the masonry, increasing impulse levels will cause more damage up to the collapse threshold. Injury can be caused by falling masonry debris even at low velocities. Some indicative capacities at the threshold of failure for brickwork or dense concrete blockwork are shown in Table III for well-supported storey height masonry panels. There will be significant variation around these values for panel sizes, support conditions and window openings. Lightweight blockwork will be more vulnerable.

Table III Indicative blast capacities of brickwork and dense blockwork

Masonry thickness Mm	Threshold pressure kPa	Collapse impulse kPa.ms
112	55	620
225 or 280 cavity wall	110	1240
340	165	1860

Facades of precast concrete cladding or structural reinforced concrete walls behind architectural cladding can be designed to resist substantially greater blast loading on a case-by-case basis, and should be the preferred choices where close-in VBIEDs are an expected threat, such as at vehicle entry control facilities. These facades can also offer substantial resistance to entrance of primary fragments from the device and secondary fragments of the delivery vehicle.

4.5 Blast testing of glazing

Blast testing of glazing systems is common, using either an explosives charge in front of a glazing unit (arena testing) or a focused shock wave created in a shock tube either by a small quantity of explosives or by compressed air and a bursting membrane. The standards on Arena and Shock tube testing, ISO 16933 and ISO 16934 strictly speaking cover testing of standard sized glazing in a frame of standard detail. In practice, the pressure and impulse combinations from these standards are also applied to systems of various sizes made with proprietary systems, and the fragment hazard. Threats in arena tests that represent VBIEDS are given in Table IV, while threats that represent package bombs are given in Table V. Comparable but not identical sets of tests apply to shock tube tests.

Table IV Arena blast test classification representing VBIEDs

Classification code	Mean airblast pressure	Mean positive phase impulse	Approximate Equivalent TNT charge for a large facade	
			Charge size	Stand-off
	kPa	kPa.ms	kg	m
EXV45	30	180	30	32
EXV33	50	250	30	23
EXV25	80	380	40	19
EXV19	140	600	64	17
EXV15	250	850	80	14.4
EXV12	450	1200	100	12.4
EXV10	800	1600	125	11

Table V Arena blast test classification representing package IEDs

Classification code	Mean airblast pressure	Mean positive phase impulse	Nominal TNT charge for a 2.4m × 2.4m cubicle			Nominal equivalent TNT charge for a large facade	
			Charge size	Charge level	Stand-off	Charge size	Stand-off
	kPa	kPa.ms	kg	m	m	kg	m
SB1	70	150	3	0.5	9	3.25	9.0
SB2	110	200	3	0.5	7	3.5	7.26
SB3	250	300	3	0.5	5	3.5	5.07
SB4	800	500	3	0.5	3	3.7	3.4
SB5	700	700	12	0.8	5.5	12	5.26
SB6	1600	1000	12	0.8	4	12.6	4.06
SB7	2800	1500	20	0.8	4	21.0	4.0

These arena tests are designed to be conducted using charges of no more than 100 kg TNT equivalent so that they can be conducted at any trial site licensed for that quantity of explosives. The number in the classification code represents the approximate stand-off in metres for a 100 kg TNT charge to produce the listed loading on a standard test sample mounted on the front of a 3 m × 3 m testing cubicle.

The reduction in impulse due to clearing around the edges of the support structure is taken into account in these values, so the same pressure/impulse combination would be produced by a different sized charge at a different range in front of a large facade with no clearing. However the loading at short range is impulsive so the damage is representative of that produced by a similar impulse but lower pressure produced by a larger charge at greater range.

The EXV 45 test was included to assess non-anchored anti-shatter film, and is not normally used to assess laminated glazing.

Because the package bombs will be at close range to smaller parts of a building facade, the fragment threat applies to smaller numbers of people and they therefore represent lower risks. It is rarely economically justified to undertake both VBIED and package IED testing for the same facade.

Shock tubes can produce an approximately triangular pressure-time history closely resembling the positive phase of a blast wave, but cannot produce a significant negative blast wave. They are therefore suitable either for impulsive short duration tests where the shock tube impulse can be compared to the net impulse from a charge at a low scale range, or long duration loading approaching quasi-static, where the peak response will occur before the end of the positive phase. They are least suited for the intermediate dynamic blast tests where the timing of the negative phase in a real blast will have a significant effect on the results.

Shock tubes generate a focused shock wave over a limited aperture. The equipment is more complex than for arena tests but requires less space. The number of shock tubes capable of emulating IED and VBIED blast over an aperture large enough to accommodate whole windows is small world wide, and there are currently none in the UK. The largest apertures are currently 3 m × 3 m, which cannot test full storey height glazing units.

In contrast, there are support structures available for arena tests that can support storey high curtain wall units or multi-bay test

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table VI Fragment hazard ratings from blast trials

Hazard rating	Hazard rating description	Definition
A	No break	No fracture or visible damage
B	No hazard	The glazing fractures but the inner leaf is fully retained in the frame with no breach or material loss from the interior surface
C	Minimal hazard	The glazing fractures but the inner leaf shall be substantially retained with total length of tears and edge pullout less than 50 % of the glazing perimeter (or more if firmly anchored and designed to pull out), plus • No more than 3 perforations in the witness panel • Sum total united dimensions of fragments between 1m and 3 m from glazing no greater than 250 mm • Glass dust and slivers with sum total dimensions less than 25mm are not counted as fragments
D	Very low hazard	The glazing fractures and significant parts are located no more than 1 m behind the glazing line, plus fragments as for rating C
E	Low hazard	The glazing fractures and fragments or the whole of the glazing fall beyond 1 m and up to 3 m behind the glazing line and not more than 0.5m above the floor at the witness panel, plus • No more than 10 perforations in the witness panel above 0.5 m • None of the perforations penetrate more than 12 mm.
F	High hazard	• more than 10 perforations in the witness panel above 0.5 m • One or more perforations more than 12 mm deep

facades up to about 10m high and 20+m long. Damage is assessed in terms of fragment positions inside the testing cubicle with a Styrofoam witness panel to intercept fragments 3m behind the glazing, as listed in Table VI.

BS EN 13123:2004 and the DIN standard from which it was derived have effectively been superseded by the ISO standards, but some existing test results may be based on it. The tests EXR1 to EXR5 closely resemble tests SB3 to SB7, but the hazard rating approach is different.

The ASTM F 1642 test specification is based on a late draft of the ISOs and contains effectively the same tests, but requires three tests for a certificate and has small but significant differences in the definitions of the hazard ratings. Some tests may also be aimed at meeting the US GSA blast standards. For these, the pressure-impulse combinations are different and may require a larger charge, but the hazard rating is similar in principal but different in definition and nomenclature.

Most common are Arena tests to the EXV test standards that are representative of 100 kg TNT charges at stand-off ranges between 45 m and 10 m from the sample. If the required level of protection for a building is specified, such as to meet EXV25(E), then manufacturers can provide reports on systems that achieved this performance in test, can test their systems to this standard or can provide dynamic analyses to demonstrate that their proposed systems should meet this performance.

The performance of a glazing system will depend on the size and proportions of the panes, so test results need to be for samples of a similar size. Test results for isolated windows are fairly common, and for panels with a mixture of opening lights or doors and fixed lights are available, but test results for storey height curtain wall panels are much rarer, as the test samples become more expensive to manufacture and support.

Tests for multi-storey, multi-bay facades have been conducted for a few facade designs. These are very expensive and primarily evaluate the supporting structure rather than the glazing units. For most facades the supporting structure can be evaluated by analysis so these tests are normally only considered for unusual supporting systems.

4.6 Bomb shelter areas and buffer zones

It is usually impractical to design a building to provide complete protection from all feasible terrorist blast threats, so most buildings leave a residual risk for occupants from the whole range of terrorist attacks. However, not all parts of a building will be equally vulnerable.

In the event of a warning of an imminent attack, the overall risk of injury and fatality can be minimised if the occupants of the building are temporarily moved to the least vulnerable parts of the building. This inwards evacuation of a building in the event of a bomb warning is more appropriate in the first instance than an outwards evacuation of a building which could take people into greater danger, particularly when the location of the bomb is still unknown.

Locations in a building identified or created as areas of low vulnerability are referred to as bomb shelter areas or protected spaces. In offices and similar buildings it is recommended that sufficient shelter areas are identified or created to accommodate all the building occupants temporarily and an inwards evacuation strategy be developed and practised, comparable to the fire evacuation strategy.

UK government recommendations for shelter areas include:

- 0.6 m^2 of floor area per person expected to use that shelter, but greater preferred.
- Ideally at least one per floor, but with maximum 90 m travel distance from any point.
- Reasonable access to toilet facilities (toilets can be part of the shelter area).
- Reasonable access to normal escape routes.
- Shelter areas can include staircases at 1.0 m^2 per person, but some unobstructed staircases desirable.
- Provision of adequate ventilation, perhaps by activation of smoke extract ventilation for shelter areas in enclosed spaces.
- PA from control room (also to shelter area standard) and telephone feedback.
- Located in the most robust parts of the building, ideally within solid internal walls or blast enhanced partitions.
- Remote from:
  - Extensive glazed elevations
  - External doors
  - Underground car parks
  - Gas and fuel lines and bulk storage
  - Areas prone to progressive collapse
  - Top floors under weak roof construction
  - Areas exposed to high blast and direct fragment hazard
- Ideally shelter areas should provide protection levels of:
  - Internal pressures less than 35 kPa (eardrum rupture threshold)
  - Doors to withstand a blast impulse of 450 kPa.ms
  - Glazing fragment hazard less than High Hazard
  - Shielded against perforation by primary fragments of the bomb and secondary fragments from the vehicle
  - No structural collapse and protected from falling debris

In many cases, areas that cannot offer the full specification will still afford substantial protection and are often termed deficient shelter areas. For example, in open plan offices the enclosed areas of toilets, staircases, lift lobbies and kitchens will often not offer enough area behind walls or partitions that resist fragments.

However, with a deep floor plate, the core open plan area can be substantially protected from fragments from an explosion on the ground. The fragments penetrate at a rising angle, and fast fragments hit the ceiling, while slow fragments fall back to the floor

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

before penetrating deeply. Similarly, for buildings with road access only at the front, open plan area behind the core but remote from the rear glazing may also be protected from fragments, even on the ground floor.

These areas may provide adequate shelter areas even though not enclosed. Glass walled meeting rooms in such locations may also be adequate provided the glazing is either laminated or toughened and fitted with anti-shatter film. Shelter areas are only of use if a suitable warning will be received and acted upon in the event of an immediate bomb risk. A number of police forces offer a warning service by automated messaging services to subscribing building managers. Procedures then need to be in place to call for an inwards evacuation when a valid warning is received.

In the 1980s and 1990s many bomb attacks were aimed at damage and disruption rather than fatalities, and bomb warnings by the terrorists were common. Now that the risk of suicide VBIEDs without warning is significant, police would need to have warnings from their intelligence sources that a bomb was in play and have a good idea of its target to call a warning in the vicinity. In these circumstances the benefits of shelter areas are reduced.

An alternative approach for high risk buildings is to provide buffer zones on the vulnerable periphery of the building, effectively turning most of the building into a large protected space. A wall or secure partition at the back of the buffer zone can provide additional blast protection and protection from bomb fragments and high hazard glass fragments if the main facade is overloaded.

Depending on the circumstances, the buffer zone may be unused dead space, sacrificed to give enhanced protection, could be used as unoccupied window display space, or could be filled with low occupancy spaces such as toilets, storerooms, plant rooms and service risers. These will provide both an increased stand-off of the occupied spaces from the charge, and space behind the visible facade to provide additional lines of protection to attenuate close-in blast affects, for example from a VBIED in the street immediately outside. This concept may have significant benefits in refurbishing existing buildings to enhance resistance to attack.

For high threat environments this concept can also be used to plan new inherently protected buildings. One example would be inwards facing courtyard buildings, with a shallow layer of low occupancy rooms around the outside perimeter and a circulation corridor between these and the main occupied spaces around the courtyard. The external facade would require only moderate glazing area, giving a less vulnerable facade, and the two corridor wall lines could be used to provide additional protection around the occupied space. The courtyard facades would be loaded only by indirect blast refracting over the building, and could be extensively clad with blast resistant glazing.

5 REFERENCES

The definition of terrorism, C.L. Ruby, *Analyses of Social Issues and Public Policy*, 2002, pp 9–14.

BS EN ISO 16933:2007 Glass in buildings – Explosion resistant security glazing – Test and classification for arena air blast loading.

BS EN ISO 16934:2007 Glass in buildings – Explosion resistant security glazing – Test and classification by shock tube loading.

RIBA guidance on designing for counter-terrorism. RIBA, London 2010.

6 SOURCES OF ADVICE

The Centre for Protection of National Infrastructure (CPNI) is a UK government authority which provides protective security advice to businesses and organisations across the national infrastructure. Their advice aims to reduce the vulnerability of the national infrastructure and crowded places to terrorism and other threats (www.cpni.gov.uk).

The National Counter Terrorism Security Office (NaCTSO) is a police unit co-located with CPNI. It trains Police CTSAs and the Argus Professional initiative to raise awareness of designing in counter-terrorism measures at the design stage. Its website includes general sector related guidance (http://www.nactso.gov.uk).

Police Counter Terrorist Security Advisors (CTSA) identify and assess local critical sites within their force area that might be vulnerable to terrorist attack; then devise and develop appropriate protective security plans to minimise impact on that site and the surrounding community. Architectural Liaison Officers (ALO) or Crime Prevention Design Advisors (CPDA) provide advice on crime prevention through the built environment to planners, developers, designers, builders, landlords and estate and facility managers. They will refer you to a CTSA if necessary. They can be contacted via your local police force websites or through www.securedbydesign.com.

The Register of Security Engineers and Specialists (RSES) is sponsored by CPNI and maintained by the Institution of Civil Engineers. The register lists experts who are able to provide a range of advice from initial risk assessment, potential design considerations and solutions, to design detailing and testing in the fields of security and counter-terrorism. The register can provide contacts in consultants that employ these experts (www.ice.org.uk).

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

7 APPENDIX 1

Security risk register example

RISK REF	ASSET	SITE	THREAT	PROBABILITY	IMPACT				RISK	MITIGATION MEASURES			RESIDUAL RISK (following application of E, D or AM mitigation measures)			RISK OWNER
					DENIAL OF SERVICE	LOSS OF REPUTATION	LOSS OF LIFE	FINANCIAL LOSS		ESSENTIAL	DESIRABLE	ADDITIONAL MEASURES	ESSENTIAL	DESIRABLE	ADDITIONAL MEASURES	
GEN1	London Head Office	Canary Wharf	TERRORISM - ALL	LIKELY	MAJOR	MAJOR	MAJOR	MAJOR	H	HVMM Security Doors, Turnstiles, Locks EACS, IDS, Guards, Postal Scanners, Hand Searches CCTV, Policies, Training	Hand Held FX Search Equipment, ArchwayFX Detection Equipment	Video Verification on ACS, Crime/ Security Analyst, Integrated C'I facility	M	M-L	L	
GEN2			PEOPLE CRIME	POSSIBLE	SIGNIFICANT	SIGNIFICANT	SIGNIFICANT	MINOR	M	Security Doors, Turnstiles, Locks EACS, IDS, Guards, Hand Searches CCTV, Policies, Training	Staff Lockers, cashless vending, staff & contractor vetting	Crime/Security Analyst, Lone Worker Protection Integrated C'I facility	L	MIN	MIN	
GEN3			PROPERTY CRIME	Likely	SIGNIFICANT	MINOR	MINOR	MINOR	M	Security Doors, Turnstiles, Locks EACS, IDS, Guards, Hand Searches CCTV, Policies, Training	Property Marking (DNA Tags) Register	Smartwater, SmokeCloak, RFID Tagging Integrated C'I facility	L	MIN	MIN	
GEN4			ENVIRONMENT	POSSIBLE	SIGNIFICANT	MINOR	MINOR	MINOR	M	CCTV, Policies, Training, Continuity & resillience co-ord & plans		Integrated C'I facility	L	MIN	MIN	
GEN5			SINGLE ISSUE	POSSIBLE	SIGNIFICANT	SIGNIFICANT	SIGNIFICANT	SIGNIFICANT	M	Security Doors, Turnstiles, Locks EACS, IDS, Guards, Hand Searches CCTV, Policies, Training	Intelligence/ Screening, Staff & Contractor vetting	Crime/Security Analyst Integrated C'I facility	L	MIN	MIN	
GEN6			CBRN	UNLIKELY	MAJOR	MAJOR	MAJOR	MAJOR	M	Security Doors, Turnstiles, Locks EACS, IDS, Guards, Hand Searches CCTV, Policies, Training	Air Filtration	Air Sampling/ Detection Integrated C'I facility	M-L	L	MIN	
GEN7			DISORDER	POSSIBLE	SIGNIFICANT	MINOR	MINOR	MINOR	M	Security Doors, Turnstiles, Locks EACS, IDS, Guards, Hand Searches CCTV, Policies, Training	Intelligence & Co-ordination	Crime/Security Analyst Integrated C'I facility	L	MIN	MIN	

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

8 APPENDIX 2

Physical security concepts and standards

Fences and Walls	Fencing may be used either round a property boundary, or to enclose specific buildings/areas within a larger site. The function of fencing falls into two general categories – (a) demarcation of property boundary only OR (b) Security fencing which provides levels of delay against forced entry/ intrusion. Note walls should be regarded as equivalent to fencing, and should specified in terms of height and anti-climb requirements.	Define whether the fence is required to demarcate site boundary OR meet a rated security standard. Where security fencing is proposed consider anti-climb and anti-burrowing solutions. Where anti-climb is applied minimum height requirements apply Planning Consent is a key constraint particularly when in close proximity to residential areas.	BS1722 – All Parts: Note security type fences are listed as below Part 10: Anti-Intruder fences from Chain Link and Welded Mesh Part 12: Steel Palisade Fences Part 14: Open Mesh Steel panel fences Part 17: Power fencing (superseding PAS47) Where fencing requirements are for installations that may be inspected by Government agencies, appropriate test standards and delay times should be specified. Refer to any 'Secured By Design' design guidance if applying to the client property
Doorsets	Doorsets can be specified to provide security protection against – • Physical/manual attack • Ballistics • Blast Define the requirements for each of the above security criteria, to achieve an attack time equivalent to walls and glazing for the structure. Security ratings for doorsets should apply where required to passive leaves and overpanels/sidepanels.	Consider DDA requirements e.g. Vision Panels/ Automation while ensuring Security rating is not reduced Consider emergency exit/panic exit requirements based on area occupancy. For any oversized doorsets (particularly loading bays etc.) LPCB ratings will be based on systems tested to a maximum size so note that oversized doorsets may not achieve accreditation.	PAS23-1:1999 PAS24-1:1999 LPCB standards — LPS1175 Security Rating (SR as appropriate) BS EN1125: 2008 Panic BS EN179: 2008 Emergency BS EN1522:1998 Ballistic Testing Where manual attack requirements for doorsets are for installations that may be inspected by Government agencies, appropriate test standards and delay times should be specified. Refer to any 'Secured By Design' design guidance if applying to the client property
Window sets			
CCTV	Closed Circuit Television (CCTV) can be utilised to provide surveillance and recording of areas of a client property. CCTV can provide a number of different functions dependent upon client requirement including the following: • Surveillance live monitoring of all images • Surveillance and recording (for post incident purposes) • Event triggered displays using CCTV to provide images of areas where intrusion is detected.	Define the function and therefore required image size and resolution **for each individual camera** based on the functional requirement i.e.: • Identification 100%R • Recognition 50%R • Observation 25%R • Detection 10%R • Monitoring 5%R Define the period for which images should be retained. Assess and define preference for IP based or analogue CCTV solutions (specifically considering impact on LAN bandwidth and resilience) Define early in the design process whether site lighting will be used for CCTV purposes, so that general lighting design allows for CCTV requirements. Alternatively specify suitable illumination to support CCTV, and compatible cameras. Establish all data protection requirements applying to CCTV in the environment. Confirm the system function with the client's data controller	BS EN50132:2001 All Parts Data Protection Act 1998 (DPA) Data Protection Act Code of Practice 2008 (issued by ICO) Refer to any 'Secured by Design' design guidance if applying to the client property

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Access Control			
Intruder Detection (IDS)	Intruder Detection Systems (IDS) can be used to provide detection and reporting of intruders either to off-site monitoring agencies OR to local security personnel on site. IDS can provide detection and verification of intrusions either as a stand-alone system; operating in conjunction with CCTV to provide a 'visual confirmation' solution; or as part of a site wide fully integrated solution.	Confirm whether the IDS is required to initiate Police attendance. Confirm the grading of system required, i.e.1–4 dependent on the nature of the property and assets. Where buildings require Listed Building Consent, full installation details including equipment types, method of installation, disturbance to building fabric, and any enabling works (cable routes etc.) should all be defined at design stage.	BS EN50131:2006 — All Parts PD6662:2004 DD243:2004 Where IDS forms part of an integrated system confirm any equipment proposed supports serial connectivity, and protocol interfaces/drivers to the Security Management System (SMS). Refer to any 'Secured by Design' design guidance if applying to the client property
Perimeter detection			
Search and scanning equipment	Search and scanning equipment is used to assist in the detection of weapons, explosives or chemical, biological or radiological material. Such material could be concealed on the person, in bags or sent via the mail or courier systems. Search and detection options are: A visual search Hand held search 'wands' Passage through metal detecting arch X ray of packages and cases Body scanning Explosive scanning CBR scanning Vehicle and Truck Scanning	Search and scanning will normally occur in reception areas, shipping and receiving areas or in designated mail/scanner rooms. Specialist advice should be sought on current technologies and equipment capabilities When designing such areas, considerations are: • The size of the search equipment. • Whether it is to be permanent, temporary or occasional • Visual screening of personnel search areas • Requirements for blast enhanced mail scanning rooms • Containment, particularly where temporary equipment may be required in foyer and reception areas.	PAS 97:2009 A Specification for Mail Screening and Security. Major Manufacturers: Smiths Detection www.smithsdetection.com Rapiscan www.rapiscansystems.com
Security control centres			

This page intentionally left blank

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

38 Sports facilities: indoor and outdoor

Philip Johnson and Tom Jones

Philip Johnson and Tom Jones are architects at Populous

KEY POINTS:

- *All sports are conducted on a field of play, whether that is a pitch, track, course, pool, field or court. The governing body for each sport will generally define dimensional requirements*
- *Within certain dimensional ranges, a number of surfaces are capable of accommodating a number of sports*
- *When planning indoor facilities, the designer must take into account the height of the performance space required for each sport. Some vary according to the standard of competition so governing bodies should be consulted*
- *When designing sightlines, the designer must determine what is required to be seen. This could be the touchlines of a pitch, the likely height of a rugby ball kicked high into the air, or the referee sat high on a chair. It should also be remembered that it may be impossible to see the entire course*

Contents

1 Executive summary
2 General introduction
3 Field of play
4 Viewing structures
5 Sports equipment
6 Support facilities for competitors and officials
7 Support facilities for spectators
8 Facilities for the media
9 Support accommodation for facility management
10 Examples of sports facilities for various sports
11 Bibliography
12 Case study

1 EXECUTIVE SUMMARY

Sports facilities take many forms but this chapter provides guidance for their technical design whether they are used for competition, training or recreation. The guidance is set out starting with the key dimensional data of the field of play for each sport, followed by principles to be applied to the design of viewing structures, and lastly the accommodation for the various users of the facility. A comprehensive reference bibliography is included at the end of the chapter as this field of design is technically complex; but because it evolves from year to year, designers should consult the guidance from the governing body of each sport, and other regulatory and guidance frameworks.

2 GENERAL INTRODUCTION

2.1 Indoor and outdoor facilities

Design information related to sports facilities is documented here in a single chapter irrespective of whether the sport is conducted inside or outside. The authors have concluded that the many factors that influence the design of a sports facility are relevant whether the sport is conducted inside or outside. That is not to say that the conditions are identical and of course the design of appropriate finishes and the design of mechanical and electrical services must be carefully considered to ensure the facility is fit for purpose. Roofs do however play a key role in the design of sports facilities and they are discussed in Section 4.9.

2.2 Scale

Sports facilities come in many different shapes and sizes, from a sandpit in a park where a casual game of petanque is played, through a small community tennis club, a local authority sports centre, school or university facilities, regional racecourse, football league stadium, to a national stadium or even an international 'sports city'. The design of these facilities clearly changes in scope and complexity but this chapter should provide the basis for the core facilities that relate to most if not all.

2.3 Sporting places

The places where sport can occur are virtually limitless. Competitions take place upon the ocean waves, alpine pass roads, and the tarmac of city centres; on turf and dirt as well as the prepared surfaces of a tennis court or bowling green. Some of these places are not designed at all, except to locate key points along a route, and some require meticulous design work. The chapter provides the dimensional considerations for the sports that require the intervention of a designer.

3 FIELD OF PLAY

3.1 Definition

This section introduces the concept that all sports are conducted on a field of play, whether that is a pitch, track, course, pool, field or court. The governing body for each sport will generally define the dimensional requirements for this, which may vary depending on the level of competition. Dimensions for the field of play for most sports can be grouped into categories.

3.2 Pitch/park/ground

The first category illustrated here, Figures 38.1–38.10, are sports that are conducted on a level surface that would have been originally turfed, but at the professional level, the surfaces are becoming increasingly sophisticated. They are all team sports and can be played in a local park or in an international stadium. They are most commonly played outdoors although indoor facilities exist for some.

3.3 Track

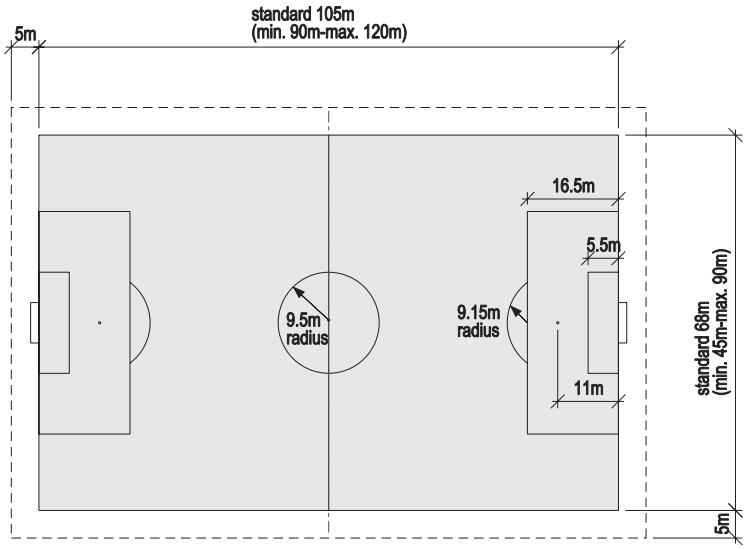
The second category of sports is conducted on a track, sometimes in individual competition and sometimes as team events, Figures 38.11–38.15. The dimensions of the tracks for athletics and track cycling are standardised to a degree although some degree of variation is permitted, whereas the tracks for BMX racing and motorsport are all different.

3.4 Court

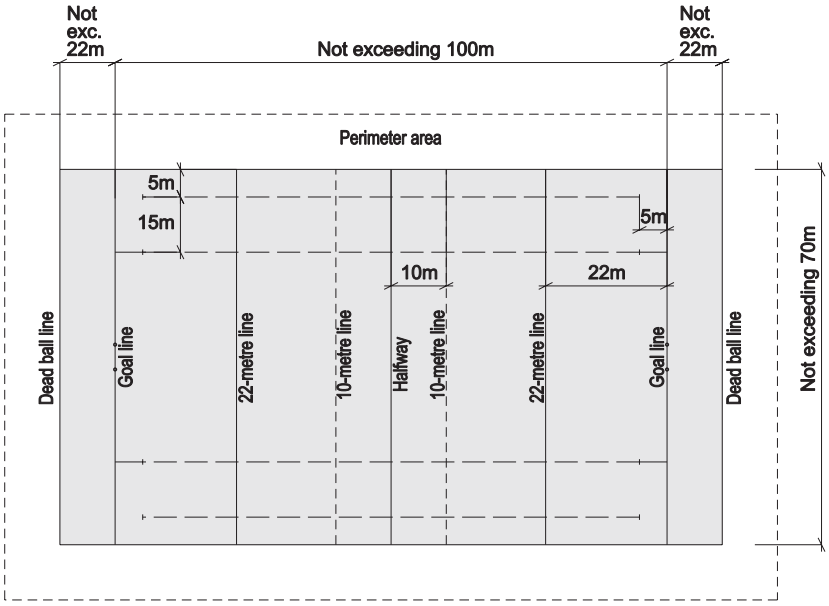
Sports that are played on courts of various different configurations can be played both indoors or outdoors and often on a number of different surfaces, Figures 38.16–38.23.

3.5 Pool

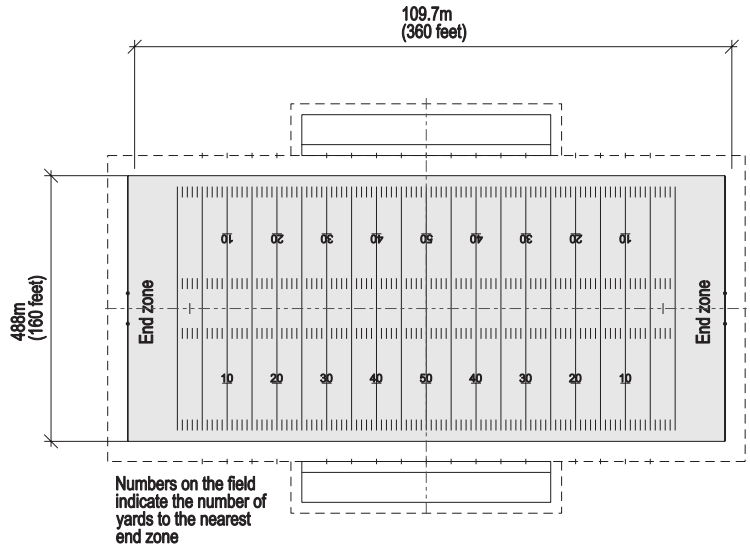
Pool-based sports are obviously conducted in standard length swimming pools, although their widths do vary, Figures 38.24–38.28. The pools are increasingly more sophisticated with moving floors to increase their usability by participants of varying competence.



38.1 *Football (soccer) pitch layout*

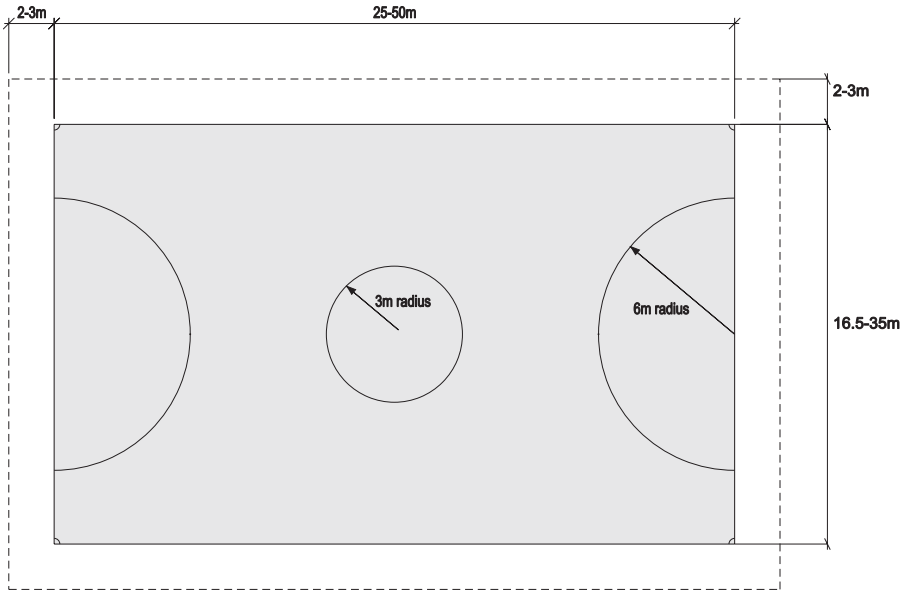


38.2 *Rugby union, rugby league pitch layout*

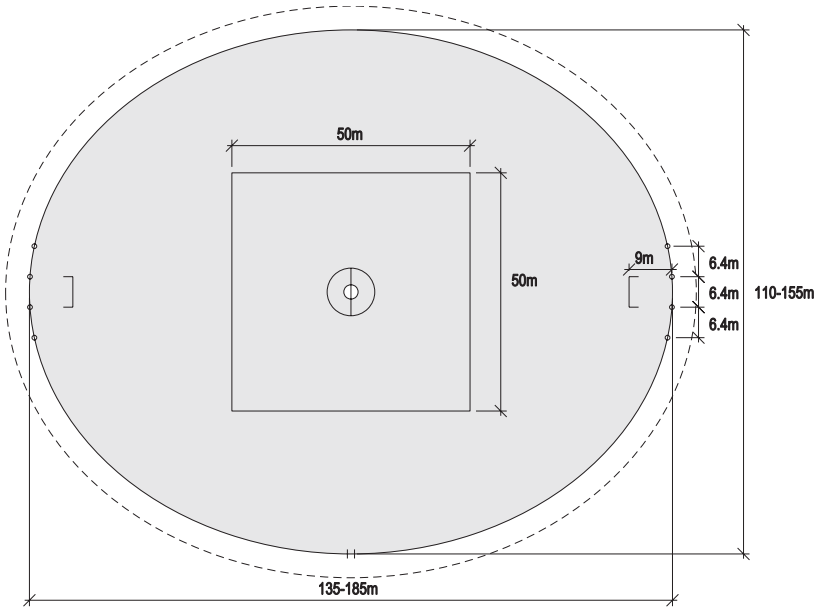


38.3 *American football pitch layout*

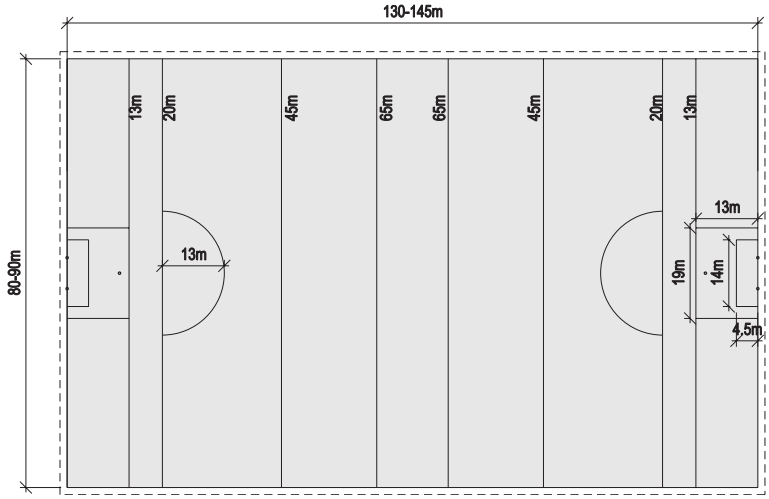
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.4 *Five-a-side football pitch layout*

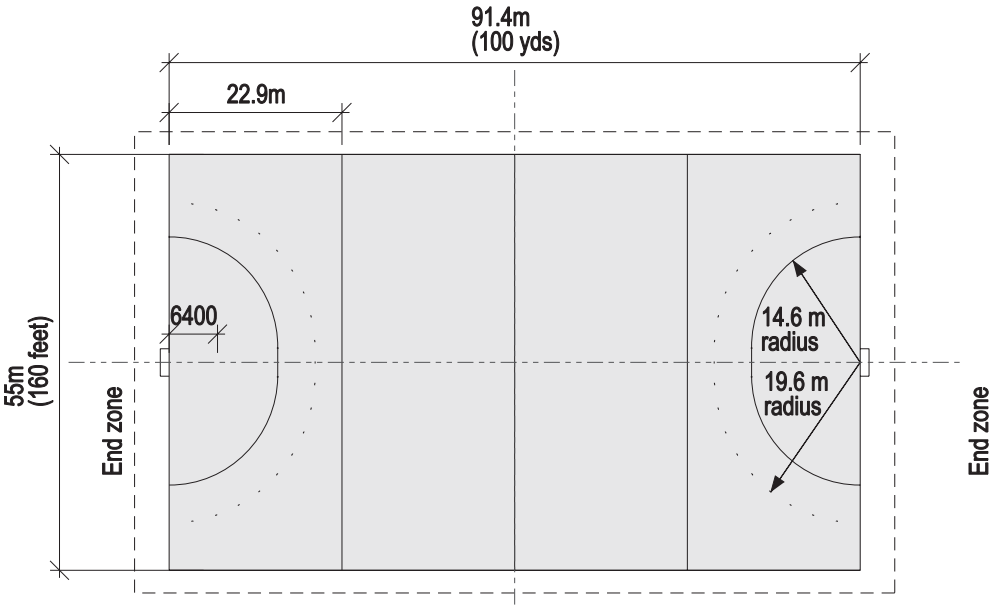


38.5 *Australian football pitch layout*

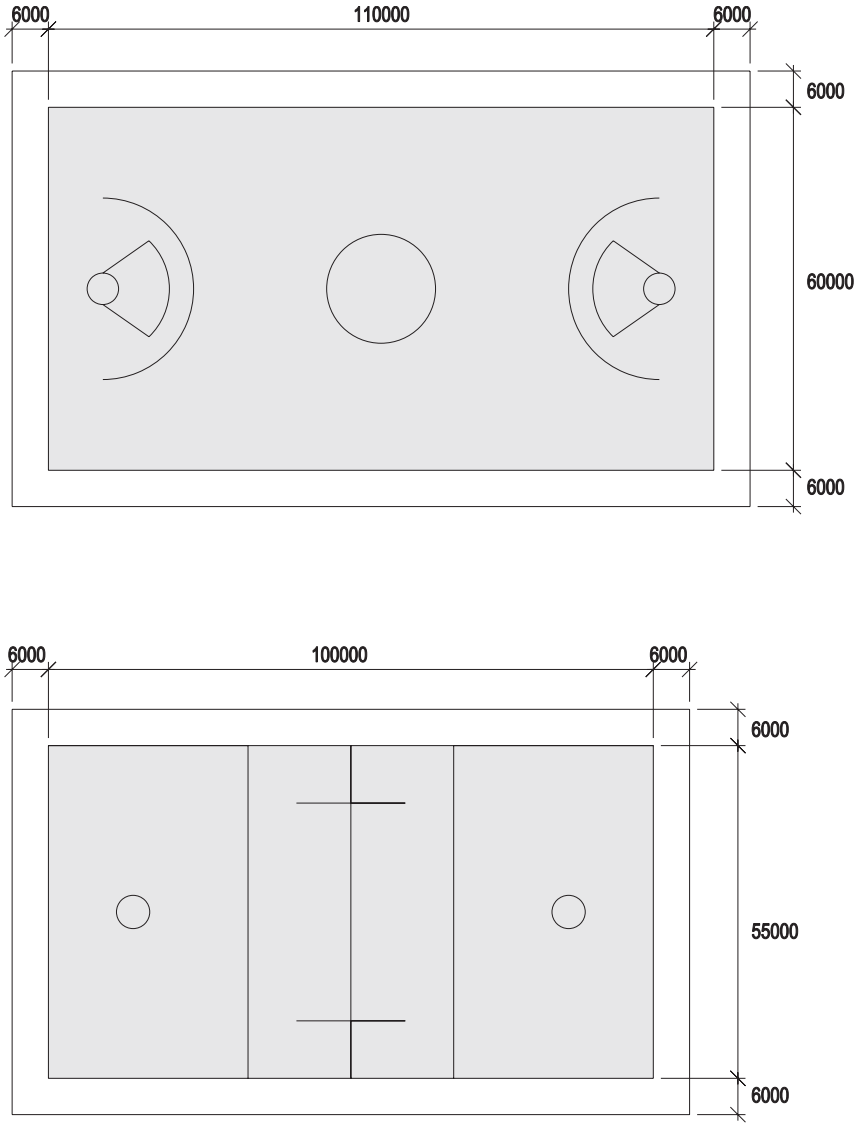


38.6 *Gaelic football pitch layout*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

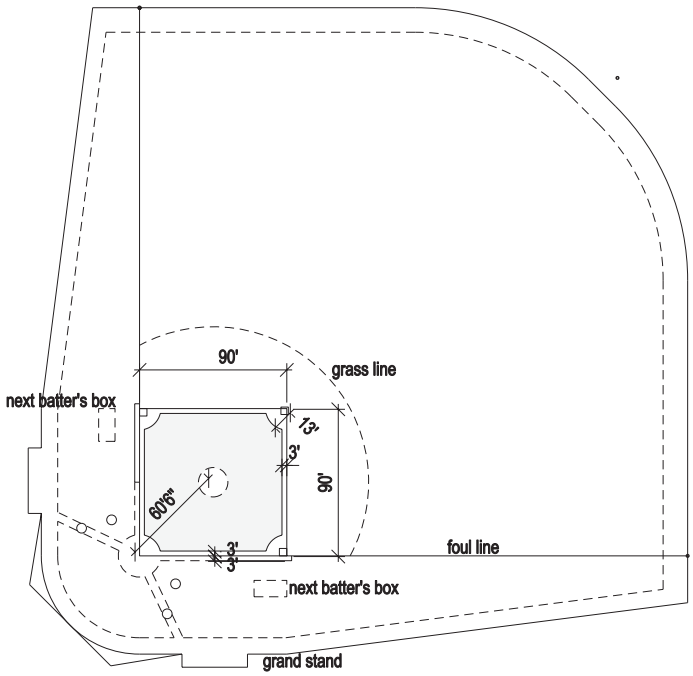


38.7 *Field hockey pitch layout*

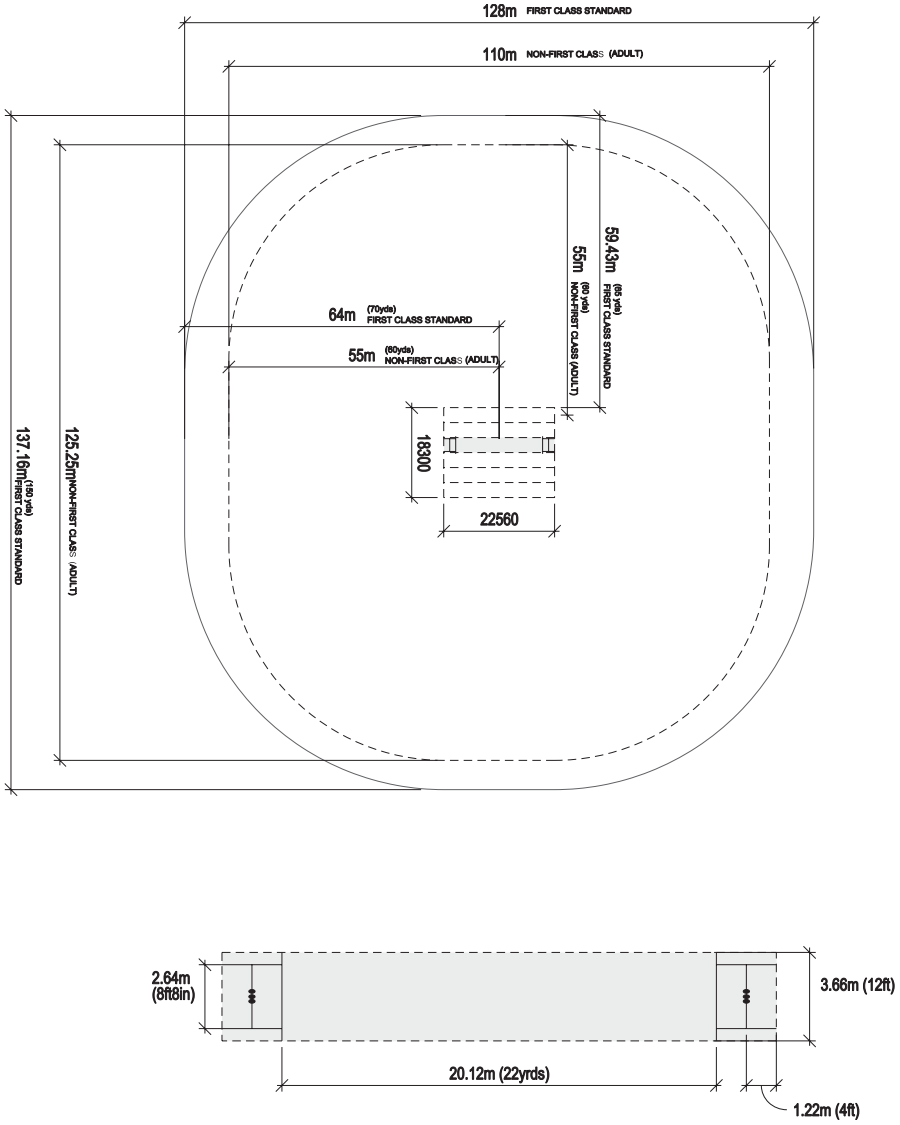


38.8 *Lacrosse (women's and men's) pitch layout*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

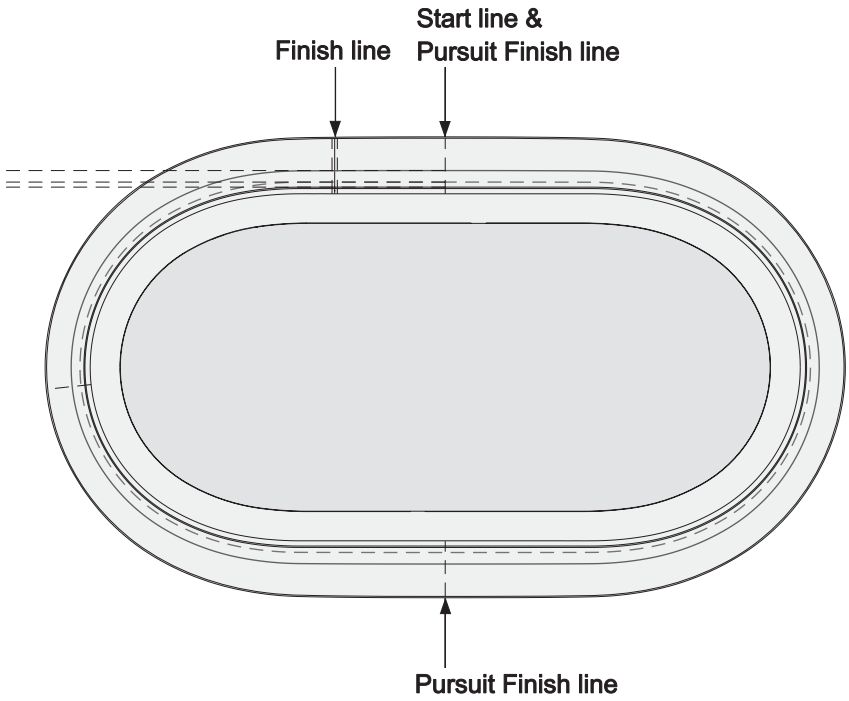


38.9 *Baseball pitch layout*

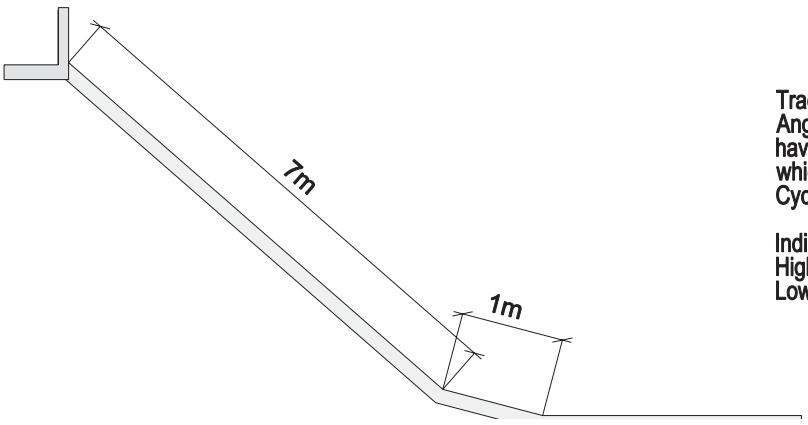


38.10 *Cricket pitch layout*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



Track (m)	Radius of Bends (m)
250	19-25m
333.333	25-35m
400	28-50m

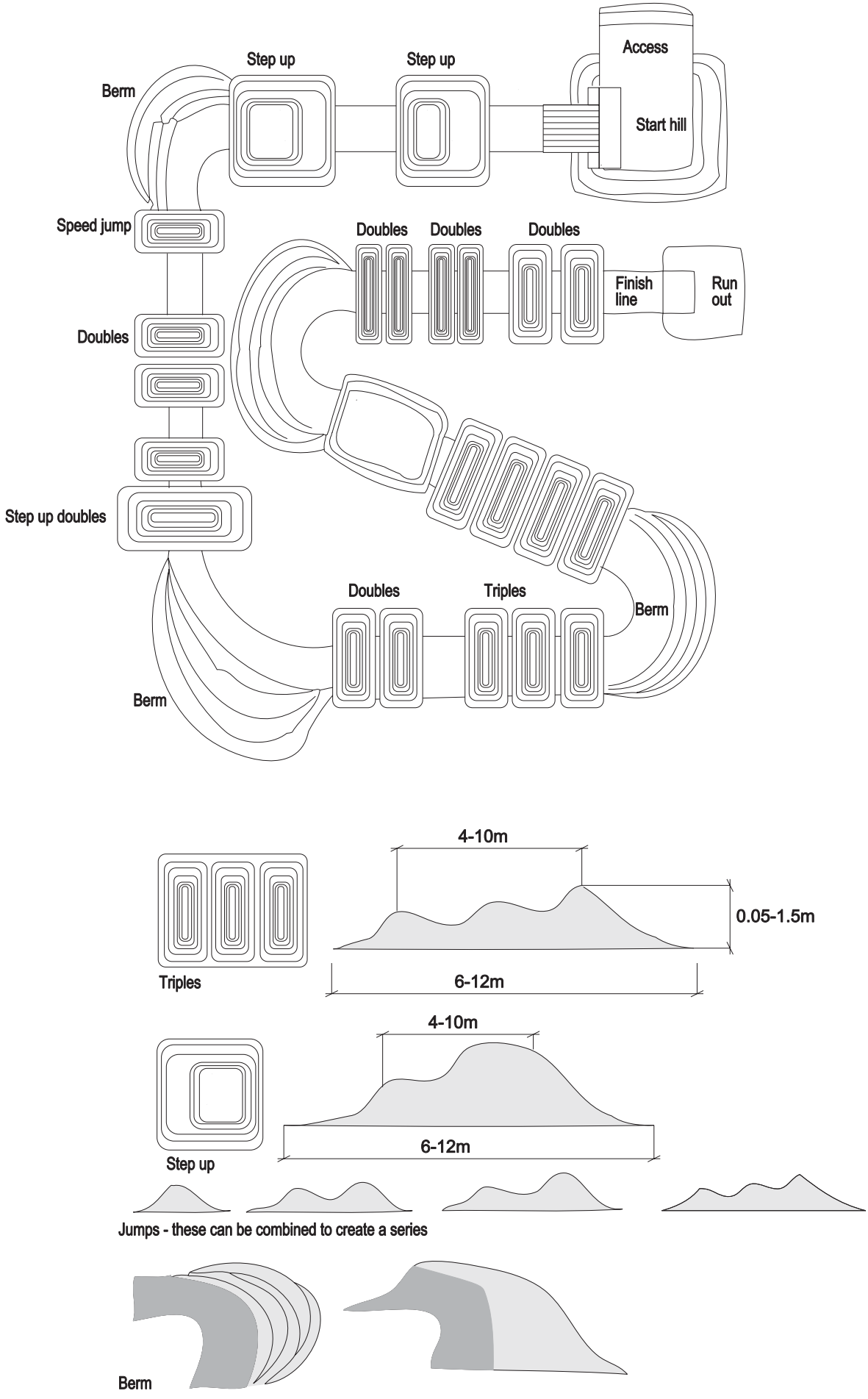


Track width 7m.
Angles can vary and each velodrome can have a different geometry which would be approved by the Union Cycliste Internationale (UCI).

Indicative angles:
Highest angle 42º
Lowest angle 5.5º

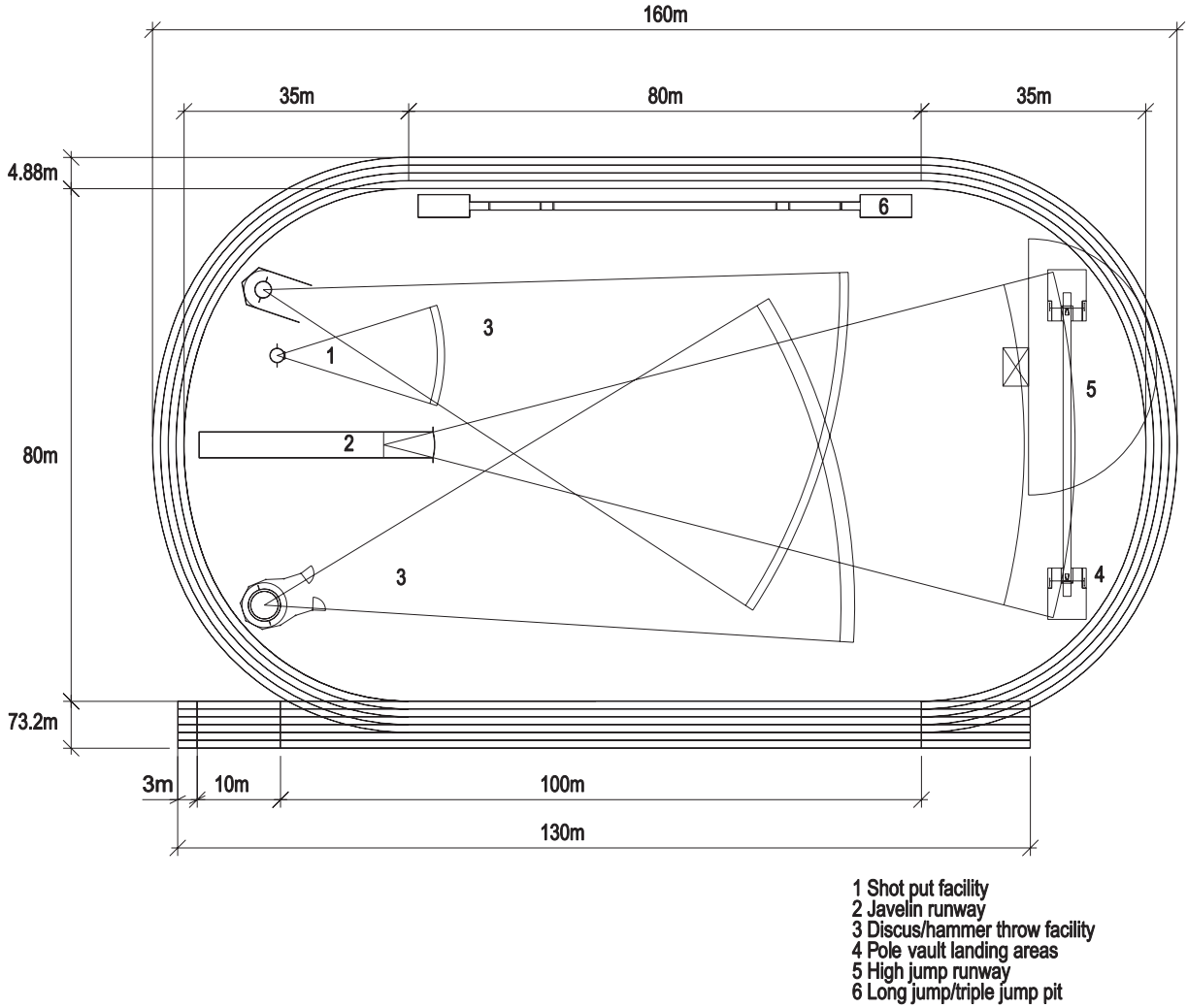
38.11 *Cycling track*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

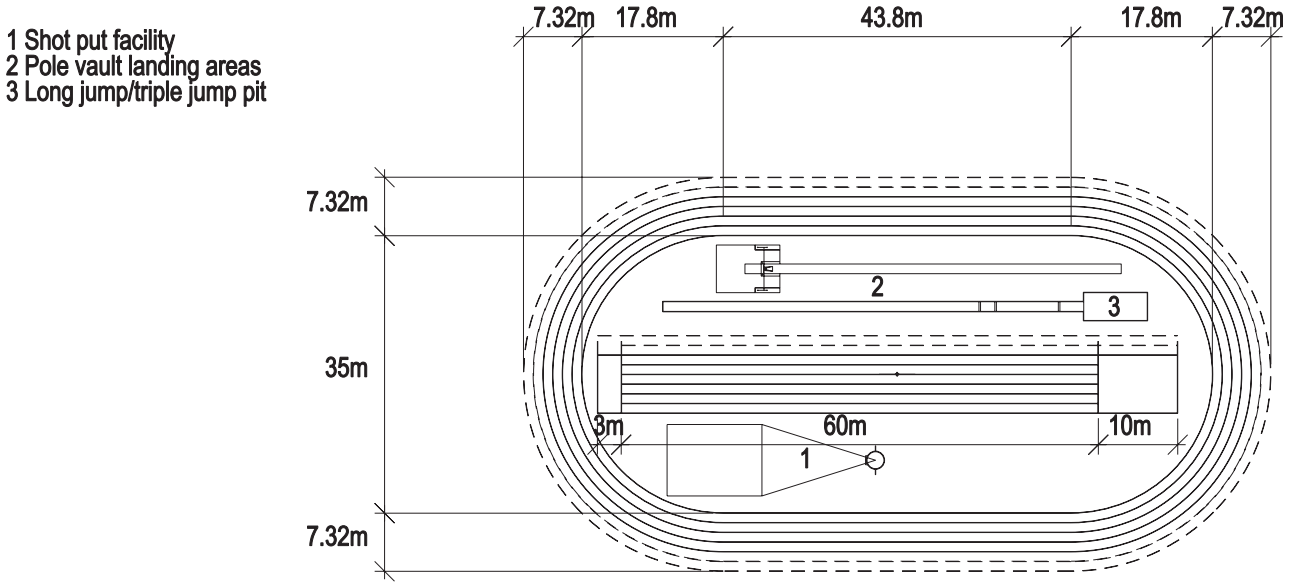


38.12 *BMX track*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

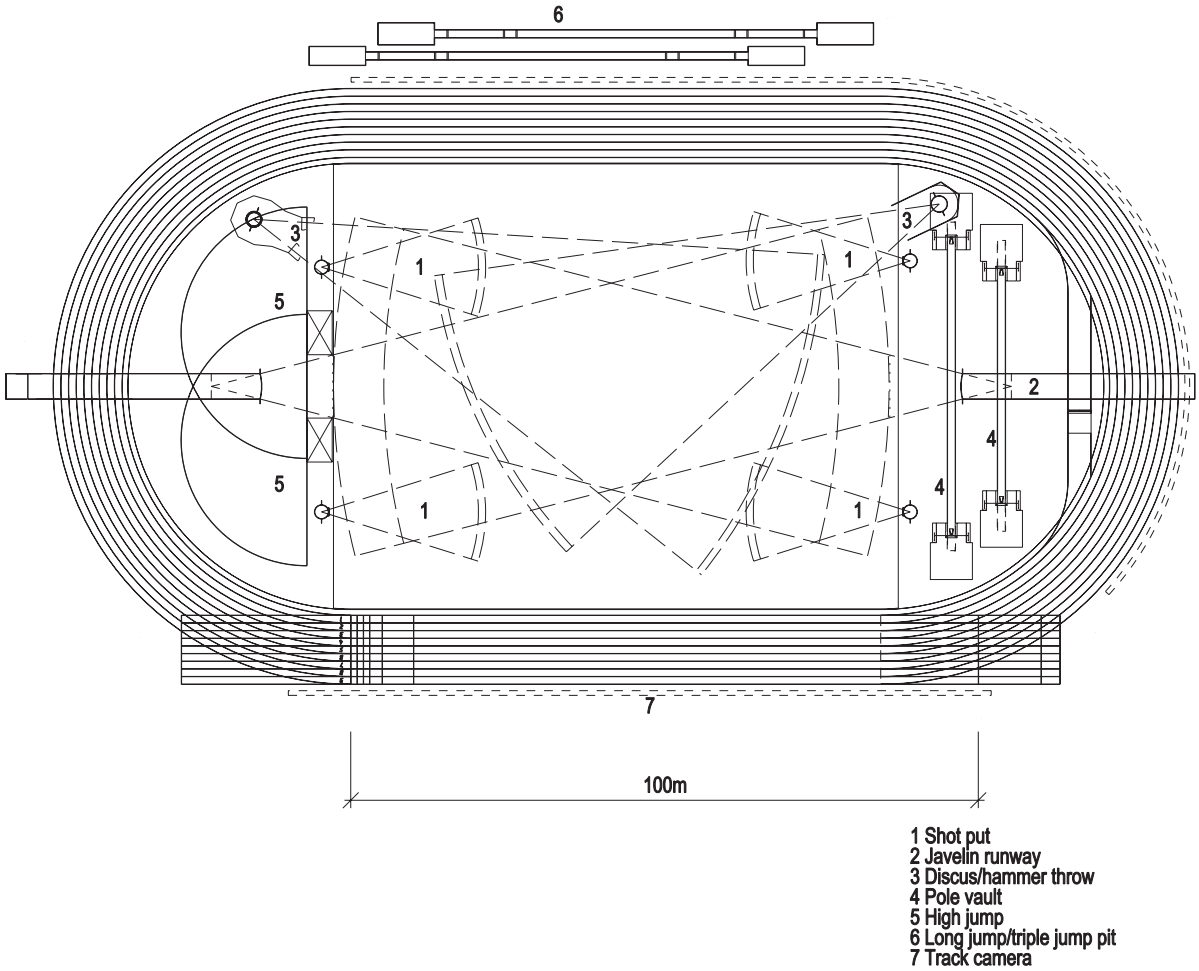


38.13 *Outdoor athletics track*

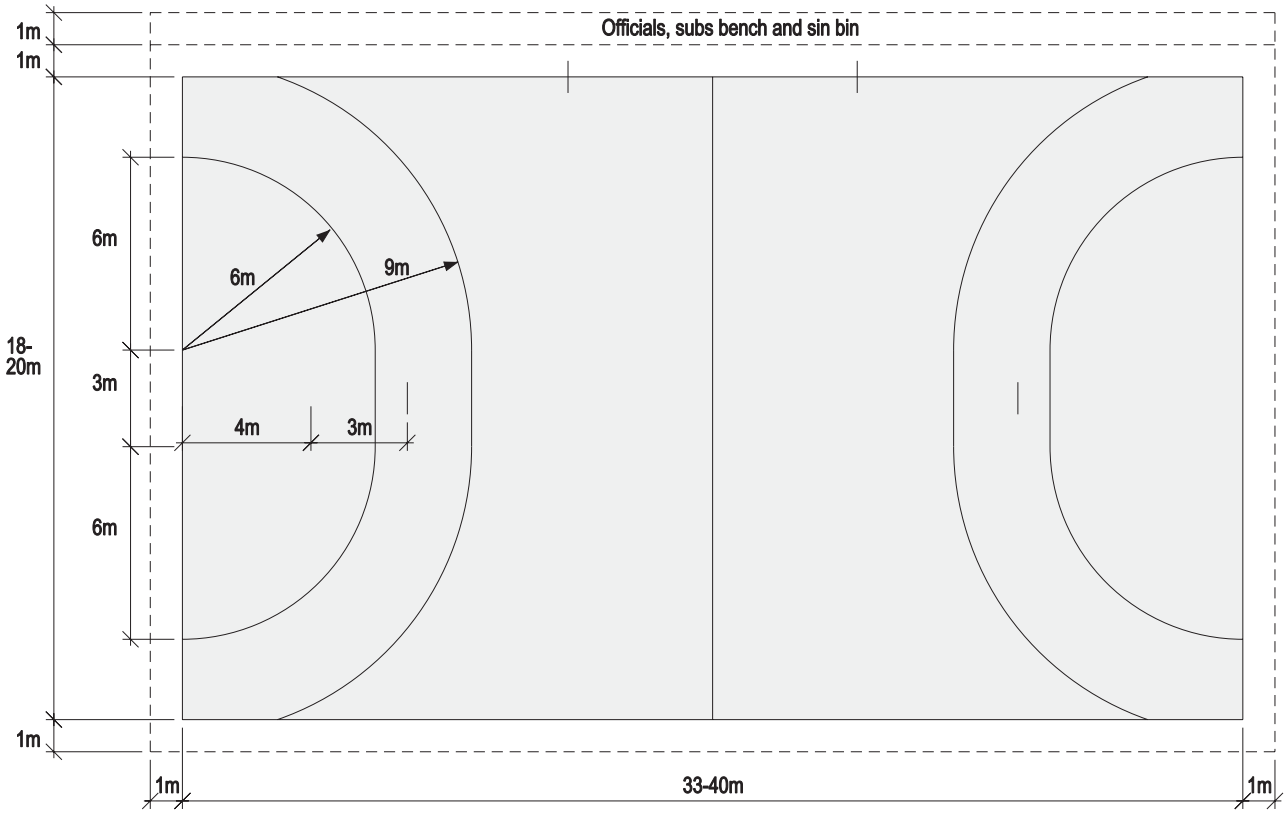


38.14 *Indoor athletics track*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

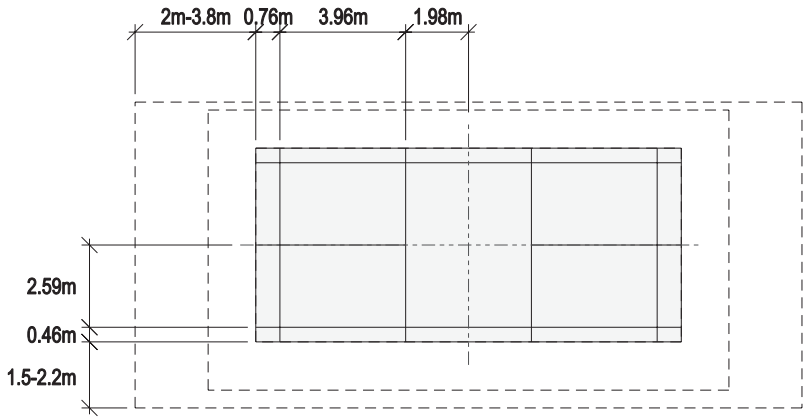


38.15 *Olympic athletics track*

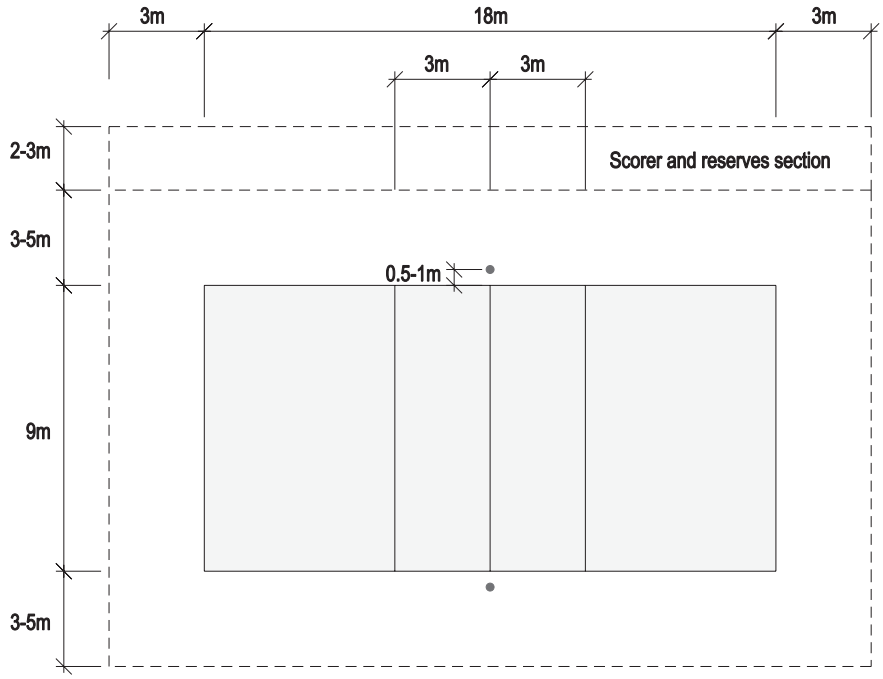


38.16 *Handball court*

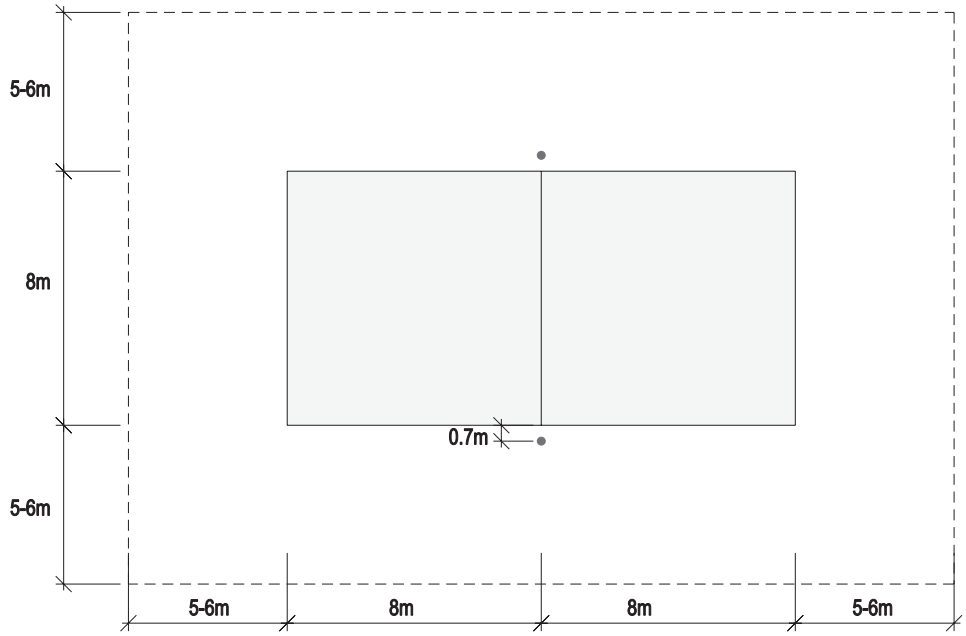
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.17 *Badminton court*

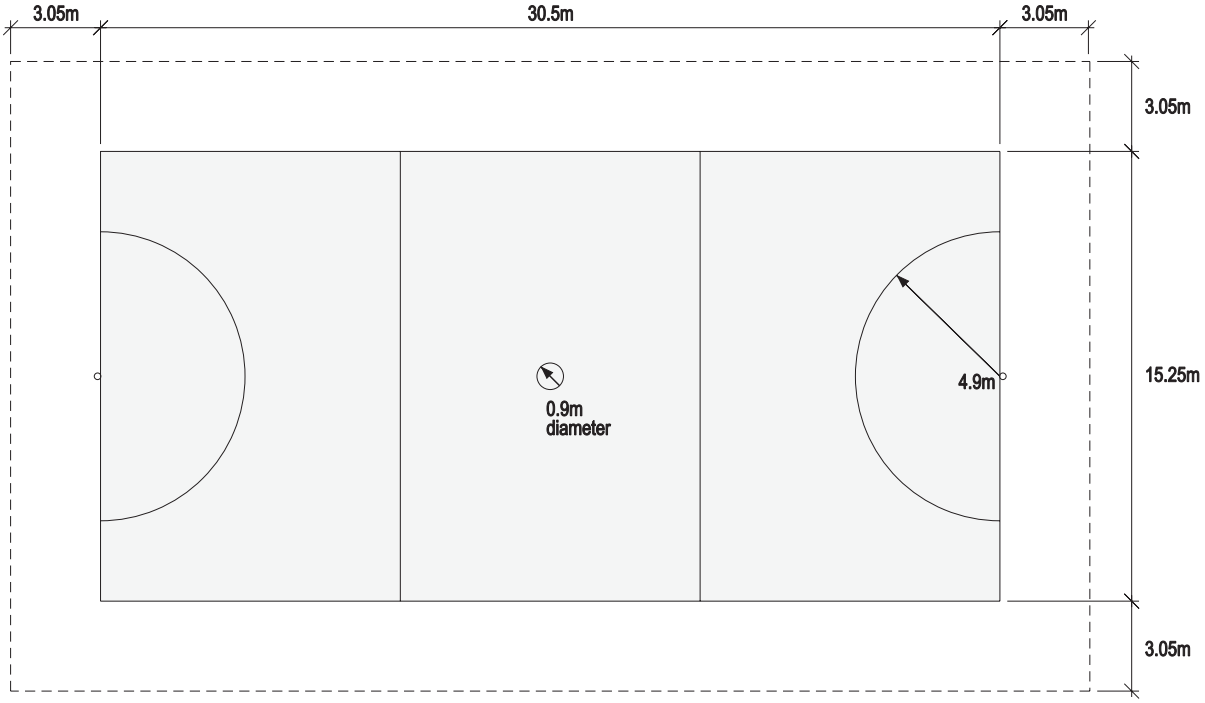


38.18 *Volleyball court*

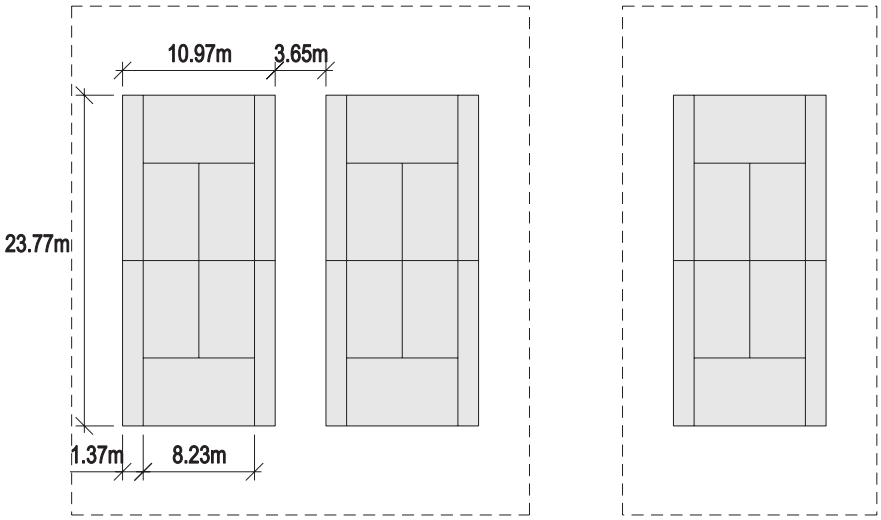


38.19 *Beach volleyball court*

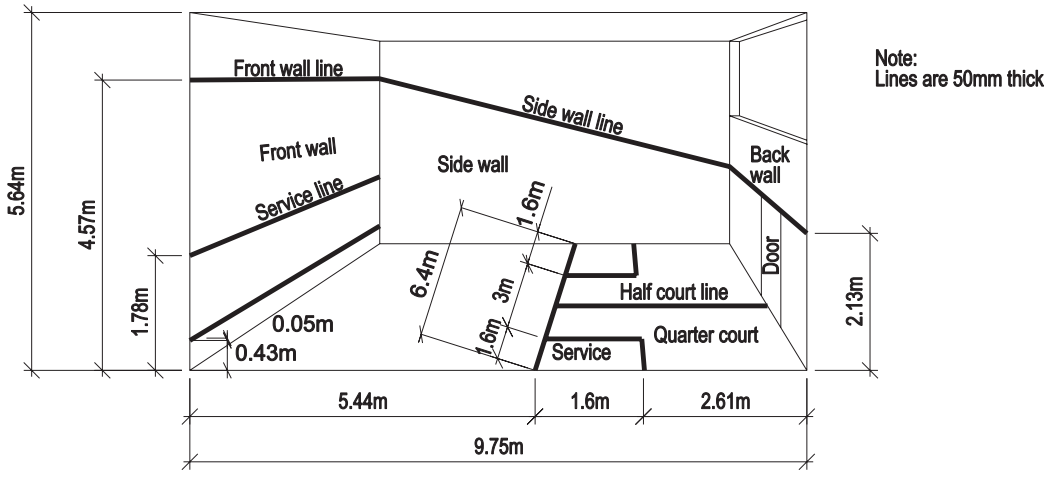
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.20 *Netball court*

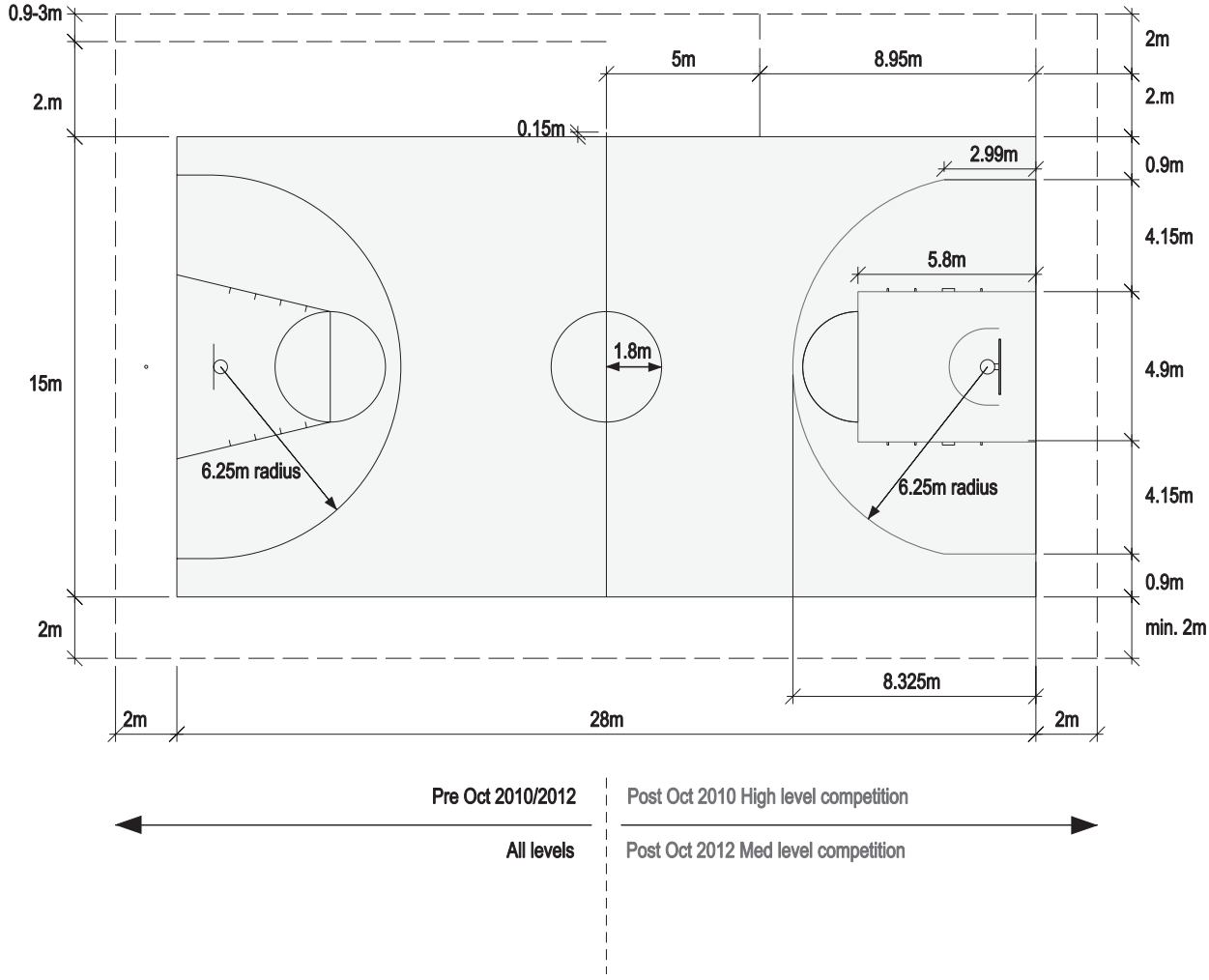


38.21 *Lawn tennis court*

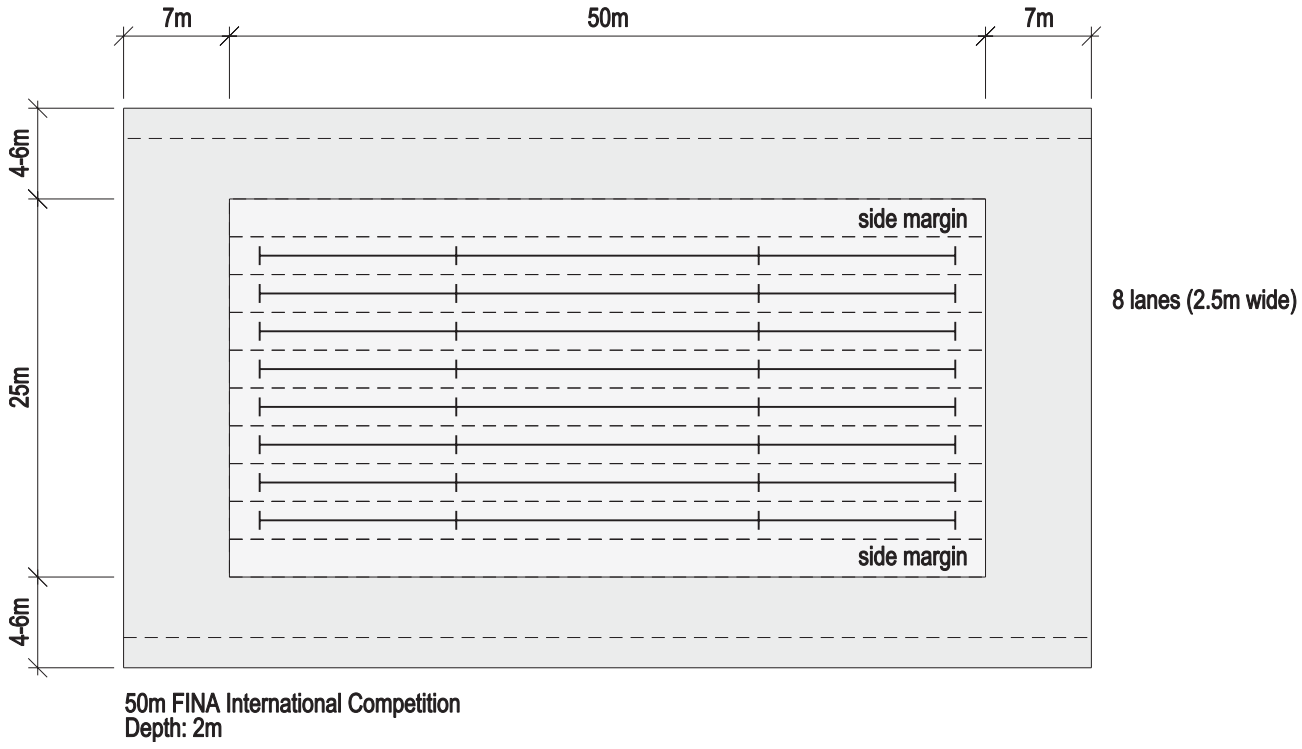


38.22 *Squash court*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

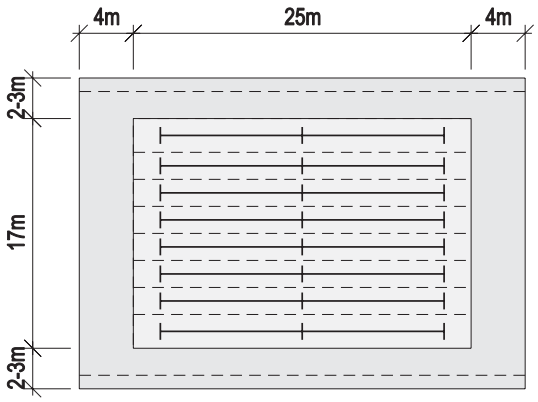


38.23 *Basketball court*

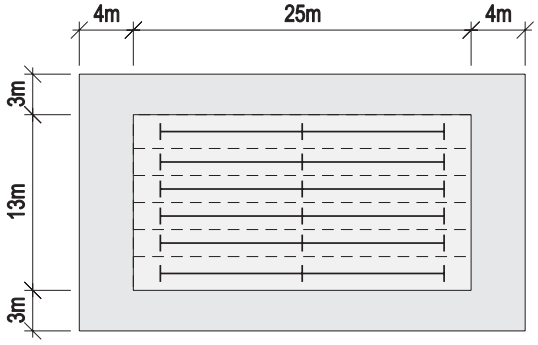


38.24 *Swimming pool*

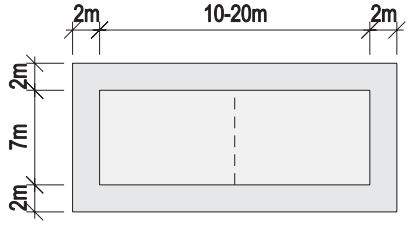
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



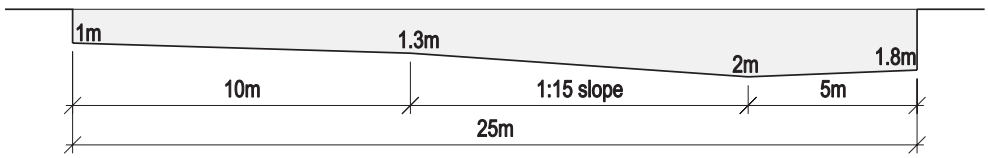
25m Competition
Depth: 1m-1.8m



25m Community Pool
Depth: 0.9m-1.25m, Preferred Depth: 1-2m



Learner Pool
Depth 0.6-0.9m

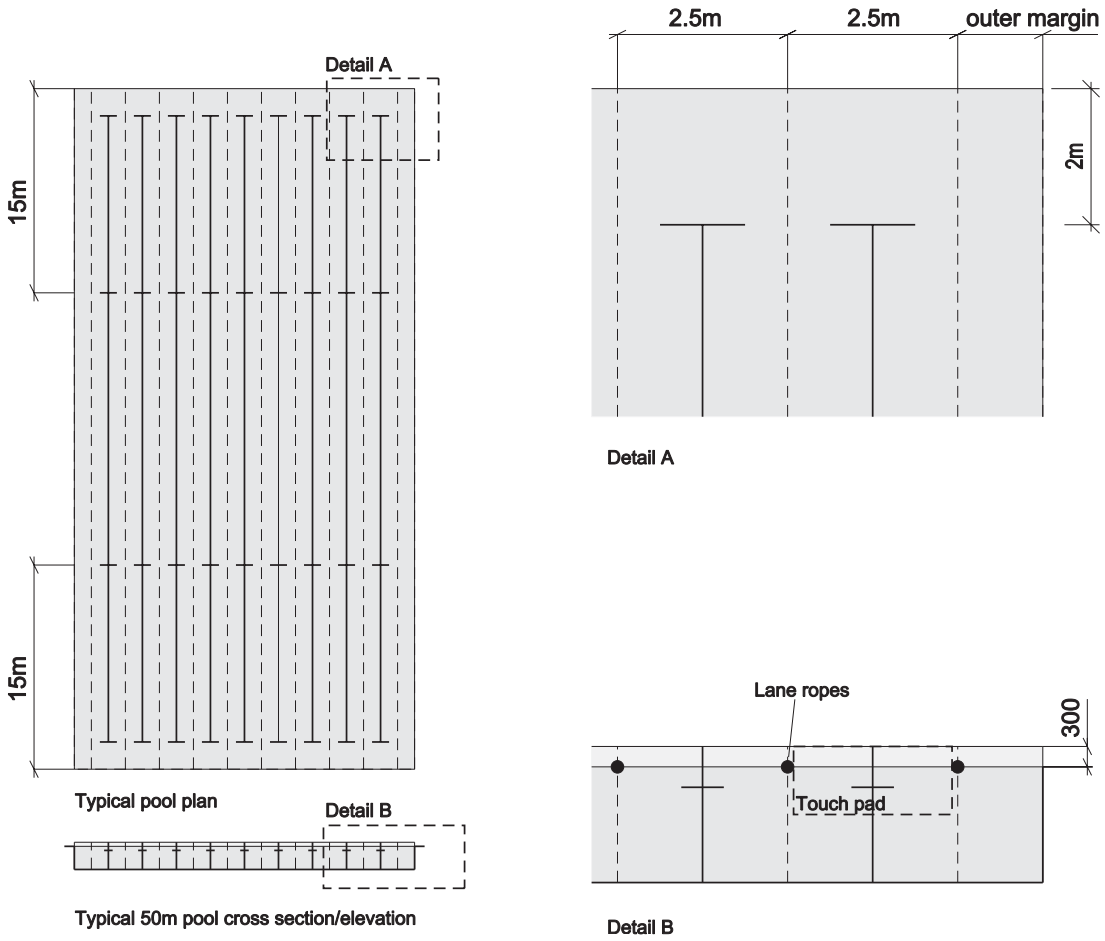


25m pool typical section

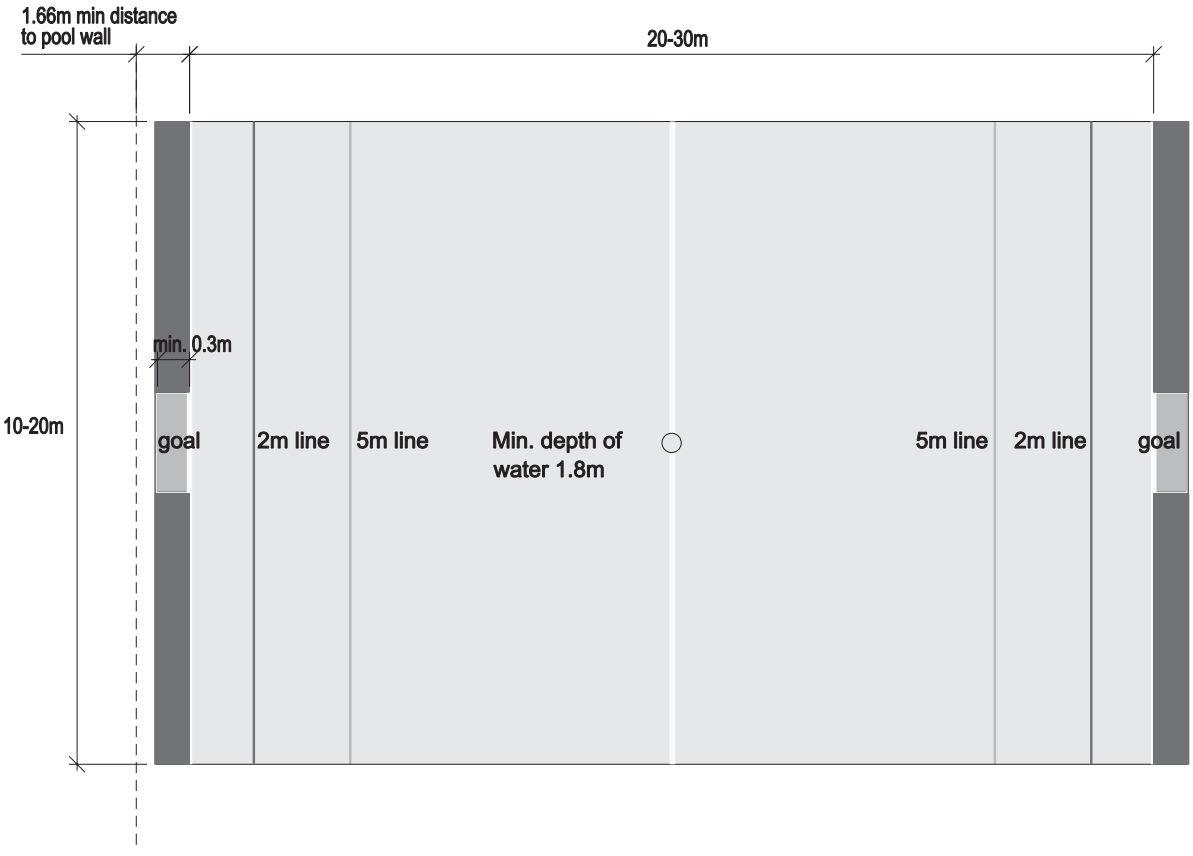


Learner Pool typical cross section

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

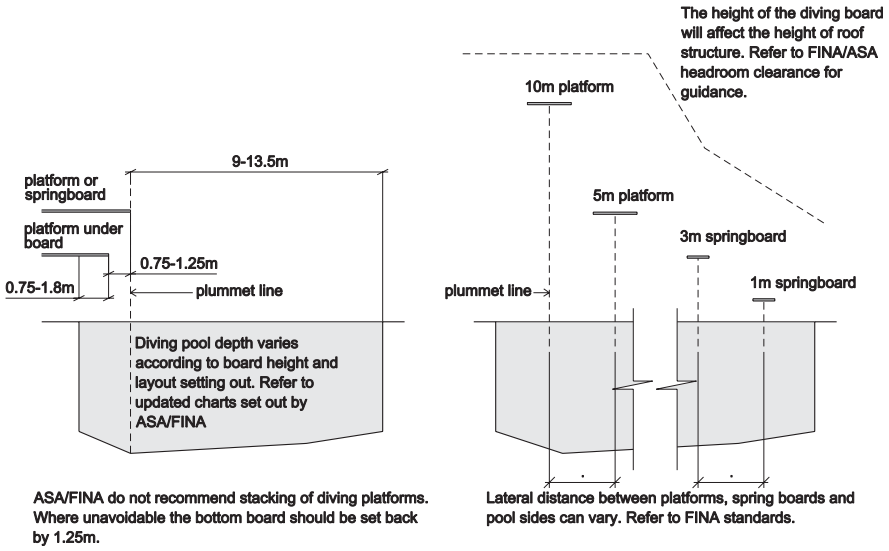


38.26 *Swimming pool*



38.27 *Water polo pool*

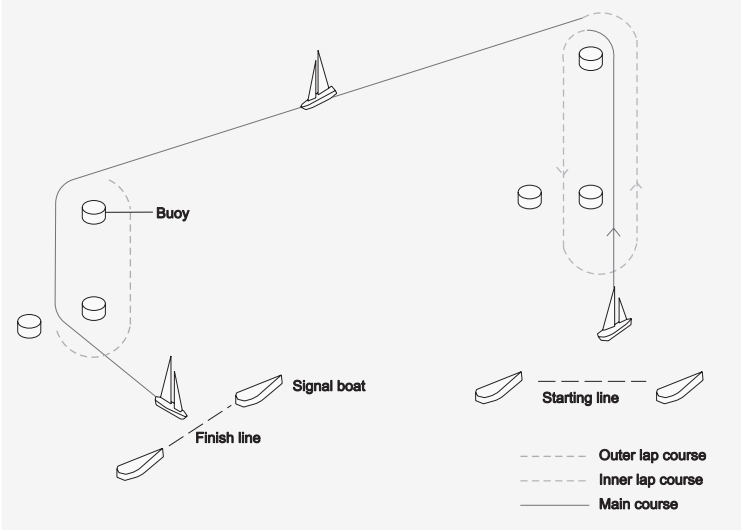
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

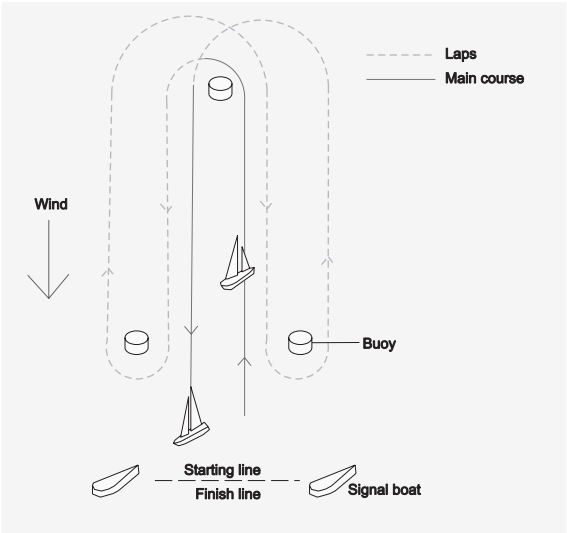


38.28 *Diving pool*

3.6 Course

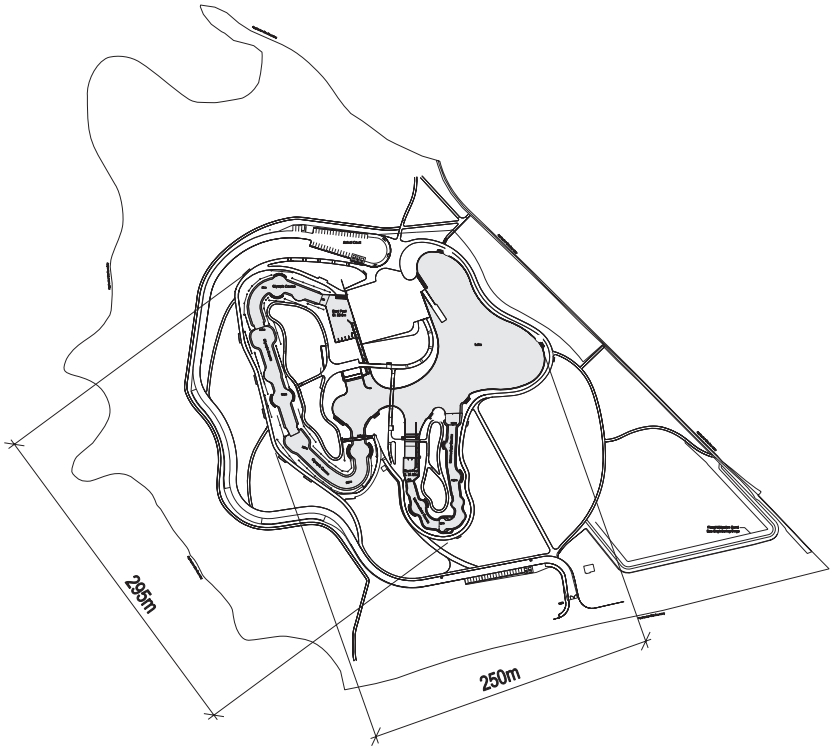
Courses for the sports in this category are rarely the same; in fact their difference is part of their appeal, Figures 38.29–38.30.





38.29 *Sailing courses*

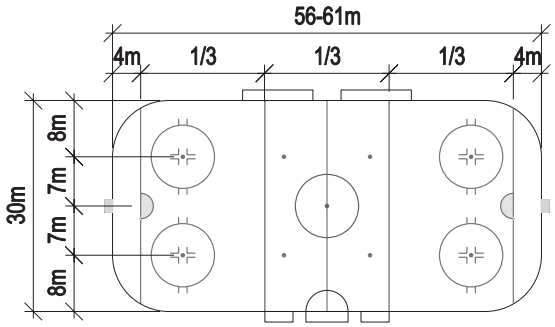
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



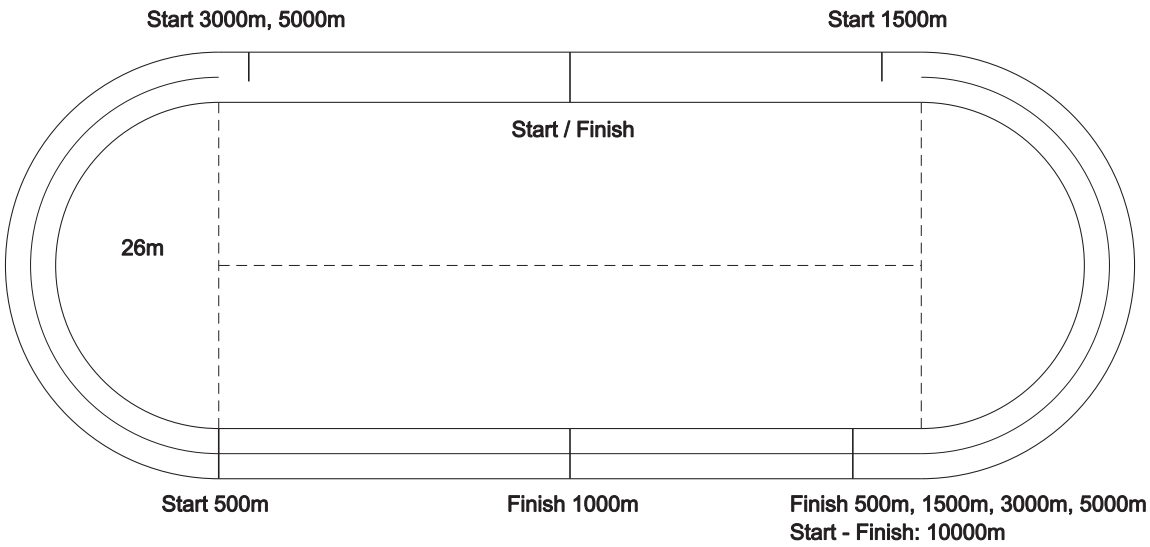
38.30 *White water kayaking course*

3.7 Rink

The following sports are each played on ice but the ice pads are required to be of quite different dimensions, Figures 38.31–38.33.

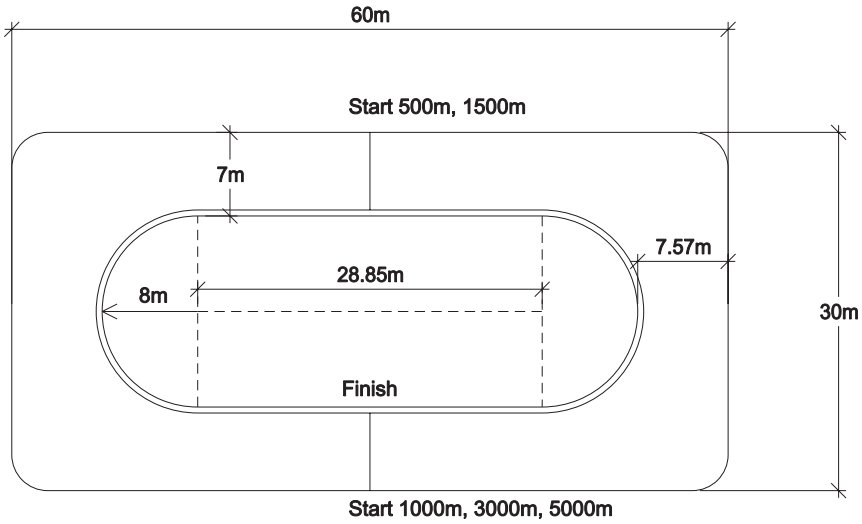


38.31 *Ice hockey rink*



38.32 *Speed skating (long course)*

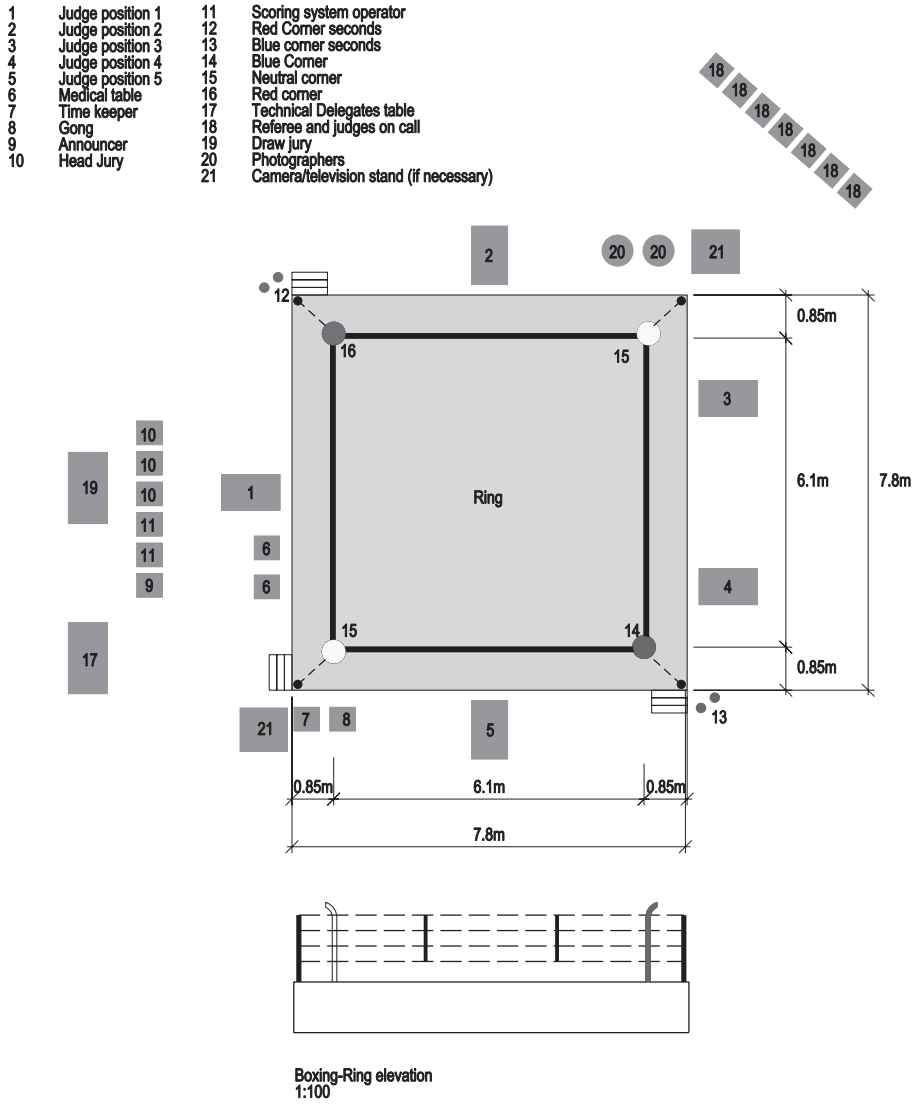
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.33 *Speed skating (short course)*

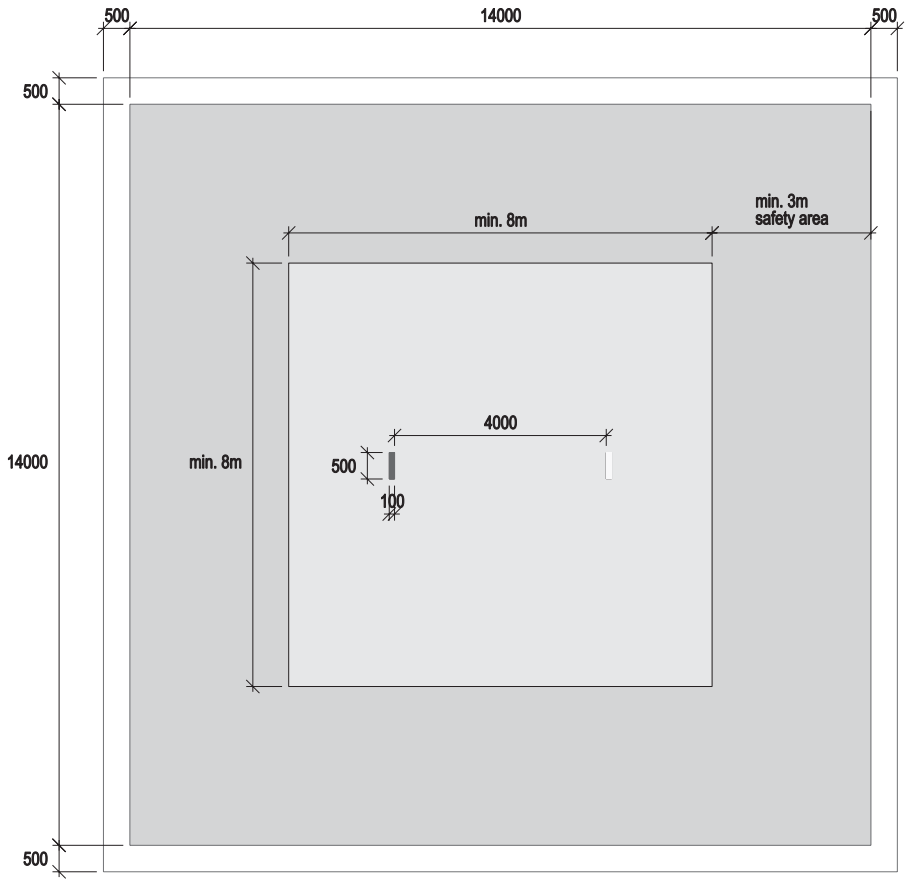
3.8 Other sports

The remaining sports illustrated in this chapter do not so easily fall into categories. Some require a ring, some a mat, others a range, green, lawn or table, Figures 38.34–38.45.

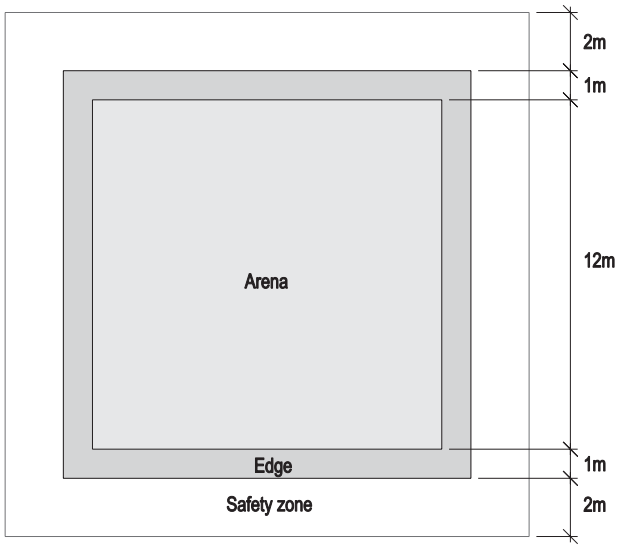


38.34 *Boxing*

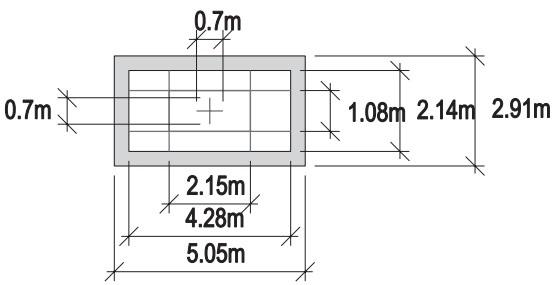
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.35 *Judo*

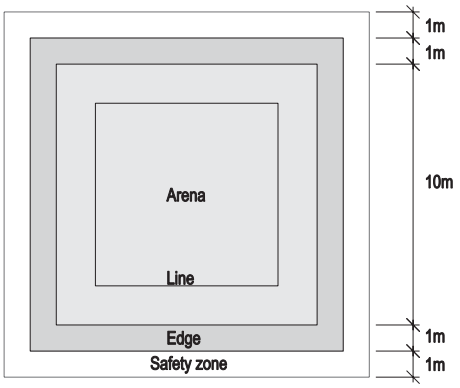


38.36 *Gymnastics (men and women)*

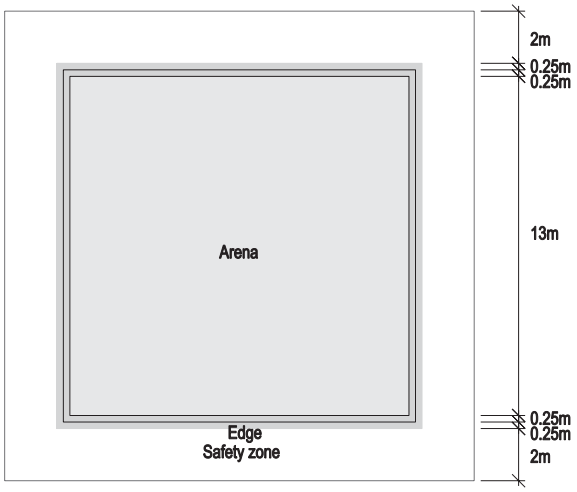


38.37 *Trampoline*

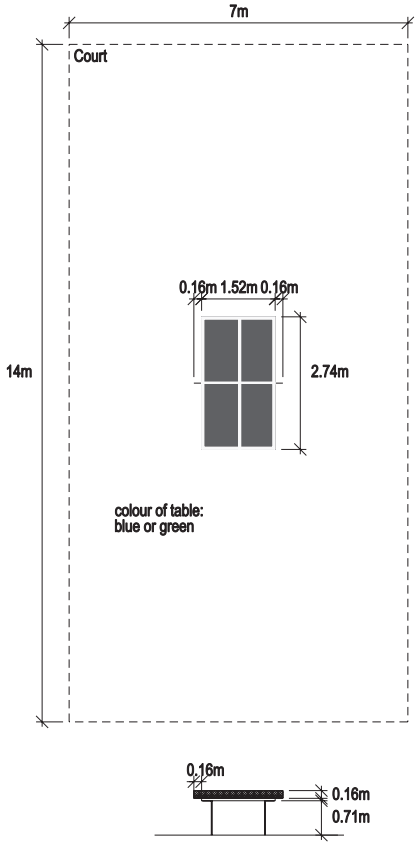
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.38 *Acrobatic gymnastics*

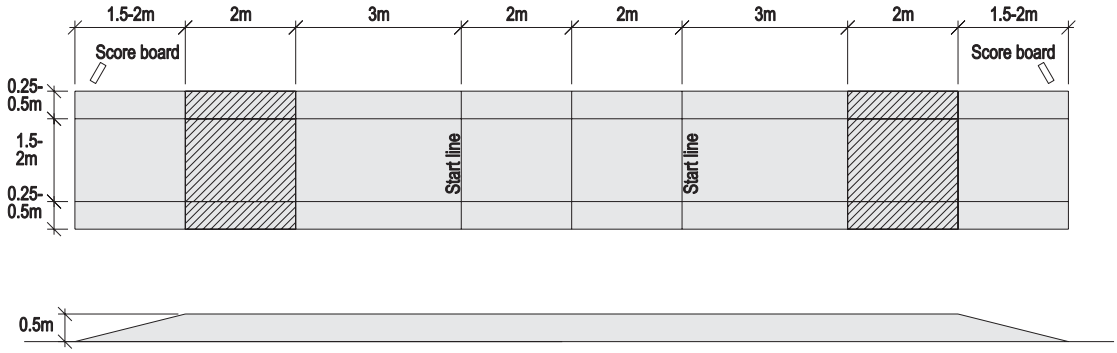


38.39 *Rhythmic gymnastics*

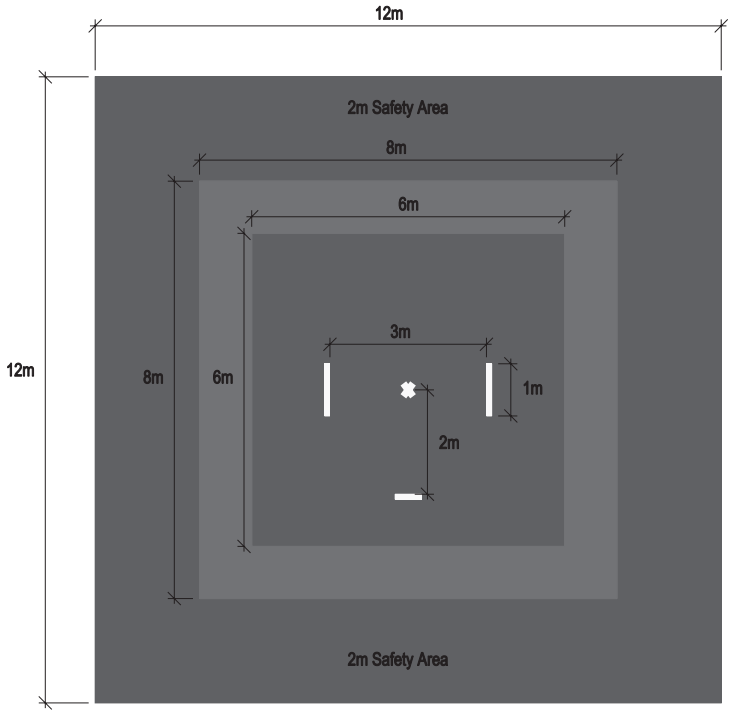


38.40 *Table tennis*

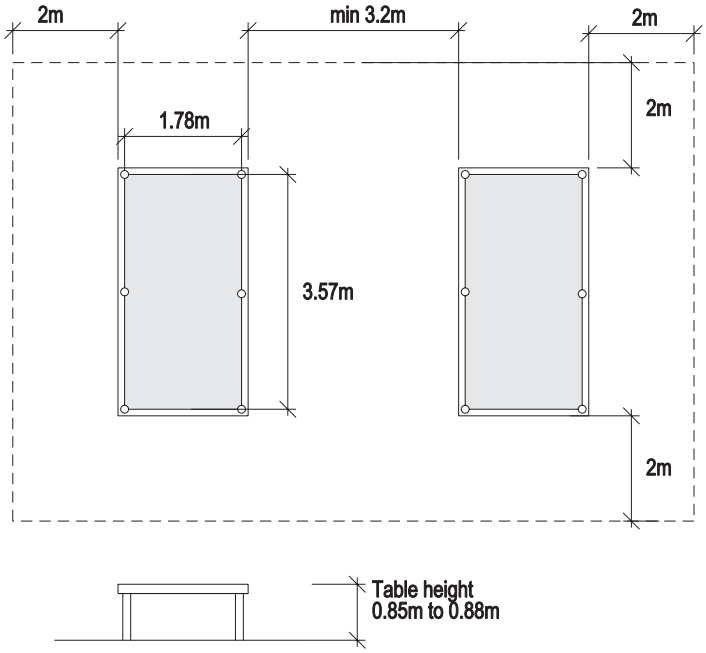
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.41 *Fencing*

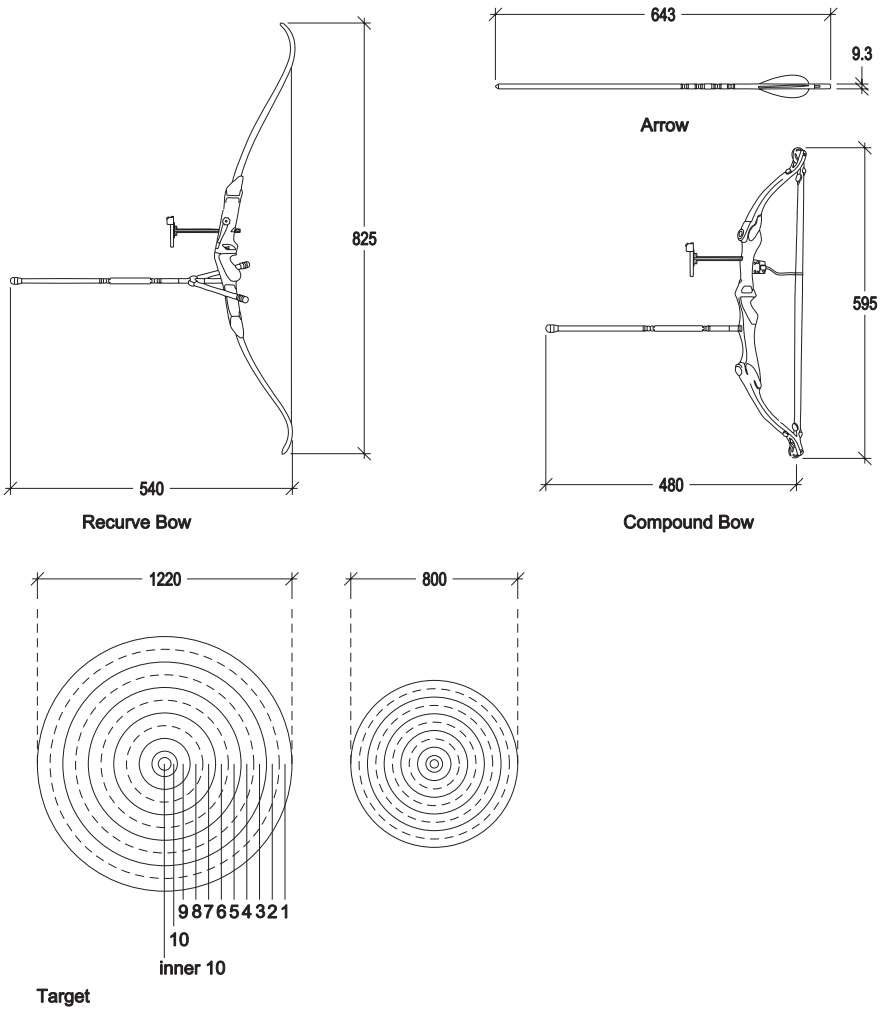


38.42 *Karate*

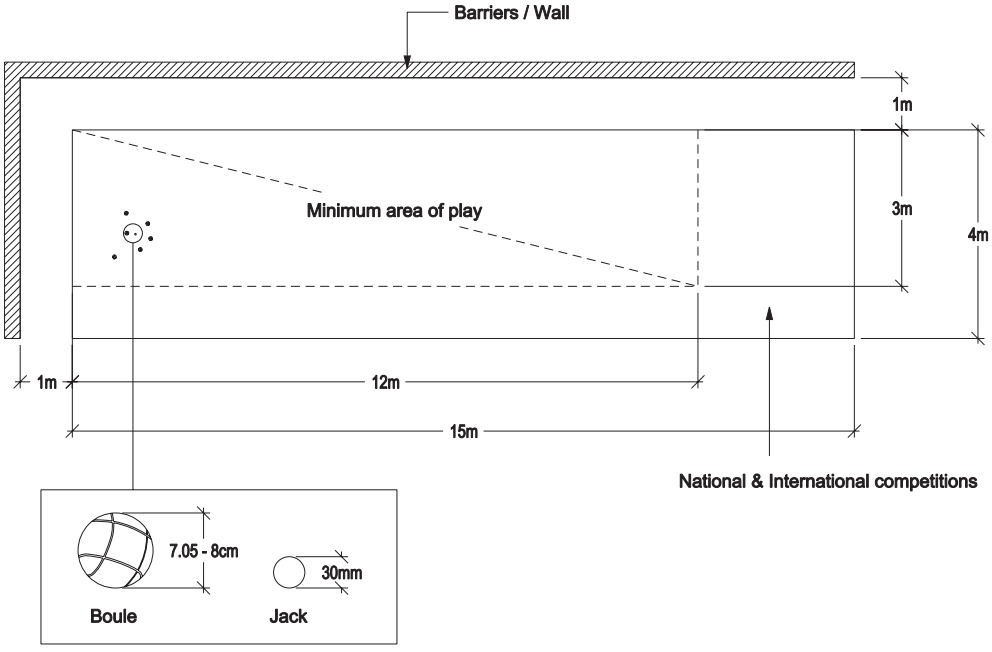


38.43 *Snooker*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.44 *Archery*



38.45 *Petanque*

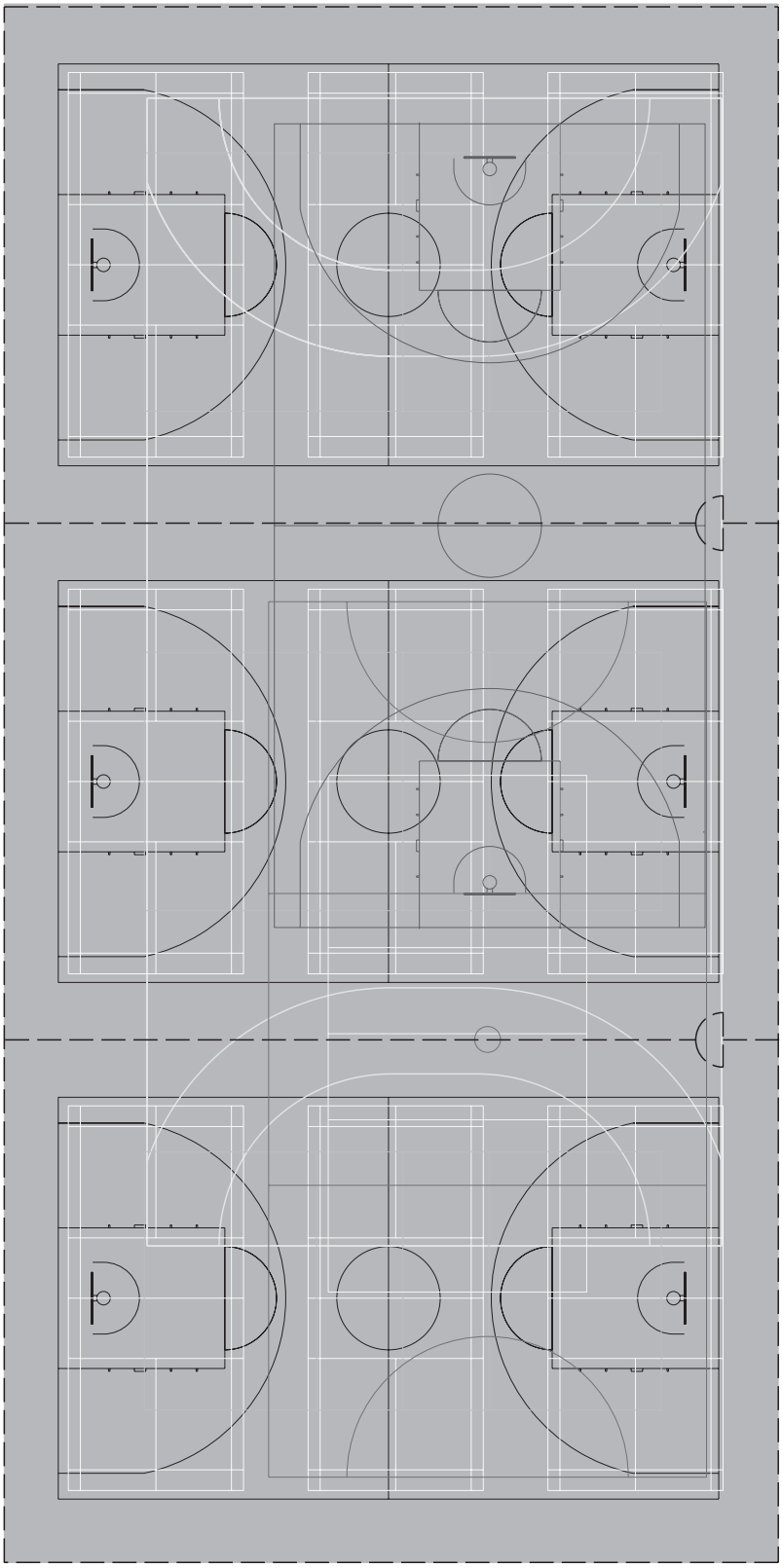
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

3.9 Compatibility

Within certain dimensional ranges, a number of surfaces are capable of accommodating a number of these sports, subject to changes to markings. Some surfaces can display the markings of more than one sport subject to appropriately coloured markings being used to clearly distinguish one from another. It is quite common for the multi-sports hall of a school or local authority sports centre to be marked out to accommodate tennis, five-a-side football, basketball, netball, volleyball and badminton, Figure 38.46.

One of the great advantages of a modern indoor arena such as the O2 Arena in London is their flexibility to accommodate a number of different events, Figure 38.47. It is possible to design the field of play to be transformable between ice hockey, basketball, netball, tennis, boxing, badminton, gymnastics, or even dressage.

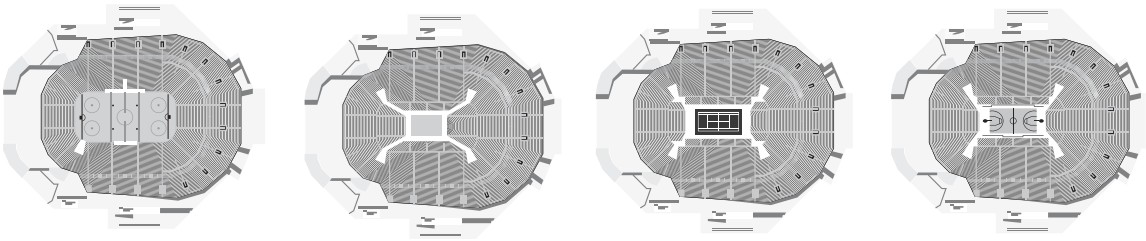
International stadia are increasingly being designed to accommodate a number of sports that can attract large crowds, including football (soccer, American football and Australian football), rugby (both codes), athletics and cricket, Figure 38.48. The



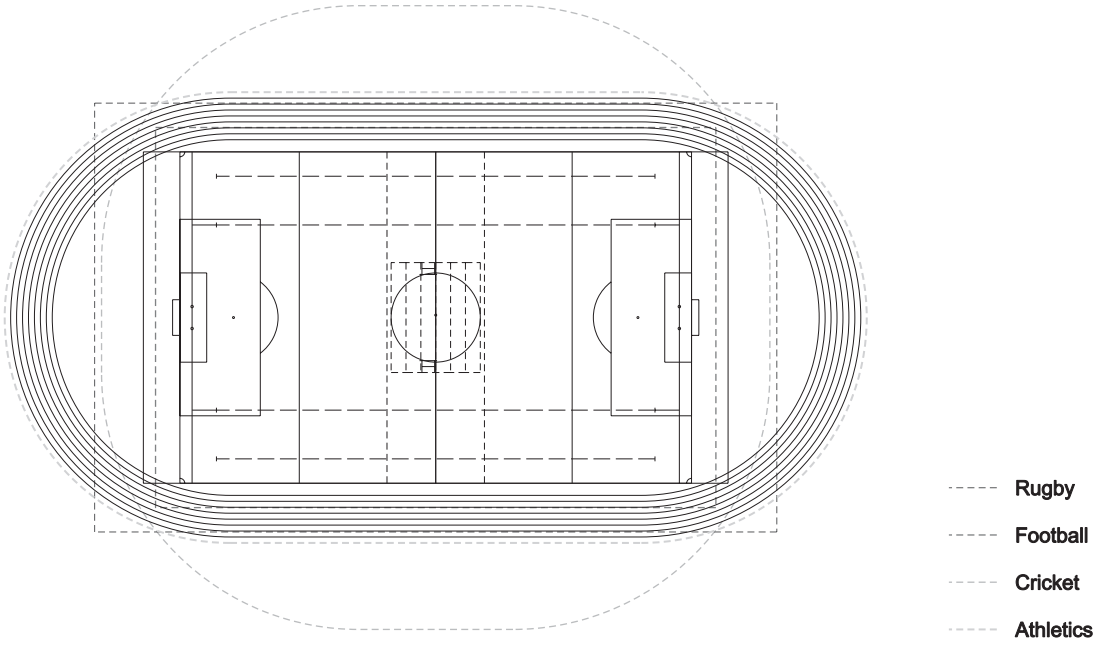
YELLOW - HANDBALL
(40,00X20,00 metre)
BLACK - FULL SIZE BASKETBALL COURT
(28,00x15,00 metre)
DARK BLUE - BASKETBALL COURT FOR
TRAINING PURPOSES
(23,00x14,00 metre)
WHITE - BADMINTON
(13,40x6,10 metre)
LIGHT BLUE - VOLLEYBALL
(18,00x9,00 metre)
GREEN - VOLLEYBALL
(18,00x9,00 metre)
RED - NETBALL
(30,50x15,25 metre)

38.46 *Multi-sport hall markings*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.47 *O2 Arena field of play configurations*



38.48 *Diagram showing rugby, football, cricket and athletics overlaid*

transformation of the field of play can take many forms and is discussed in Section 4.8.

3.10 Playing surface

Sports are played on a vast array of different surfaces from simple sand, for beach volleyball and petanque, through turf of varying complexity to quite sophisticated sprung timber floors for indoor courts.

Natural turf

Considerable research has been conducted into sports turf, in order to provide the appropriate specification for the intended purpose. This includes the species of grass, the growing medium build-up, flexible reinforcement to aid longevity but protect players, irrigation systems and under-pitch heating to maintain appropriate playing conditions around the calendar. Consideration also needs to be given to the health of the grass which requires, for good sustainable growth both wind and natural light, sometimes supported by artificial means. Reseeded every year, rye grass courts are still used in the UK and some other parts of the world for tennis, notably for the Queens and Wimbledon tournaments. Grass courts are generally the fastest type of court surface with the least bounce which has historically favoured the serve and volley style of play.

Artificial grass

All weather pitches laid with artificial grass, made from synthetic, often polyethylene, fibres made to look like natural grass are becoming increasingly common in order to reduce the maintenance required for natural turf and guarantee playability throughout the year. Most pitch-based sports can be played on artificial grass, including football although some tournaments prevent their use. Artificial grass surfaces provide a consistency and flatness which is particularly suitable for field hockey and for cricket nets, and of course because neither sunlight nor irrigation is required, are especially suitable indoors.

Rubberised surfaces

The fastest athletics tracks have a natural or synthetic rubber surface, which can be applied in long strips or as a homogenous surface on top of a tarmac sub-base. This gives a sprung feel which is supportive to the athletes' efforts and less damaging to their bodies. Similar surfaces can be applied to sports halls and the like and are suitable for a range of pitch and court sports.

Timber floors

Indoor halls are often fitted out with a timber playing surface, sprung to protect the participants, making them suitable for a range of sports such as gymnastics, tennis, netball, squash, badminton etc. They are typically constructed on a screeded sub-floor using 22 mm solid timber board nailed or clipped to a batten system laid on a resilient underlay. Timber species include beech, maple and ash.

Although velodrome tracks have historically been constructed from a variety of materials including concrete and cinder, modern indoor velodrome tracks are usually constructed from pine. The track at the velodrome in the Olympic Park in London was constructed using Siberian pine, because the trees are known for being straight and tall making them suitable for the lengths of timber required to shape the track; and the extreme Siberian climate also means the timber is very stable and will not shrink or contract in the environmental conditions of the velodrome.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Other tennis surfaces

There are four surfaces used for professional tennis competitions: grass courts (discussed above), clay courts, hard courts and carpet courts. Clay courts are made from crushed shale, stone or brick, can be either red or green and are common in Europe and South America. Red clay, slower than the green, is used for the French Open at Roland Garros. Clay surfaces tend to be slower than others resulting in less dominance of the server during the game. Hard courts can be acrylic or synthetic with a painted surface containing sand. They are generally between grass and clay in terms of speed and bounce. Hard courts are used for the Australian Open in Melbourne and US Open at Flushing Meadows, and are common throughout the world. Short artificial grass weighed down with sand is a removable carpet court and is common in Asia. Indoor courts are normally hard courts although when tennis is played in a multi-event arena, a rubberised carpet is laid on the arena floor.

At lower levels of the game, tarmac surfaces are cheaper low maintenance substitutes.

3.11 Field of play orientation

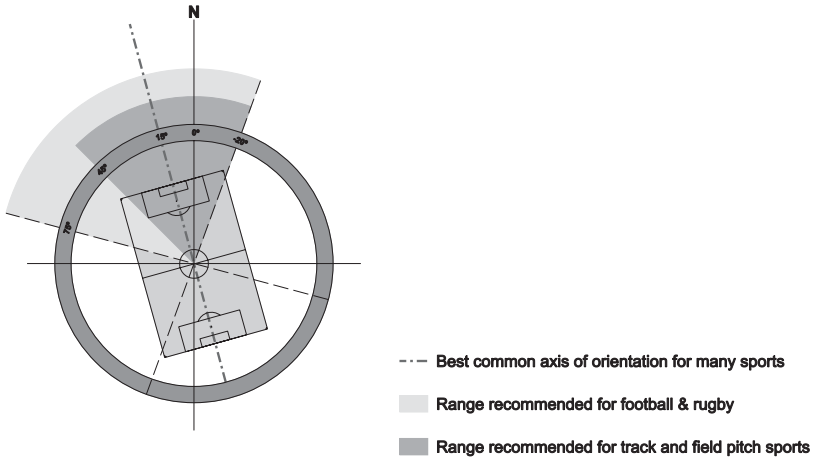
There are general 'rules of thumb' and sometimes regulations for the orientation of outdoor pitches, particularly those that are designed for spectators and television coverage, Figure 38.49. Generally for temperate climate situations, locating the long axis of the pitch in a north-south orientation is preferred with a 15 degree tolerance either side. This is to ensure that neither team is looking into a low westerly sun in the afternoon/evening. Spectators will therefore naturally gravitate to the west side of the pitch as they too will not be looking into the sun. The prevailing wind direction can also be a factor in orientation. There are of course always exceptions to the rule including famously Wembley Stadium which is orientated East–West.

3.12 Pitch technology

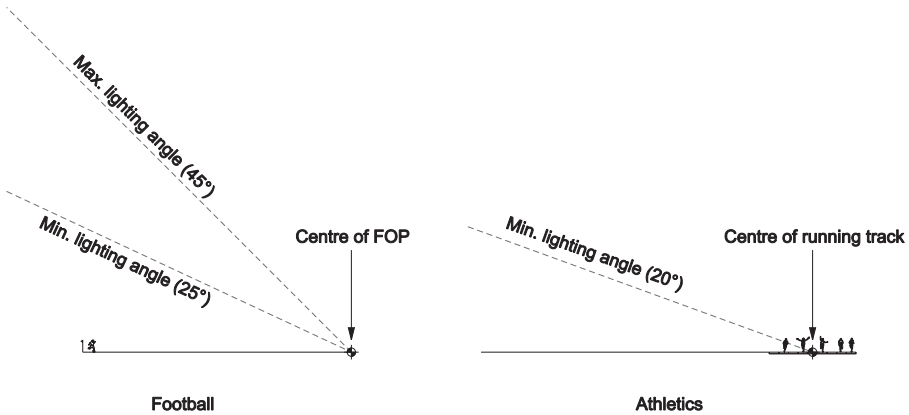
The most sophisticated natural turf pitches built for professional play will often employ a range of technology in order to maximise the quality and usability of the pitch; they can include built in irrigation systems with pop-up sprinklers or pitch-side canons, and heating and systems embedded in the sub-base which can be electrical, water or air based. The system beneath the pitch at the Cardiff Millennium Stadium employs a series of large ducts which can be used to heat, drain and ventilate the root zone. Where the field of play needs to be changed to suit different sports or activities, it is becoming increasingly common for pitches to be laid in pallets that can be slotted together by forklift truck and then removed when required. This allows a turn-around time of approximately 2 days. A few stadia around the world have even been constructed where the entire pitch can be slid out of a letterbox opening at one end of the stadium; this can be a swift process and allows for the grass to be grown and maintained in an open air environment and then deployed inside the stadium where the environment is not as conducive to long term grass growth.

3.13 Floodlighting

If the sport is to be played outside at night then clearly floodlights will be required so that the participants can play and train in safety, Figure 38.50. If the facility is designed to accommodate spectators then care needs to be taken to ensure that glare from the floodlights is avoided. At major events where television cameras will



38.49 *Field of play orientation*



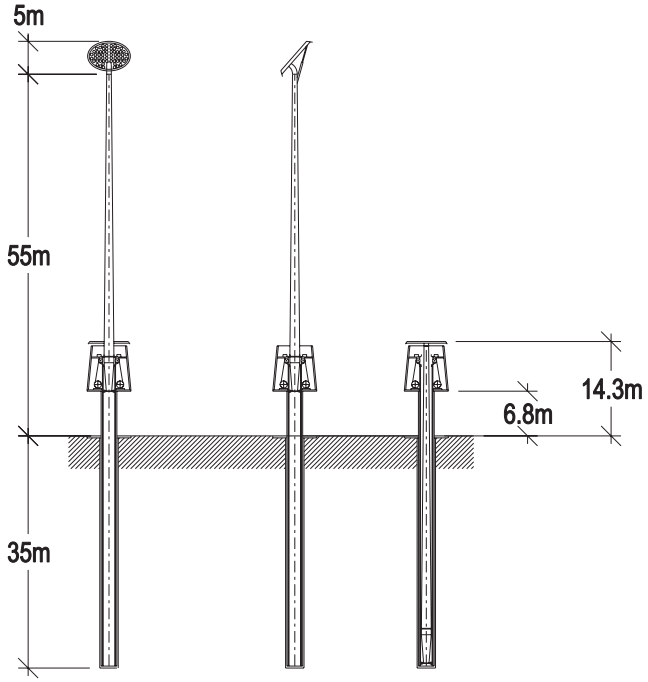
38.50 *Diagram showing lighting distribution onto stadium field of play*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

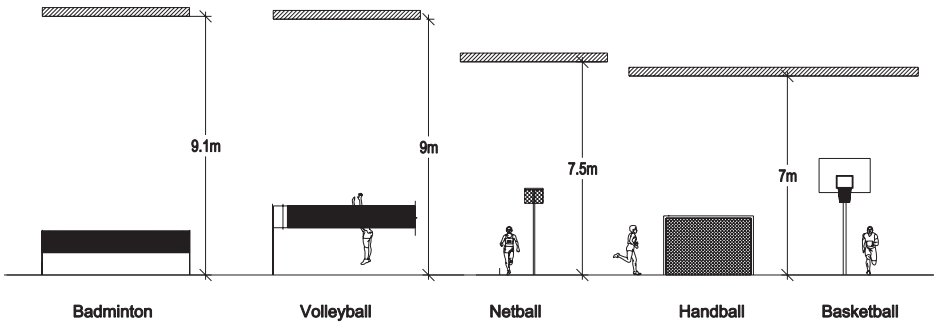
be present, the light levels on the field of play need to be suitable for broadcast requirements. Whilst fixed floodlights are most common, either as part of the roof design or at the top of dedicated towers, a number of facilities including Lords Cricket Ground have erected retractable lighting towers so that their visual impact on the city skyline is reduced on non-event days, Figure 38.51. The height of the lights will depend on the illumination levels required on the field of play and the angle of the projected light.

3.14 Head/clearance height

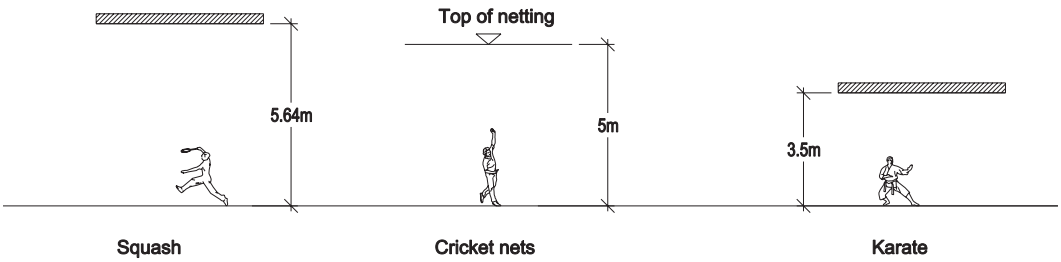
When planning the design of indoor facilities, the designer must take into account the height of the performance space required for each sport. Some vary according to the standard of competition so governing bodies should be consulted, however Figures 38.52–38.54 show recommended minimum heights for club, county, regional and national level competition.



38.51 *Diagram of retractable floodlights*

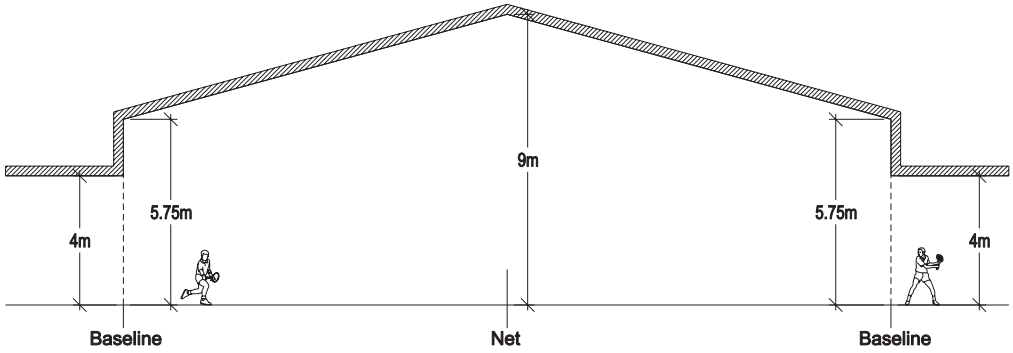


38.52 *Diagram for vertical clearances for different sports (badminton, volleyball, netball, handball, basketball)*



38.53 *Diagram for vertical clearances for different sports (squash, cricket, karate)*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.54 *Diagram for vertical clearances for indoor tennis*

4 VIEWING STRUCTURES

4.1 Introduction

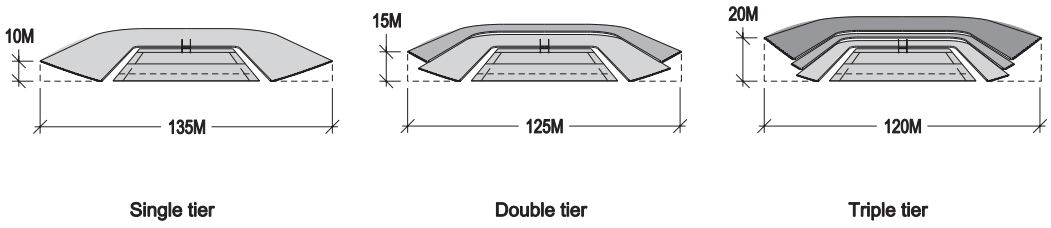
This section relates to the requirements for spectator viewing structures should these be required to observe the action on the field of play. Clearly a school playing field may have some spectators attending a match and they may simply stand at the touchline, but once the numbers of spectators reaches 2 or 3 rows of people, then viewing of the action becomes more difficult and so tier structures will be required, Figure 38.55. For example a road stage of a large cycle race such as the Tour de France will often attract thousands of spectators along the route but because the route is so long, viewing structures are only required at the finish.

The design of viewing structures can have a significant effect on the atmosphere enjoyed by the spectators and indeed the participants. This is where the art and science of design are indivisible. For any given seating capacity, the spectators can be accommodated in a number of ways, related to the overall footprint and height, resulting in quite different experiences for all.

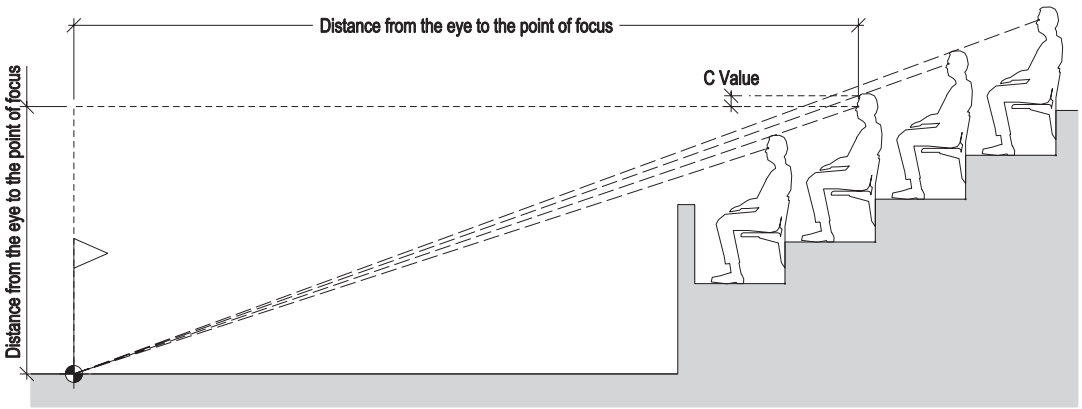
4.2 Viewing standards and sightlines

The first step when designing sightlines is to determine what is required to be seen. This could be the touchlines of a pitch, the likely height of a rugby ball kicked high into the air, video screen and scoreboards, the pitch-side dug out so a manager's reaction can be seen, or the referee sat high on their chair at a tennis match. It should also be remembered that it may be impossible to see the entire course for some sports such as motor-racing or horse racing depending on the terrain of the course.

Once the sightline target line or point is established, then the rows of spectators can be laid out. Consideration should be given to whether the spectators will be standing or seated, or sometimes in combination, to view the event. The specific rake of the terracing is established by determining the distance of the first row of spectators from the target line and the c-value. The c-value is a dimension measured in millimetres between the sightlines of spectators in adjoining rows, perpendicular to the target, as shown in Figures 38.56 and 38.57. This is typically between c. 60 and c.

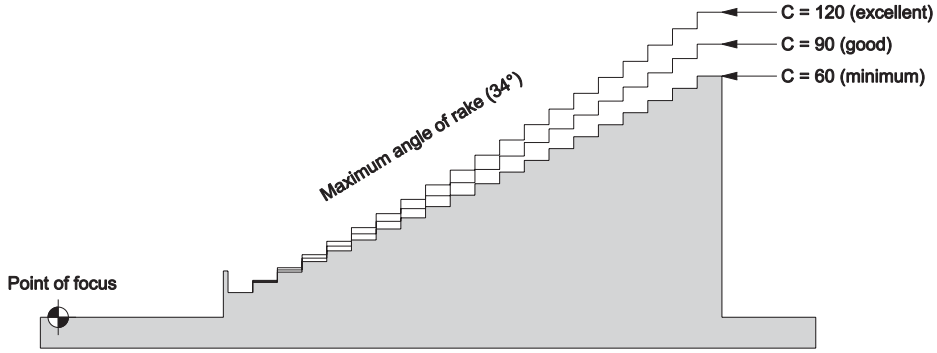


38.55 *Diagrams showing how spectators can be accommodated in different configurations*

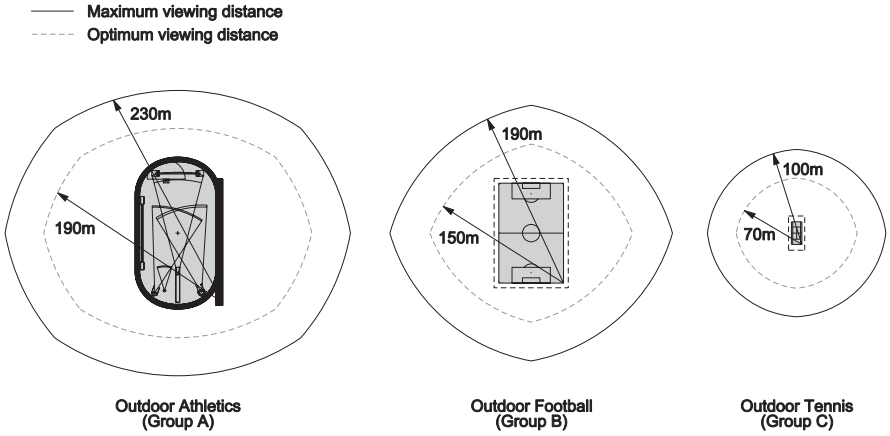


38.56 *Diagram showing definition of c-values*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.57 *Diagram showing effect of different c-values*



38.58 *Diagram showing maximum viewing distances for 3 sports*

120 with the higher numbers offering superior views. The mathematics calculation results in a parabolic curve for the profile of the tier, but an important consideration is that the maximum allowable rake of a tier is 34 degrees. The technical dimensions of sightlines however are only one part of perception of quality of view, and other factors are relevant. Some spectators prefer to be close to the action and will sacrifice the birds-eye view effect that a higher viewpoint would offer, and the reverse is also true. At sports such as horse racing and motor-racing, the view may need to be more panoramic where diagonal views are arguably just as important as views directly to the track in front. The speed of movement of the action is also a relevant factor.

4.3 Viewing distance

The size of the viewing area is determined by a number of factors, including client aspiration, the business plan, site constraints and essential activities on the field of play perimeter, but also by the relevant recommended maximum viewing distance for each sport. For a ball sport, the smaller the ball and the faster it moves, the harder it is to see and therefore the closer the spectator needs to be. Conversely a larger ball moving more slowly can be seen from a greater distance. This means that the maximum viewing distance for tennis would be considerably smaller than that for football, Figure 38.58.

There are of course exceptions to this rule, such as golf or cricket where spectators aren't really expected to be able to follow the ball in flight, but simply observe the reactions of the relevant sportsmen and women.

4.4 Seating and standing provision.

Some spectators will prefer to stand and others to sit, Figure 38.59. This may depend on the tradition of the sport, the level of excitement, the duration of the event and governing body regulations. Football grounds to the UK are required to be all-seated, whereas there is more flexibility for other sports. The sightlines will clearly be different for each so care should be taken to ensure that views are not impeded should standing spectator positions be located in front of seated spectators.

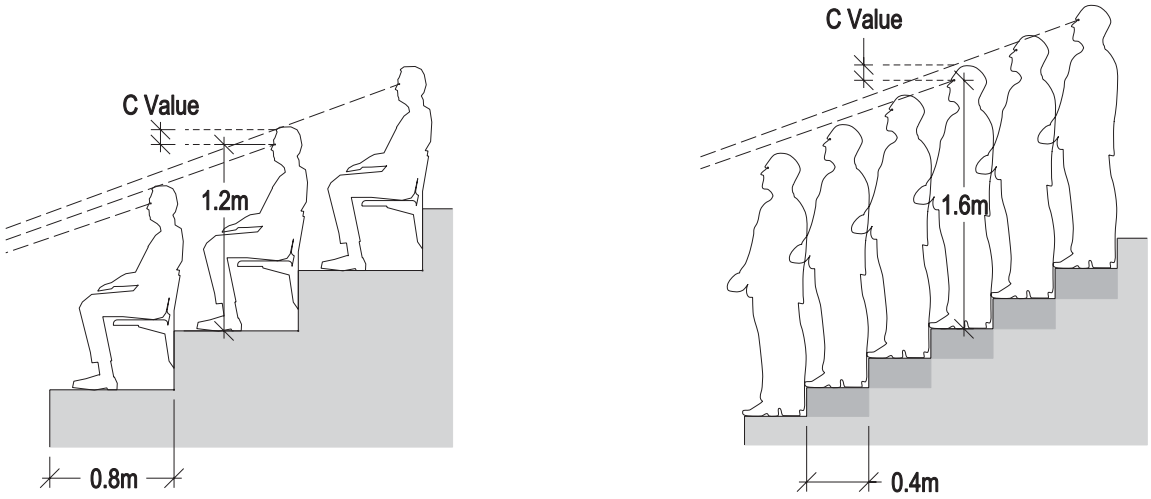
4.5 Seats

Seating can take many forms depending on the type of event and nature of the tier to which they are fixed, Figure 38.60. Simple bleacher benches without backs are common in the USA typically for High School or University facilities but less so in the UK. Plastic tractor seats, without backs, which are fixed down to the terraces are common in continental Europe but again less so in the UK. Whilst fixed seats with backs are occasionally also used, the most common form is for a tip-up seat, which permits the greatest area for circulation when the spectators are on the move. Advances in the design of the seats, using polypropylene injection moulding, have significantly improved the comfort of spectators with padding increasingly used and upholstered seats in VIP areas. The addition of UV-stable additives into the plastic can reduce the faded appearance common at older exterior stands. The recommended minimum spacing of seats is 500 mm with a maximum number of 28 seats between gangways or aisles, Figures 38.61 and 38.62.

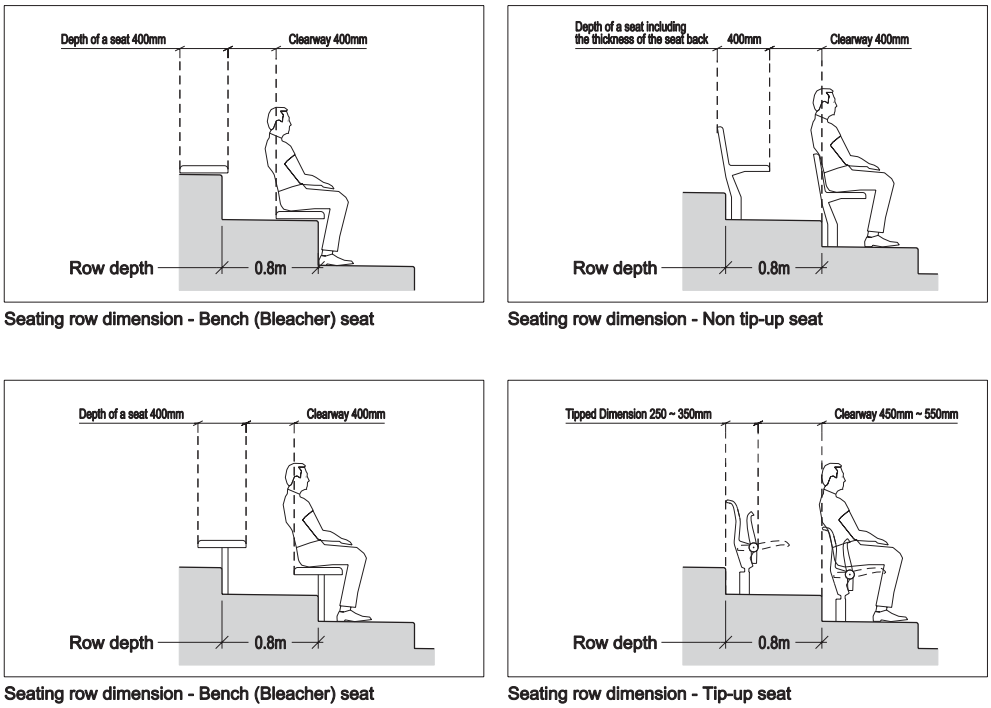
4.6 Access to and egress from seating

When large numbers of people are gathered together, the dynamics of crowd movement needs to be carefully considered in order to ensure the safety of everybody involved. The Guide to Safety at Sports Grounds (the Green Guide) exists to assist designers and inspectors of sports facilities and should be used as a primary reference document.

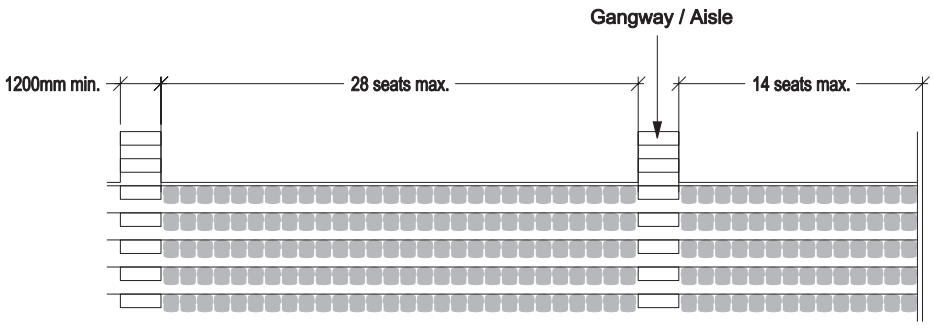
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.59 *Diagrams showing c-value calculations*

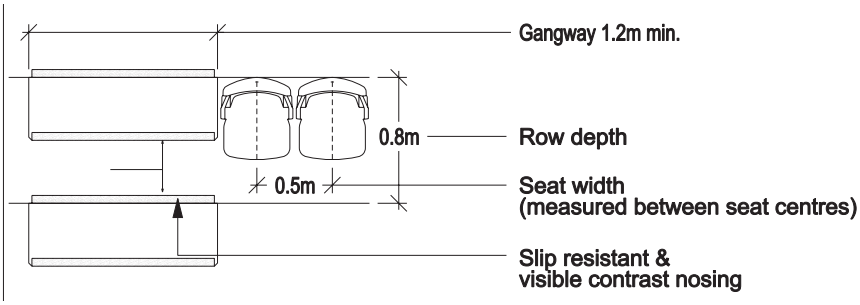


38.60 *Diagrams showing different seat types*



38.61 *Diagram showing maximum number of seats in a row*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.62 *Diagram showing seats spacing*

At the earliest stage of planning a sports facility, the crowd movements of spectators, be that from local transport links, car parks or a combination of the two, need to be understood in order to ensure that the areas outside the facility are correctly sized to accommodate them. This logic flows through to the number of turnstiles or other ticket checking measures required, as the UK venue licensing laws require that an accurate record of spectators attending events is maintained.

The space inside that ticket check zone is often termed the concourse and there are minimum sizes recommended for this area depending on the event. From here, access is gained into the viewing structures, terraces or auditorium by means of aisles or gangways – apertures formed in the seating tier. The minimum width for these access ways is 1200 mm but the actual size should be calculated in relation to the number of people using the route, the rate at which they flow through along it and the length of time they need to do it in. The Green Guide advises rate of passage such that 82 spectators can reasonably exit per minute for every metre width on a level surface. Clearly the larger the venue, the more complex the calculation will be. The guide also recommends that no seat should be further than 30 m from a point of exit, Figure 38.63. Once inside the seated viewing area, the minimum distance between adjacent rows of tiered seating is 800 mm, with increased row depths recommended when larger upholstered seats are used. The aisle, row and seat numbers all need to be clearly identified.

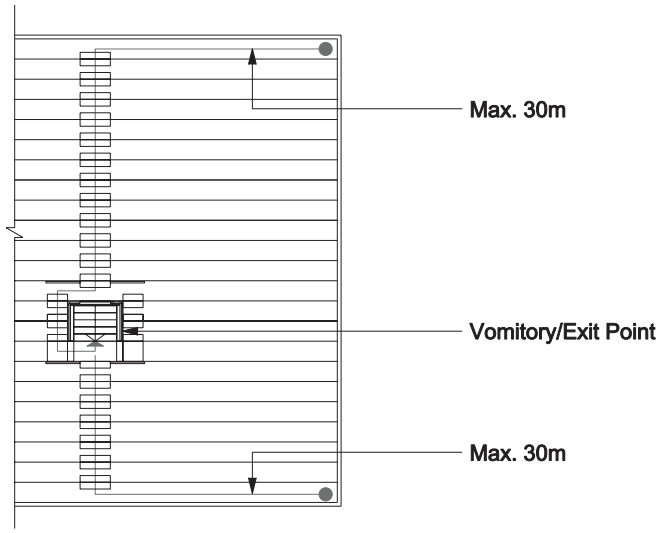
4.7 Disability Discrimination Act, 2005

In order to comply with the DDA, the viewing areas of a venue need to take into account the needs of disabled people in order to be inclusive. This equally applied to wheelchair users, ambulant disabled people and people with other disabilities. Particular care should be taken in the design of viewing structures to ensure that the view from a wheelchair position is not obscured by a spectator standing in the row in front, Figures 38.64, 38.65. Wheelchair positions, with adjacent companion positions, would be expected to be distributed in a number of locations throughout the viewing areas to offer the similar level of choice as for other spectators. The minimum recommended number of wheelchair viewing positions and other accessible seating types is defined in the Football Licensing Authority (FLA) document, 'Accessible Stadia'.

4.8 Stand design

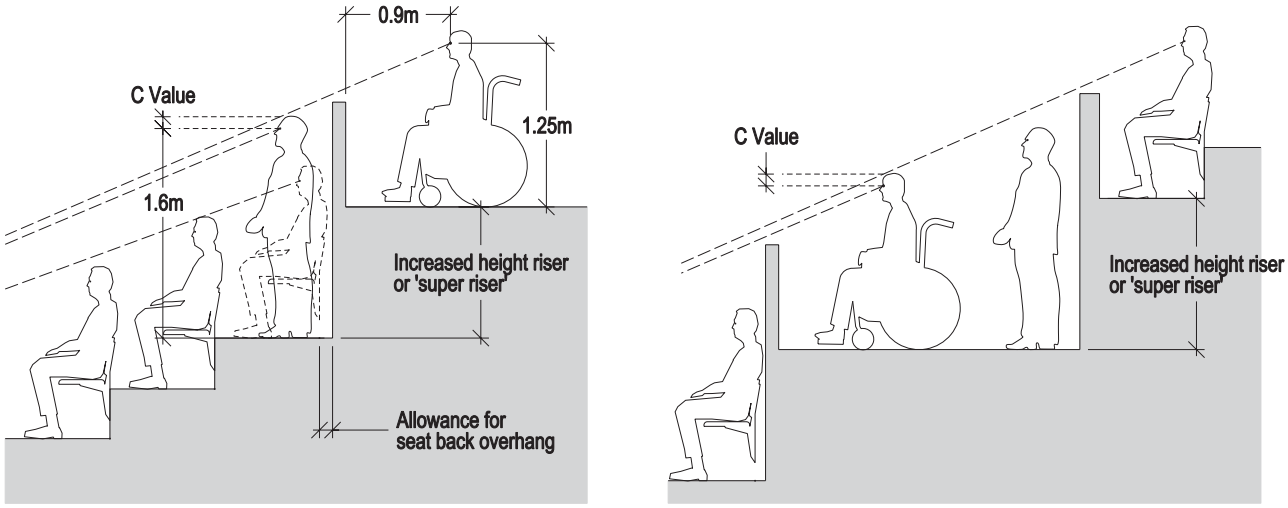
The construction of the viewing tiers can take many forms, depending on the nature of the event or events, Figure 38.66. For one-off or annual temporary events such as the London 2012 Olympics Beach Volleyball event at Horseguards' Parade in London or Henley Regatta or where supplementary seating is required for large events such as Royal Ascot or the British Grand Prix at Silverstone, it is common for these tiers to be provided in a temporary form based on a scaffold system. For permanent tiers, the construction favoured is usually insitu concrete or bespoke precast concrete planks spanning between raker beams. The use of timber for these structures is now rare due to fire risk concerns. Steel sandwich plates with an inert core to deaden the sound are also beginning to be used as an alternative to concrete. In some major stadia around the world, the tiers have been designed to move, so that they can be reconfigured for events with different requirements. For example the stadium built for the Olympic Games in Sydney included a retractable lower tier so that it can be transformed between Australian Rules Football and Rugby pitch configurations.

All types of tier need to be designed to accommodate the fixing and the considerable loads applied to safety barriers, and care needs to be taken in the design of these barriers to limit as much as possible any obstructions to viewing, Figure 38.67.

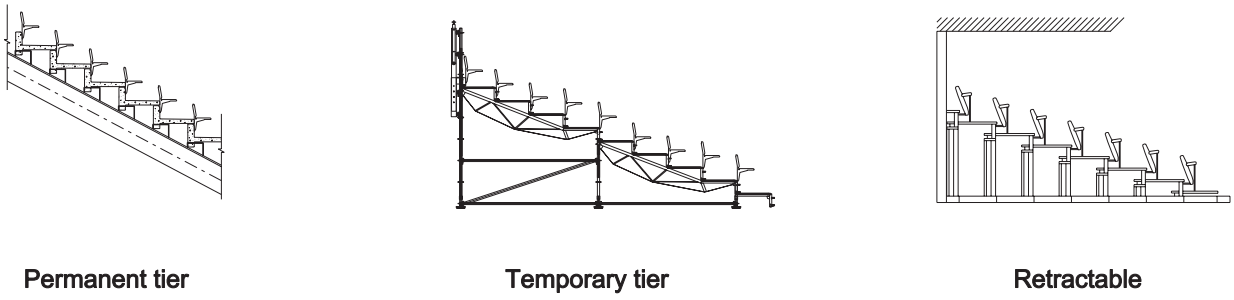


38.63 *Diagram showing the 30 m rule*

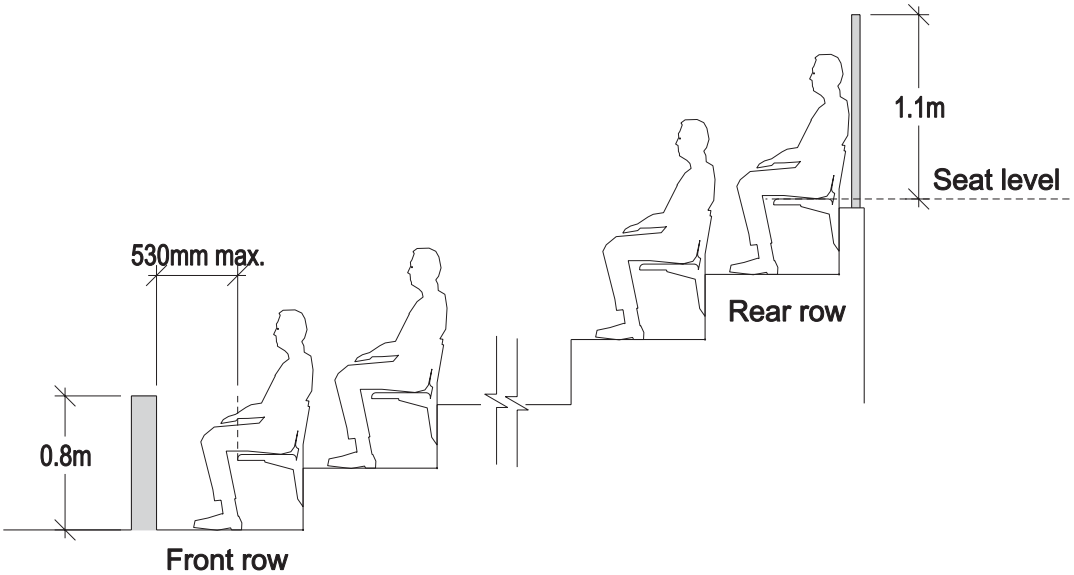
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.64 and 38.65 *Diagrams showing wheelchair viewing relative to other viewing*



38.66 *Diagram showing different kinds of stand*



38.67 *Diagram showing barrier design*

4.9 Roofs

The degree to which shade and/or shelter will be required over the spectators will depend on a number of factors including national climate, local conditions including prevailing wind strength and direction, client aspirations and any relevant governing body regulations, including viewing to high balls and other projectiles, Figure 38.68. For example: at the highest club level of both football and rugby, a roof over all spectators is recommended. Roofs can be erected as temporary structures, although their support columns will often obstruct views, which is obviously not desirable. In UK stadia it is common for a permanent canopy to be provided over the spectators, but not over the field of play. Larger international stadia, such as the Millennium Stadium in Cardiff, are being increasingly designed with retractable roofs to afford them the flexibility

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

to accommodate a number of different kinds of events. Modern international arenas such as the O2 arena in London have fixed roofs that cover both the spectators and the field of play.

The roofs of larger sports facilities often involve large span structures, for which reinforced concrete, timber glulam and steel cable or trussed designs have all been employed. Roof coverings tend to be steel or aluminium-profiled sheet, polycarbonate or tensile fabrics like PTFE/glass or PVC/polyester. The larger the span, the more the efficiency of lightweight designs is required. At the scale of the stadium or arena, the roof is often the defining element of the architectural design.

4.10 Video screens and scoreboards

Central to the modern spectator experience is information. Scores, statistics and replays bombard the viewer on television and the spectator at a live event is increasingly demanding a similar experience, Figure 38.69. Advances in LED and other technologies have allowed significant improvements over older dot-matrix scoreboards and typical cricket scoring devices. The size of the information displayed needs to relate to the distance from which it is viewed to ensure that it is readable. For examples, at athletics, the height of the characters of the display should be between 3 and 5 per cent of the distance to the furthest spectator. The number, size and position of screens should not impede the view of the action on the field of play.

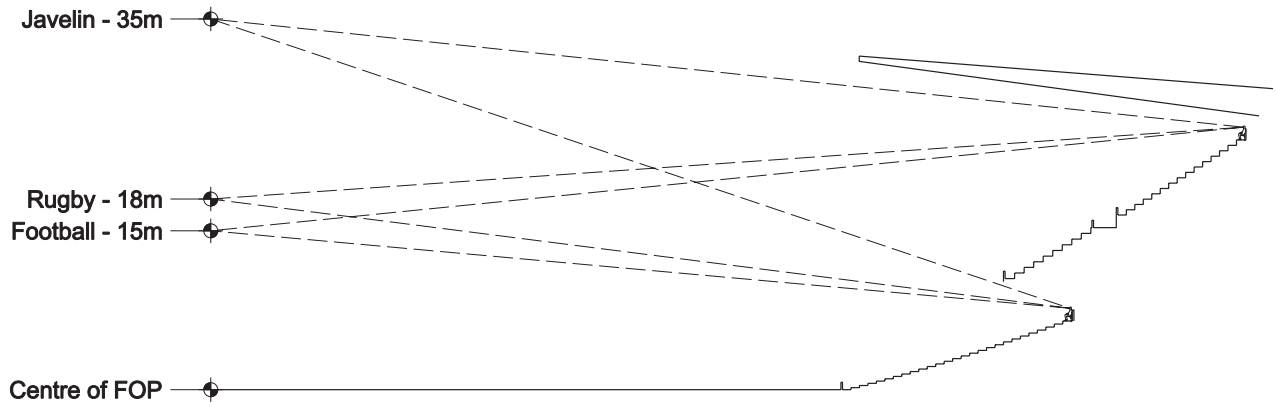
5 SPORTS EQUIPMENT

This section includes dimensional data for sports equipment typically incorporated into the planning of sports facilities, whether they are for training or competition.

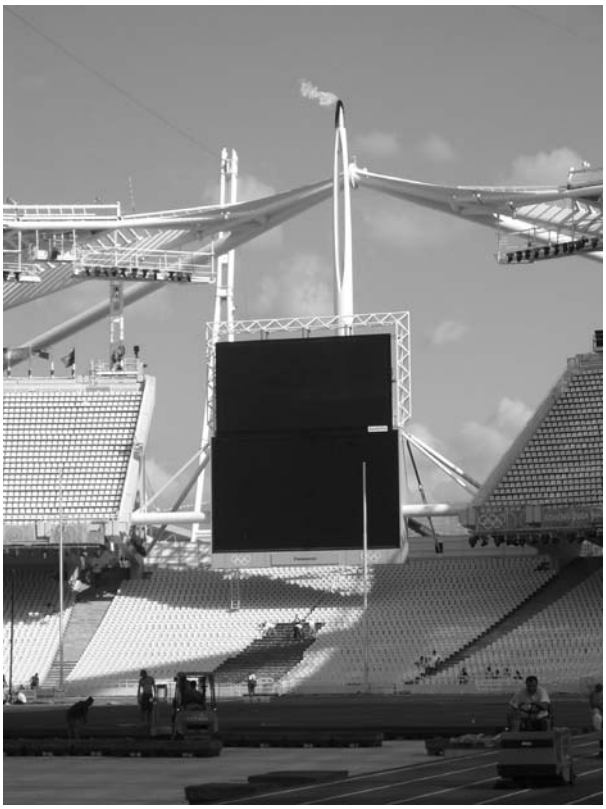
5.1 Gymnasium equipment

This may include the following:

- Rowing machines
- Spin bikes
- Weights machines
- Treadmills, Figure 38.70.



38.68 *Diagram showing high-ball viewing for football, rugby and javelin*



38.69a *Video screen between stands at a stadium*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.69b *Video screens incorporated amongst the stadium seating*

5.2 Pitch sport equipment
Figures 38.71–38.80 show dimensions for pitch sport equipment.

5.3 Track sports equipment
Figures 38.81–38.86 show dimensions for track sport equipment.

5.4 Pool equipment
Figure 38.87 shows dimensions for diving boards.

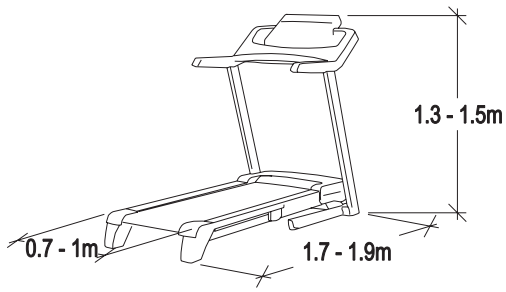
5.5 Court sport equipment
Figures 38.88–38.92 show dimensions for courts sport equipment.

5.6 Water sport equipment
Figures 38.93 and 38.94 show dimensions for water sport equipment.

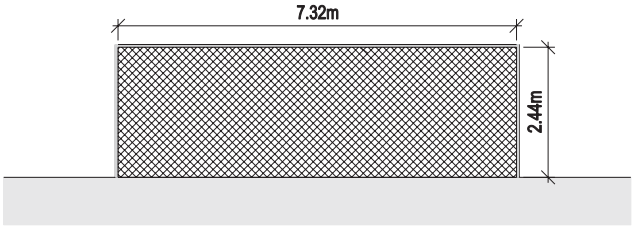
5.7 Other sport equipment
Figure 38.95 shows dimensions for gymnasium equipment.

6 SUPPORT FACILITIES FOR COMPETITORS AND OFFICIALS

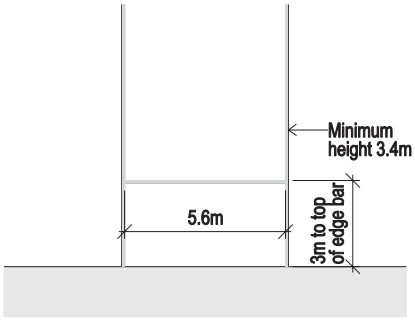
6.1 Introduction
The size and range of accommodation for participants and officials will vary depending on the level of competition. These facilities will typically include changing rooms, toilets and showers, gymnasia, strength and conditioning areas, warm-up areas, sometimes supplemented by medical and drug testing facilities for professional sports and areas for information and results. The accessibility of



38.70 *Treadmill*

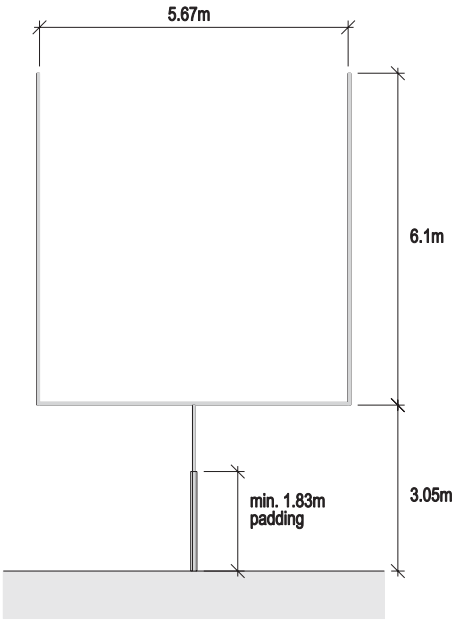


38.71 *Football (soccer) goalposts*

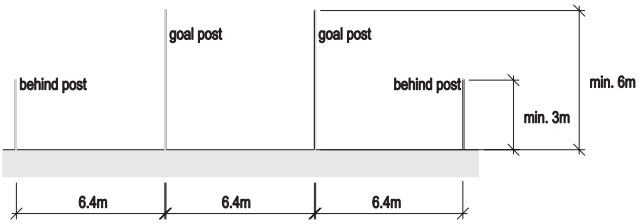


38.72 *Rugby posts*

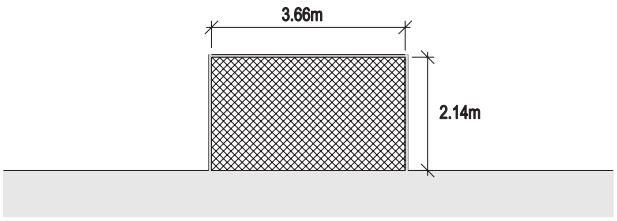
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



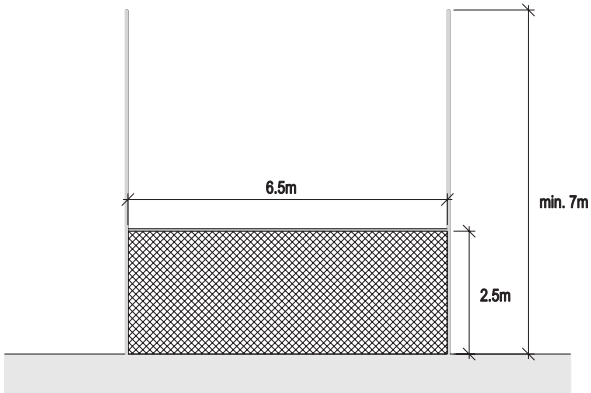
38.73 *American football posts*



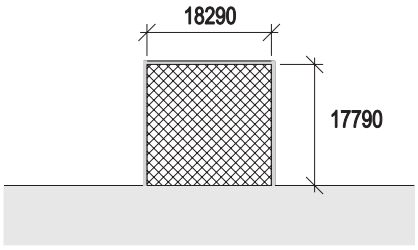
38.74 *Australian rules posts*



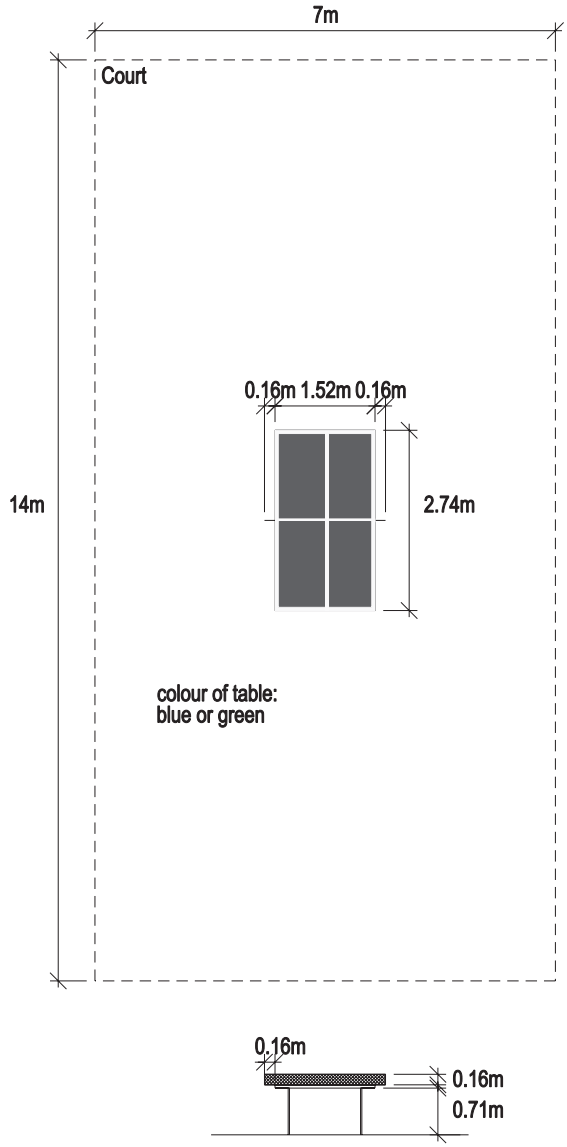
38.75 *Hockey goal*



38.76 *Gaelic football*



38.77 *Lacrosse*



38.78 *Table tennis*

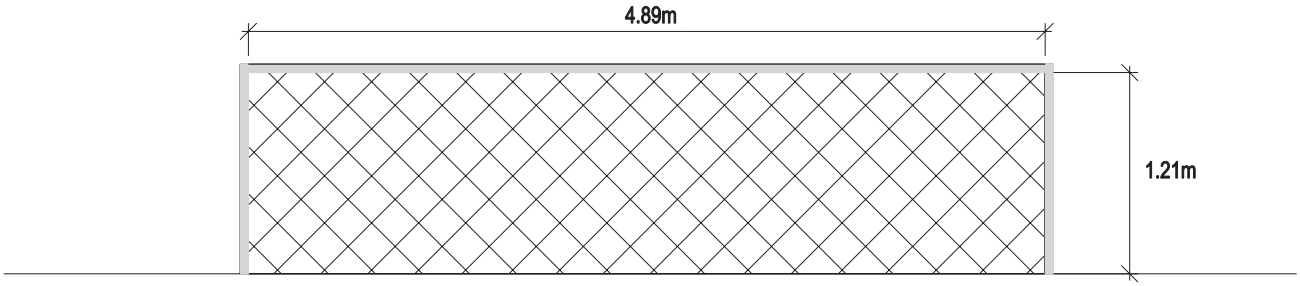
these facilities must also be considered. The degree to which these facilities can be and are shared by the general public varies from sport to sport as well as by the level of competition.

6.2 Competitors and other participants

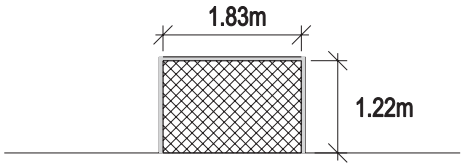
Most sports' buildings will require changing facilities for competitors, appropriate to the nature of events being held at the venue. The amount and type of accommodation varies depending on the type and scale of the event. For school, university and club level sport or for where competitors are not divided into teams, a changing room with toilet and shower facilities for each gender may be all that is required. For team sports, separate changing rooms are

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

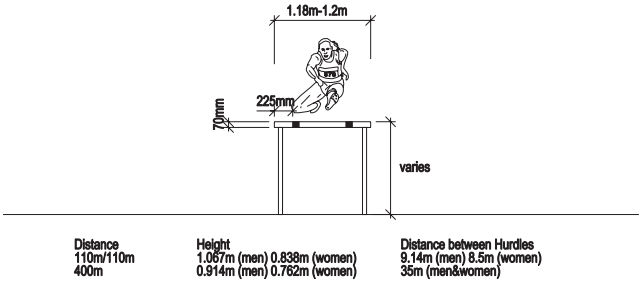
Goal Posts:
Recommended size between 3.66m wide by 1.83m high.
Indoor with restricted height: 4.88m wide by 1.22m high (seniors) or 3.66m/2.44m wide by 1.22m high (juniors)



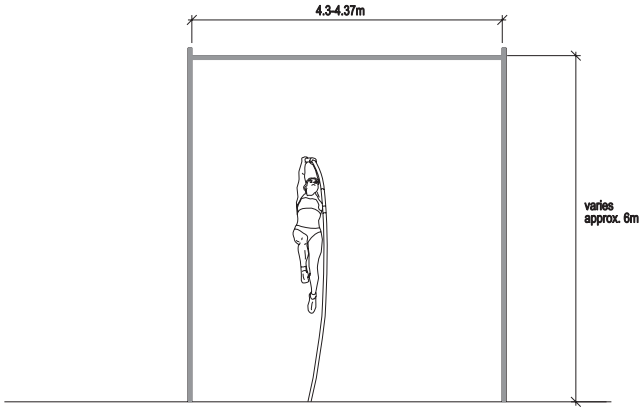
38.79 *5-a-side football*



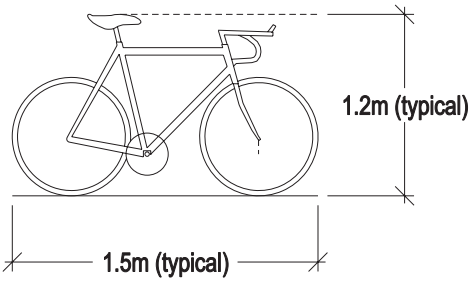
38.80 *Ice hockey*



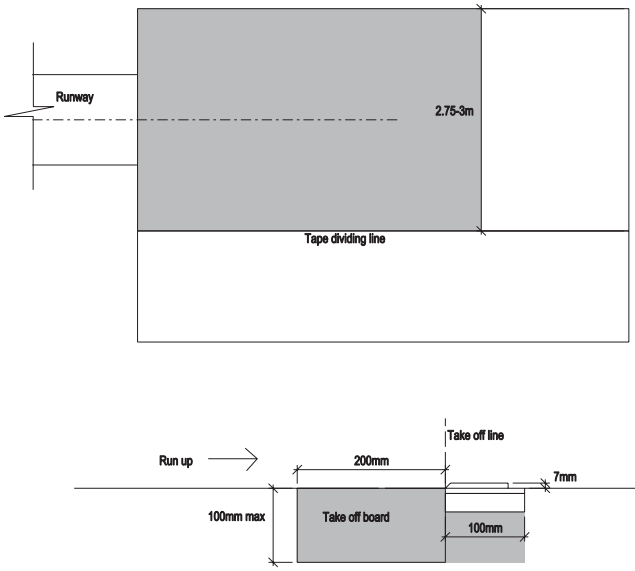
38.83 *Hurdles*



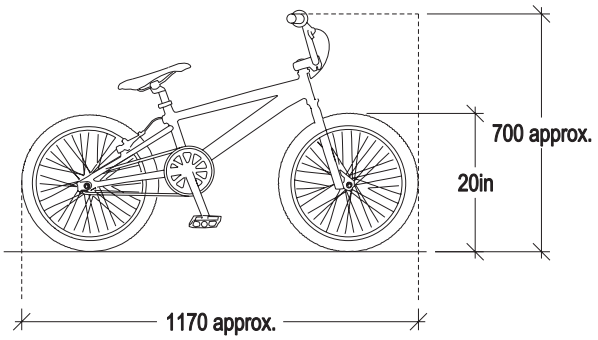
38.81 *Pole vault*



38.84 *Racing bike*

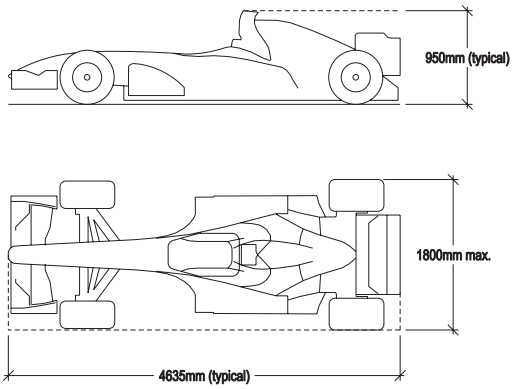


38.82 *Long jump*

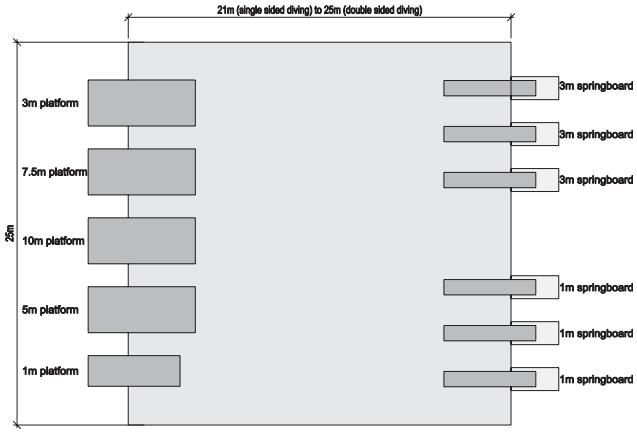


38.85 *BMX bike*

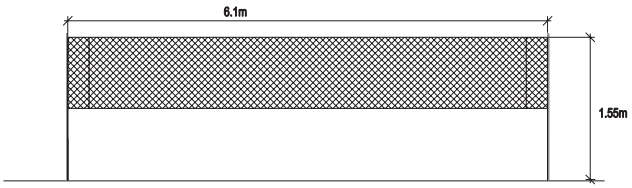
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



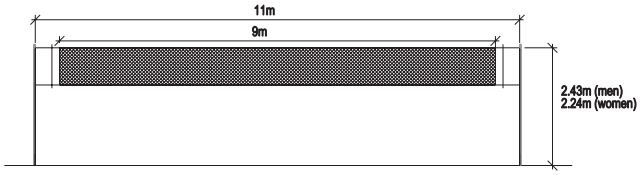
38.86 *Formula 1 car*



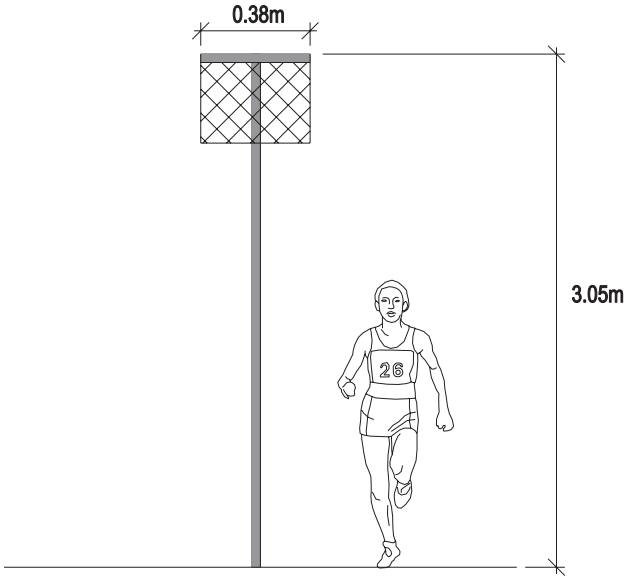
38.87 *Diving boards*



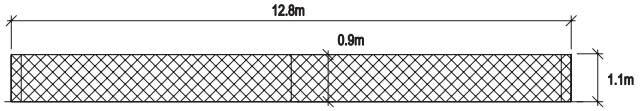
38.88 *Badminton net*



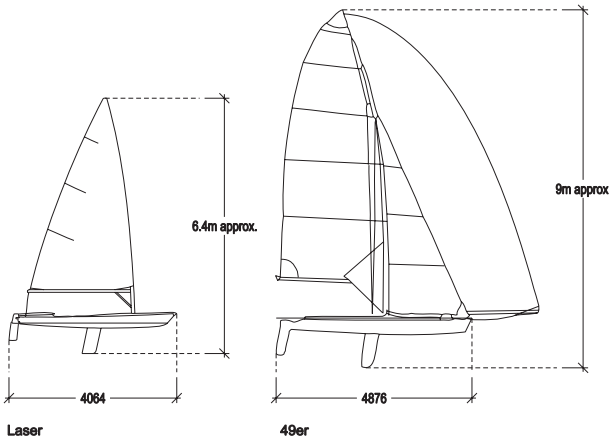
38.89 *Volleyball net*



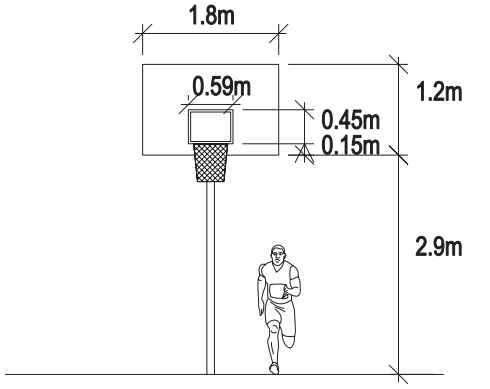
38.90 *Netball hoop*



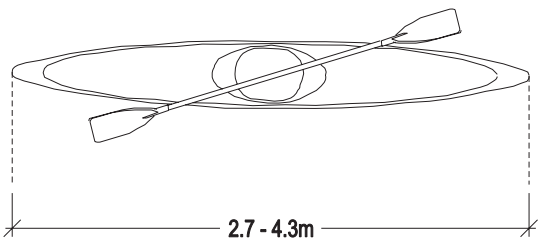
38.91 *Tennis net*



38.93 *Sailing dinghies (49er, Laser)*

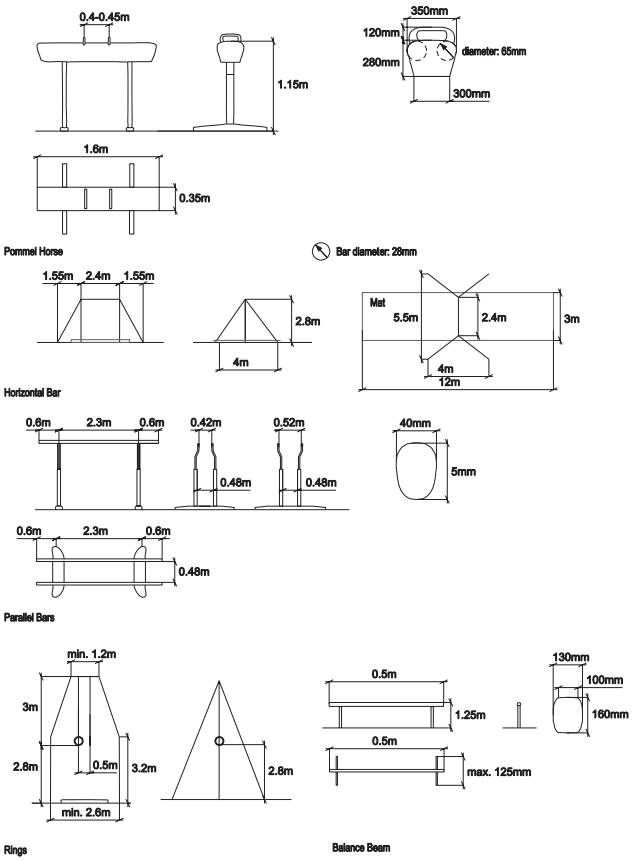


38.92 *Basketball hoop*



38.94 *Kayak*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.95 *Gymnastics equipment: vaulting horse, balance bar, parallel bars, rings*

usually required for each team as the rooms will be used for team briefing. If there is a 'home team', then most of the accommodation is concentrated on their requirements; however consideration should be given for multi-purpose use. In larger stadia the use of four changing rooms can provide flexibility in catering for a range of team sizes and additional participants such as ball boys and girls, mascots, marching bands and other entertainers.

Corridors used by competitors should be generously sized, preferably to a minimum of 1800 mm clear width. Consideration should be given to the requirements of wheelchair competitors for the intended sports, as competition chairs can have very a wide or long wheelbase. This will inform the requirements for corridor widths and turning spaces and doors, where competitors are likely to be using their competition chairs within the building.

Changing rooms should be laid out to suit the requirements of the intended sport, and should allow for a minimum of 1.6 m^2 per person. Generally team-based pitch sports require open layouts with a peripheral array of changing stations and lockers for competitors, which allows the team coach or manager to see and address all the occupants. Each changing room should contain locker facilities, bench seating and garment hanging space for each individual competitor, including substitutes. For elite sports facilities each changing position should be at least 750 mm wide, on the assumption that all changing positions will be occupied by the team during key periods. For community sports facilities each changing space of bench seat should be provided at a minimum width of 500 mm.

Elite sports changing rooms, Figure 38.96, will also require space for TV monitors and tactics boards, small refrigerators for refreshments storage, telephone and adjacent space for massage and physiotherapy beds. Integrated coaches' office and changing rooms may also be required. Multiple event and individual event venues such as athletics may have changing rooms divided into zones by free-standing banks of lockers and bench seating. Public access sports buildings should also contain family changing cubicle facilities within the changing rooms. For larger family groups, cubicles measuring 2 m × 2 m are also suitable as accessible changing groups. All changing rooms should include accessible changing facilities.

Sanitary facilities, including WCs, urinals, hand basins, hand drying fixtures and showers should be designed to meet local building regulations. For elite competition venues, main changing rooms should be provided with dedicated sanitary facilities, accessed from within the changing facility. The toilet fixture numbers should be based on the likely peak occupancy of each changing room and the sport code recommendations. Publically accessible venues should have toilet facilities located adjacent to the changing room entrances, but accessed from common circulation areas. The toilet fixture numbers should be based on the likely total building occupancy. As a minimum, at least one unisex accessible toilet facility should be provided for participants' use adjacent to other toilet provisions. In larger facilities, accessible sanitary facilities should be included in gender specific toilet facilities, in addition to the unisex facilities.

Elite competition venue main changing rooms should be provided with shower facilities in accordance with sport code recommendations, and generally at not less than 1 shower per 2.3 changing positions. Publically accessible venue changing rooms should have shower facilities provided at not less than 1 shower per 10 changing positions and preferably 1 shower per 6 changing positions, and include some showers with cubicle enclosures. Dependent on layout drying areas between showers and main changing areas may be required.

6.3 Officials

Each sports event requires officials, judges, umpires, linesmen or referees, who normally require separate changing and toilet accommodation. Their changing facilities should be close to but ideally separate from the competitors' facilities and in good proximity to the field of play, but must be inaccessible to the public or the media. The accommodation should be sized for the appropriate number of officials, allowing 2.5 m^2 per person including associated lockers, toilets and showers in accordance with the sports code recommendations.

The nature of sport requires different event-specific facilities for officials: these might vary from a race committee room or boat for a sailing race, a timing and scoring room at an athletics track or a velodrome, or space for a third umpire and scorers at a cricket ground. In most instances a view of the field of play is essential and increasingly technological links will also be required. Internally, a seat and desk with clear sight of the playing area is a recommended minimum. Other facilities may also be required for operating the event. These could include an appeals room for up to ten people, a competition management room and also a place for processing results, and other sport-specific areas such as a weighing room at a racecourse, Figure 38.97.

6.4 Team management

If a sports building houses a home team, then it is likely that a suite of team management spaces will be required, preferably in close proximity to the main changing rooms. These facilities should not be confused with venue management facilities described in Section 9. The spaces could include: a designated reception area with general support office and secretariat, team manager and assistant managers' offices, and meeting rooms (which could be shared with other administrative activities).

Other subsidiary activities of team management and participant management that also require space may include uniform and kit storage, laundry and drying rooms, boot and shoe stores, equipment storage, and equipment repair and maintenance facilities such as tennis racquet stringing services.

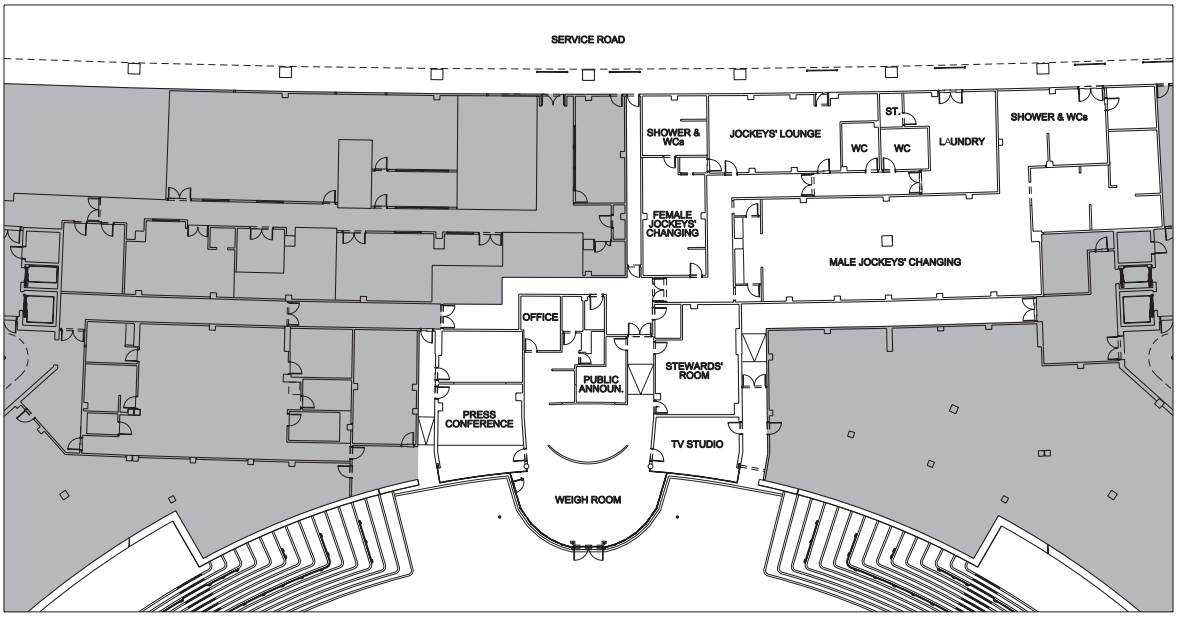
6.5 Warm-up

Many sports require a space for the competitors to warm up, prior to engaging in their sport. This could be a simple space to stretch,

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.96 *Plan of Premier League football stadium players' facilities*



38.97 *Plan of racecourse weighing room complex*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

usually part of the changing room, dedicated areas adjacent to changing rooms, an indoor 60 m warm-up track for athletics, or even a completely separate warm-up track and field for major athletics events. If a separate warm-up area is provided, then a dedicated connection will be required to link the warm-up area to the field of play.

6.6 Marshalling area/players' tunnel

Many sports require the competitors to be gathered into their teams, heats or event groups prior to entering the field of play. For example, athletics meets will have a final call room where athletes are checked for event schedule, compliant kit and correctly displayed identity numbers before being escorted with their event group onto the field of play. For pitch sports, competing teams will be assembled in a designated players' tunnel to run out in formation onto the field of play as part of the event spectacle. Competitor tunnels and field of play entrances may also be used for the movement of event entertainers, essential field of play equipment and officials as required during the event.

6.7 Medical facilities

Medical support facilities should be designed in accordance with local safety and licensing requirements, and sports codes recommendations. In major competition venues, the medical room is generally located in close proximity to the main changing rooms, with designated step-free access routes suitable for stretcher transport from the field of play and to a nearby ambulance parking bay. Ideally the routes from the field of play and to the ambulance point should be away from media areas.

This medical room is likely to be staffed by a doctor and other medical staff during the event, and should have more than one stretcher bed or treatment table position separated by mobile screens, and space for competitors to sit awaiting treatment. In large venues, a suite of rooms may be provided, including reception and waiting area, a small staff office, stretcher treatment and ambulant minor injury treatment areas and shower facilities. Medical rooms should be provided with at least one accessible WC cubicle, and separate hand washing facilities, secure medical supplies storage cabinets and space for treatment and diagnostic equipment. For very large events, more than one medical room may be required.

For publically accessible sports buildings, such as sports halls, a first aid room will be required. This room will be sized to suit the venue activities and management strategy, and may range from a dual purpose office or staff room to a dedicated facility. As a minimum, a shared room should contain hand washing facilities, a drinking water supply, a secure first aid cabinet, a clear space of 2.0 m x 1.6 m and door width suitable for stretcher access, and an adjacent accessible WC compartment.

A dedicated first aid room should be large enough for a treatment trolley bed in addition to the above facilities. Large sports facilities may have dedicated doctor's rooms or consultation rooms as part of more extensive sports medicine or therapy facilities. These may also include dedicated x-ray or ultrasound diagnostic rooms, specialist physiotherapy and other treatment spaces.

6.8 Doping control facilities

Major competition venues will require a facility which can be used for doping control activities, where competitors are tested. This does not have to be a dedicated facility, if appropriately equipped spaces can be provided for the duration of the event, although they must be in a discrete location in close proximity to the competitors' changing rooms.

The size of facility will depend on the event and numbers of competitors to be tested; however the suite of facilities will generally include a reception/waiting area with seating for competitors and chaperones, with a drinking water supply; a working or testing room with a desk and chairs and a secure samples refrigerator, with dedicated access to a WC cubicle with hand-washing facilities. Some sports codes also recommend shower facilities. Doping control testing may also occur at smaller venues and outside of events. A dedicated large first aid room may also be used for this occasional purpose, provided it meets the minimum criteria set out above.

6.9 Lounge/recreational space

A lounge or recreational space is desirable for participants to use after their activity and in smaller facilities can take the form of a club room. This consists of an open lounge often equipped with a bar and sometimes adjacent catering facilities. In most professional sports this space will be segregated from the public, but in other sports facilities this will be a communal space to gather after an event.

Some sports, such as cricket, take place over a long period of time and therefore require catering facilities. This would include a kitchen, server, catering storage and space for the participants to eat. For amateur sports this space would double-up as the recreational space. In facilities open to the public, such as an indoor training centre, a café or cafeteria is usually available, where participants and visitors alike would share the area.

6.10 Access and inclusion

Designers should refer to Football Licensing Authority (FLA) 'Accessible Stadia', BS 8300 and Approved Document M of the UK Building Regulations, in order to address the Disability Discrimination Act 2005 (DDA) and Equality Act 2010 in relation to the built environment. These documents cover the requirements for accessible and inclusive design including but not limited to the design of parking, corridors, vertical circulation, doors, toilets and washing facilities, ensuring the needs of all participants and officials are met.

6.11 Parking/drop off/storage

Consideration should be given to how participants may arrive at the venue. Some will arrive on foot carrying kit bags, some in cars requiring car parking, and some may arrive on a team bus. Parking will be required close to the changing facilities, including a drop-off point for team buses. Sports that require personal equipment such as sailing, rowing, kayaking, triathlon will need space for parking trailers and for storing the equipment. Watersports will also need launching facilities at the water's edge.

6.12 Gymnasium/fitness centre

Used for training rather than competition, a gymnasium or fitness centre will provide a range of equipment and spaces and can include the following:

- Open-plan studio with fitness training equipment and free weights
- Separate studios for dance, aerobics and other specific work-out classes
- Swimming pool
- Hydrotherapy
- Sauna
- Steam room.

7 SUPPORT FACILITIES FOR SPECTATORS

7.1 Introduction

The size and range of facilities for spectators will vary depending on the level of competition. As a minimum, toilets will be a requirement of the venue licence, with catering facilities such as cafes, bars, and restaurants often provided. Ticketed events obviously require accommodation for ticketing and larger venues often contain private boxes/suites and lounges for hospitality, retail and merchandising, medical facilities and information.

7.2 External circulation/approach to venue

The approach to a venue needs to provide clear and safe access for all spectators. This will require the use of wayfinding signage, PA/VA

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

systems and external lighting. Where large crowd numbers are expected to attend an event, crowd management barriers may also be required to control the flow of people.

7.3 Ticketing and security

All spectators attending a ticketed event will need to pass through a ticket control point, Figure 38.98. This can be a simple manual ticket check, digital ticket scan or via a turnstile, depending on whether the venue licence requires an accurate count of the number of people attending as is usually the case at a large UK event. Turnstiles can be half-height, offering little in the way of a secure perimeter but a more user-friendly experience, or full-height acting as a perimeter fence also. They should be provided on the basis of one per 500 to 750 spectators. If spectators do not have a ticket when they arrive at the venue then they will need to pick one up from the ticket office. This usually consists of a counter with an in-built tray that enables the exchange of money for tickets. The counter should have one lowered section at 760 mm for wheelchair users. For larger events, spectators will often be required to pass through either random or mandatory security searches with magnetic detectors for both spectators and their bags.

7.4 Sanitary provision

The quantity and gender ratio of toilet provision will vary in accordance with the type of sports venue and event and should be addressed with the local licensing authorities. General guidance advises that the gender split of toilet fixtures should be based on 50% female: 50% male provision, see Table I. However, it is accepted that for many sports facilities, the gender ratio should be based on the normal (or expected) number of male/female spectators. This may alter the ratio significantly, for example to 30% female:70% male for some pitch sports.

Also, for multi-purpose venues, where significant swings in the audience gender balance can be expected, a level of flexible provision or over-provision should be considered where the number of spectators is increased above 100% for the purpose of the calculation, up to 120%. For competition venues, reference should be made to BS 6465:2009 for initial guidance, particularly Section 6.8 and Table 7 – 'Minimum provision of sanitary appliances for assembly buildings where most toilet use is during intervals' for pitch sport and similar short duration events.

Table I Sanitary provision

	Urinals	WCs	Wash basins
Male	2 for every 50 males, plus 1 for every additional 50 males or part thereof	2 for up to 250 males, plus 1 for every other 250 males or part thereof	1 per WC and in addition 1 per 5 urinals or part thereof
Female		2 for up to 20 females or part thereof up to 500 females; and 1 per 25 females or part thereof over 500 females	1, plus 1 per 2 WCs or part thereof

7.5 Food, drink and other spectator services

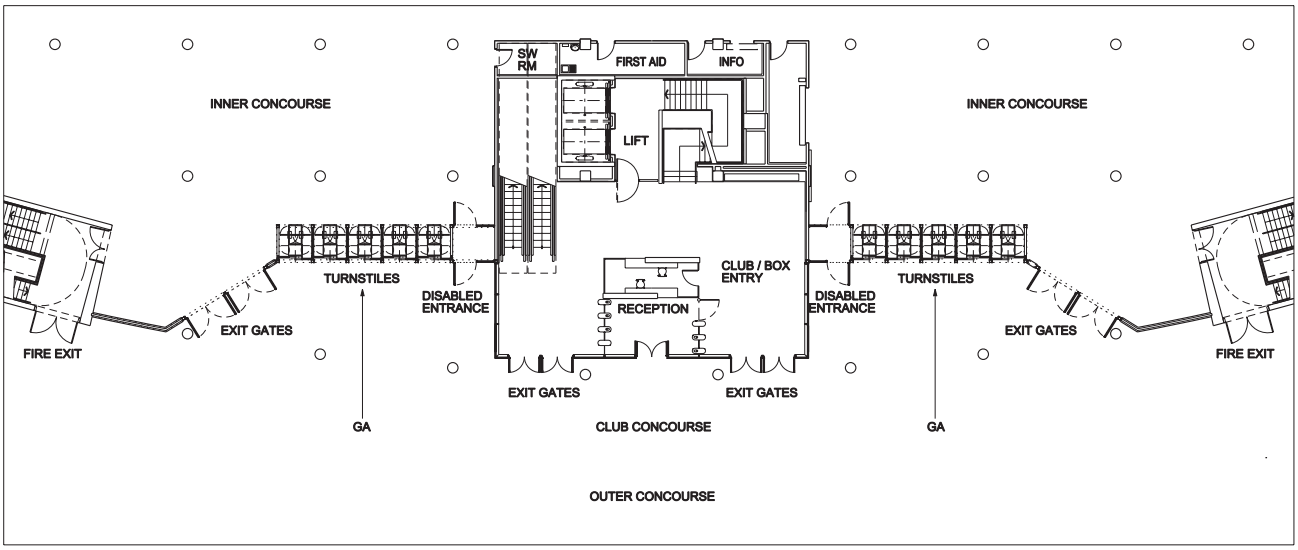
The range of food and drink on offer to spectators will depend on the length and type of the event and the aspirations and business plan of the venue owner or operator. At the very least, all spectators should be provided with a water supply. Visitors to a club level competition might expect vending machines or a cafe or server providing basic food. At larger facilities, spectators will often expect to be able to access a range of food and beverage outlets during their time at an event, provided either on a temporary or permanent basis. Temporarily provided concessions typically take the form of road trailers with fold-down counters serving a range of fast food, and both alcoholic and soft drinks, and so need sufficient space for delivery, set up and collection. Permanent concessions can be provided either in a single booth or in a range of dedicated booths. A typical concession will consist of a preparation area with serving position and counter. A standard module for 2 serving points is 2.6 m and each length of counter should have one lowered section at 760 mm for wheelchair users. Queuing lines or rails may be required in larger facilities to control the approaches to concessions and prevent crowd circulation problems.

It is also typical at larger events to include areas where information can be provided to spectators, both to assist wayfinding around the venue, but also a results service related to the competition schedule. Some buildings, especially racecourses, will require a range of betting facilities, in the form of Tote booths or betting shops. First aid facilities will need to be distributed throughout spectator areas, with access to a central area for more serious injuries.

7.6 Hospitality

Larger sports buildings will incorporate a range of hospitality lounges and restaurants within their premises as required by their business plan. These don't have to be but can be of higher value if arranged to afford a view of the field of play. The following categories are typical:

- Club Lounge – where spectators have access to food and drink in an open lounge and a seat within the seating bowl.
- Box/Suite – spectators have access to food and drink in a private room and dedicated seats immediately in front of the Box/Suite.



38.98 *Plan of Premier League football stadium spectator entry*

- Premium Club – where spectators have access to food and drink in a small, exclusive lounge and dedicated seats in front of the Club.
- Owners/Directors/Royal Box – where VVIPs have access to food and drink in a small, exclusive lounge and dedicated seats in front of the Box.

7.7 TV screens

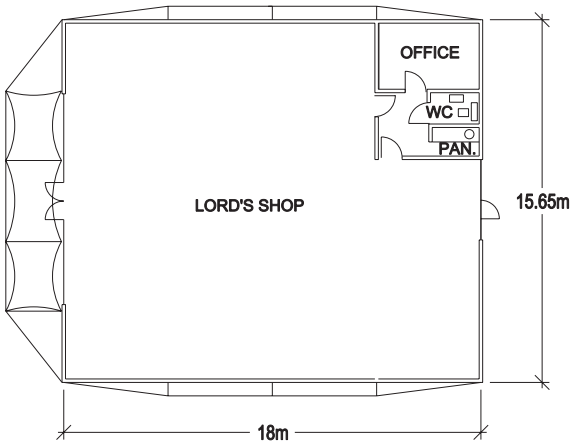
In addition to information points, TV screens and monitors are often helpful in relaying information or footage of an event to spectators. These need to be mounted at a suitable height to maintain visibility within crowded areas.

7.8 Retail

Retail spaces enable spectators and other visitors to purchase sports-related equipment or merchandise related to a sports team or activity, Figure 38.99. These can range in size from a display at the reception desk of a community sports facility, to a dedicated megastore at larger sports buildings. The layout of the retail spaces will depend on the range of merchandise on offer, but can include rails and wall displays. Shirt printing is a popular offer in some sports buildings and may require queuing rails. Payment is usually processed at tills or counters set out at the exit point of the retail space.

7.9 Museum/visitor attraction/tours

Some sports grounds can attain national or regional tourist significance and will incorporate a museum or visitor attraction that can be open during non-event days. These are often linked to tours of the sports building, which inevitably finish their journey in the retail space.



38.99 *Plan of Lord's cricket ground shop*

7.10 Access and inclusion

Designers should refer to Football Licensing Authority (FLA) 'Accessible Stadia', BS 8300 and Approved Document M of the UK Building Regulations, in order to address the Disability Discrimination Act 2005 (DDA) and Equality Act 2010 in relation to the built environment. These documents cover the requirements for accessible and inclusive design including but not limited to the design of parking, corridors, vertical circulation, doors, toilets and washing facilities, ensuring the needs of all spectators are met.

8 FACILITIES FOR THE MEDIA

8.1 Introduction

For events at which the media is in attendance, the needs of broadcast (radio and TV), written press and photographers need to be taken into account in the planning of the venue. The size and range of facilities will vary depending on the level of competition, and may need to include press workrooms, a press conference suite and outside broadcast.

8.2 Dedicated routes

The media are often provided with a separate entrance point to sports buildings. This entrance will usually have a reception desk, which is used to undertake accreditation, prior to the media entering the building.

8.3 Specific media requirements

There are a wide range of media and each type has their own requirements, as follows:

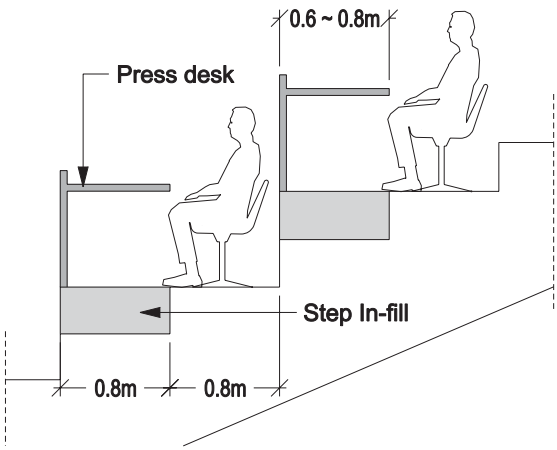
- Written press: this group requires access to the seating structures, and ideally a desk there at which to work, Figure 38.100. Larger facilities typically have a press workroom in addition where copy can be completed and uploaded to editors, Figure 38.101.
- Photographers: this group requires access to the perimeter of the field of play of a pitch sport, with moats sometimes provided around the edge of a field of play to enable photographers to work during an event, without restricting the view of spectators. At some course sports such as road cycling, photographers would travel in media cars in order to photograph en route.
- Broadcast media (radio and television): this group is the most difficult to accommodate since the technology advances so rapidly and different broadcasters have different requirements. Radio broadcasters will typically want to relay commentary from the event either from within the seating area or from a room with a view of the field of play, and sometimes an opening window so the sound of the crowd can be heard in the background. They may also want to conduct pitch-side or 'flash' interviews prior to and after the event. Television broadcasters require a number of television camera positions within the viewing structures, which need to be carefully designed in order to limit obstructions to spectator sightlines. These are typically 4 m^2. Television studios from where the event can be presented can be incorporated either as a permanent facility or as part of the temporary event overlay, but an elevated view of the field of play is usually required.

8.4 Press workroom

This room is essentially an office with an extensive array of tables and chairs to provide individual working spaces for the media and will generally require full IT network capacity for instantaneous data transfer. A central location for the distribution of notices, results and general information to the media will also be required, together with a lounge serving food and drink.

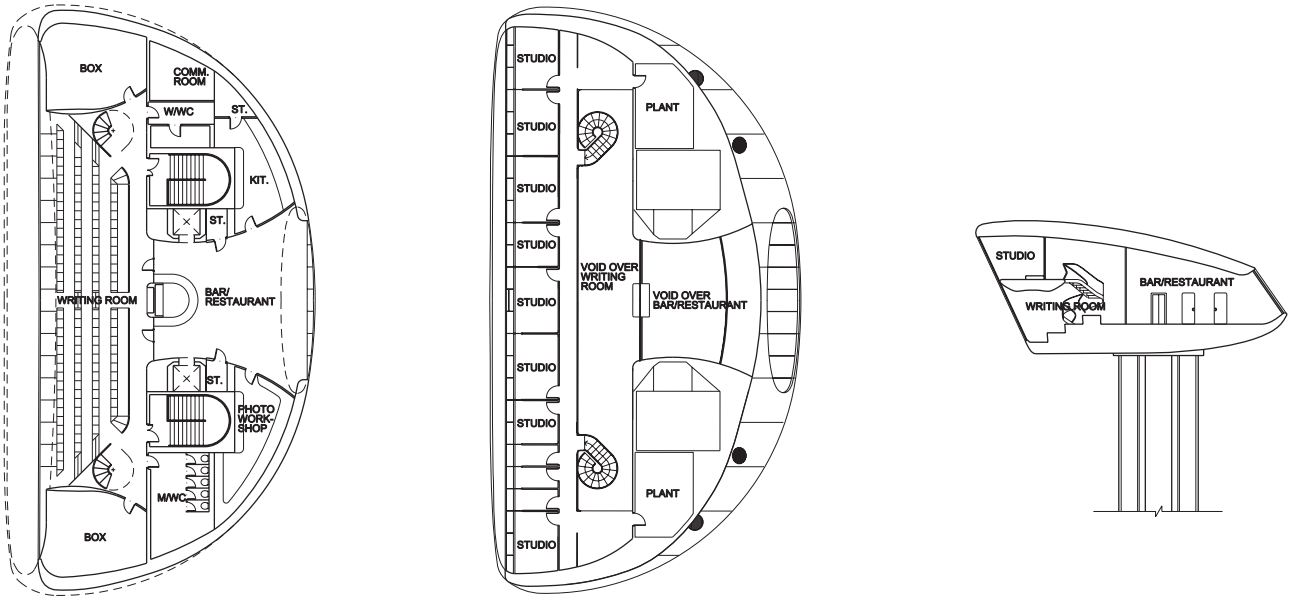
8.5 Press conference room – including translation booth

In some larger sports buildings a press conference room will be required to facilitate interaction between participants in an event and the media. This would typically be a dais for the participants and seating, sometimes raked, for the media, Figure 38.102. For

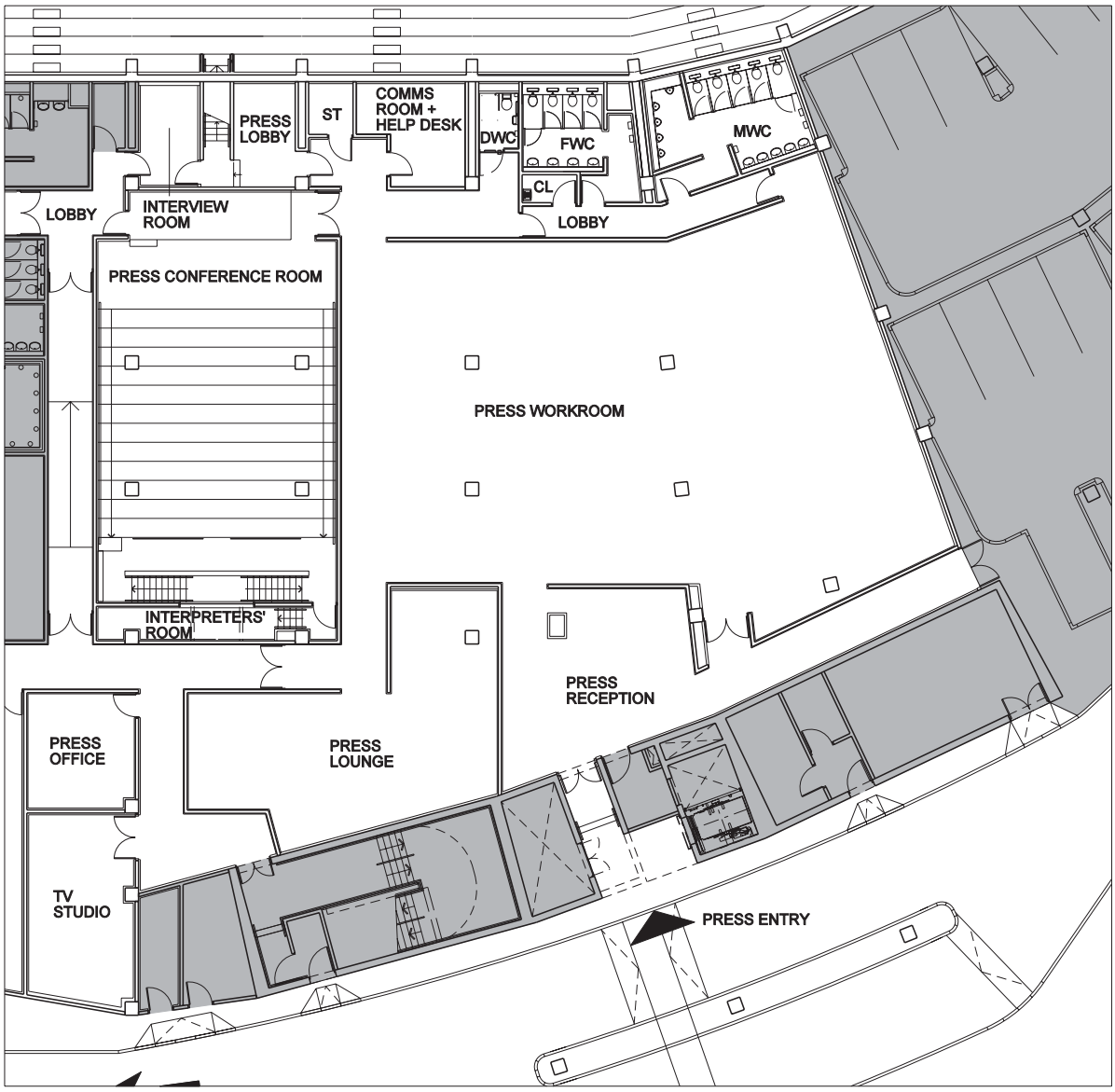


38.100 *Conversion to press seat*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.101 *Plan and section of Lord's cricket ground media centre*



38.102 *Plan of Premier League football stadium media areas*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

international events, translation facilities may also be required and this can be provided with enclosed translation booths at the rear of the conference room.

8.6 Mixed zone

For some events, such as a major athletic or football event, a mixed zone is provided for participants and the media to interact. This is a controlled environment that has access from both the participants' changing rooms and the media workroom. A designated space is usually allocated for this purpose.

8.7 Outside broadcast

Broadcasters will also require an outside broadcast area, which will need to be sufficiently large to accommodate the trucks and vehicles that are required. This area will also need to have the ability to connect satellite uplinks, for the instant transmission of sporting action being broadcast from the event. This space is often provided in a separate compound, but can also be built into larger sports buildings.

9 SUPPORT ACCOMMODATION FOR FACILITY MANAGEMENT

9.1 Introduction

Sports buildings need to be managed as do the competition events they contain. Apart from the smallest clubhouse-type buildings, most facilities would typically include offices, with larger buildings including control rooms overlooking the field of play for the safety and security of spectators, for the control of video screens and scoreboards and for competition management. Other back of house areas may be required for equipment stores, catering facilities, storage of catering and other consumables, plant and waste management.

9.2 Reception

A reception desk, located within view of the main entrance of the building, is required where visitors are expected. Larger sports buildings may have a separate service entrance, usually associated with the movement of vehicles in and out of the building, with the reception acting as a security point.

9.3 Venue management offices

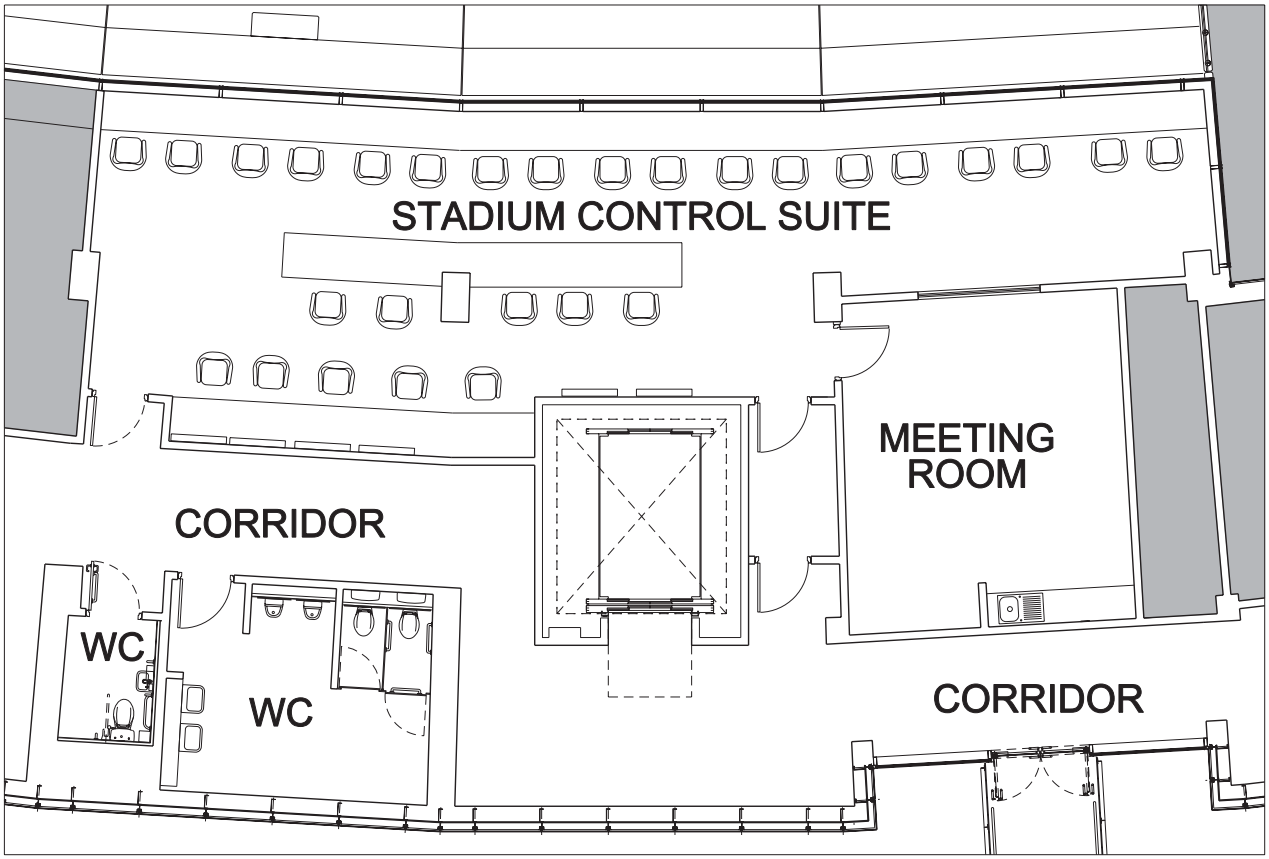
In larger sports buildings, and where the operating management is located at the venue, there should be offices for the director (20 m^2), secretariat (12 m^2), other staff members (12 m^2 per person), public relations and marketing (12 m^2 per person) and event organisation (12 m^2 per person). In smaller sports buildings some of these rooms and functions can be combined for efficiency. A boardroom may also be required for meetings and the display of trophies and other associated memorabilia. This room would typically be between 30 m^2 and 50 m^2.

9.4 Venue control room

A venue control room, often linked to an adjacent security control room (in larger facilities), is required to enable management of the sports competition and also the operation of the sports building, Figures 38.103 and 38.104. This should have a clear sight of the field of play and may require a specific position, depending on the requirements of the particular sport. Should CCTV be required at the venue, then the screens and recording equipment would be located in this room.

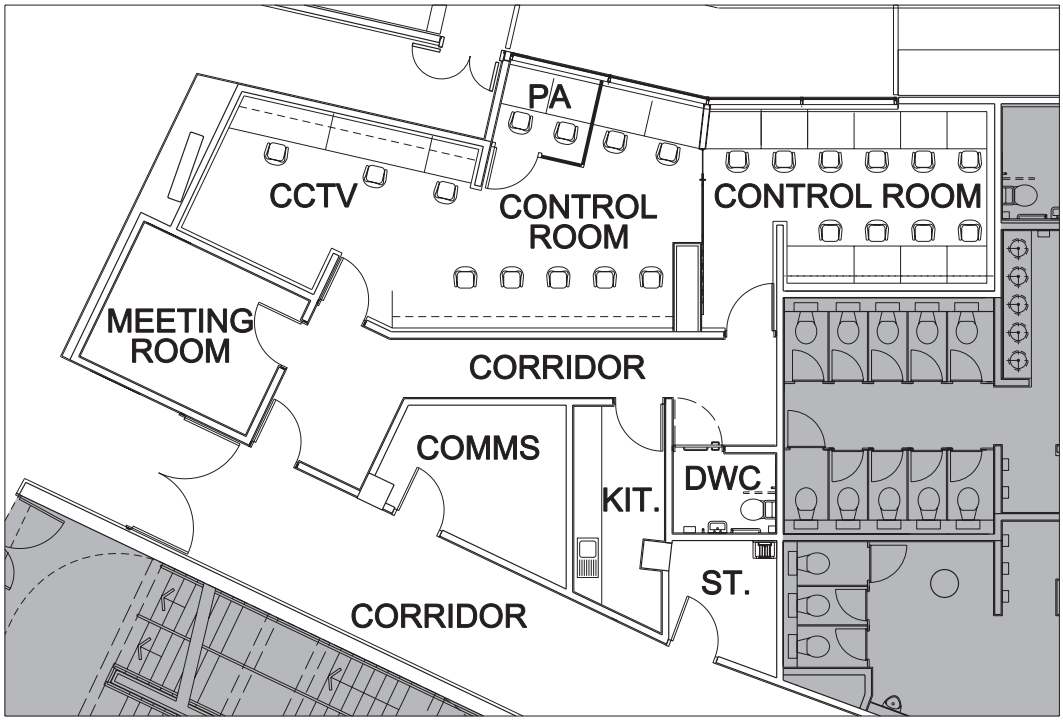
9.5 Scoreboards and video screens

Most sports buildings will require a scoreboard for the display of competition results and this should to be located in a position where both participants and spectators can view them clearly. In smaller buildings the scoreboard may be operated manually, but in larger buildings the scoreboard is likely to be electronic and controlled from either the venue control room or timing and scoring control room depending on whether these functions are separate. Spectators increasingly expect to see live action relayed onto large screens, or at the very least replays of key action, so large format LED screens play an important role in the design of this building type. The screen



38.103 *Stadium control suite – example 1*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.104 *Stadium control suite – example 2*

size and location will depend on the size of the building and the type of event, but like scoreboards, needs to be located in a position where the majority of spectators can view it without glare.

9.6 Staff accreditation
Staff entering a sports building will need to be registered and accredited upon arrival. This usually requires a reception area and desk for this purpose. For larger sports events the permanent staff can be supplemented by a large number of temporary staff and the accreditation area will need to be sized accordingly.

9.7 Staff change
The staff change area should provide a staff cloakroom, where staff can change and leave their clothing in lockers, as well as storage for uniforms and a small refreshment area.

9.8 Briefing room
A briefing room should be provided for issuing instructions to staff about the operation of an event. The room should be based on 1.5 m^2 per person.

9.9 Catering
Most sports buildings will require some form of kitchen, although off-site kitchens may sometimes be used to provide catering facilities. The main kitchen will require spaces for storage, preparation, delivery and clean-up. Bar stores may also be required for buildings serving alcohol. Larger buildings may employ a series of satellite kitchens that provide warm-up and distribution facilities closer to hospitality spaces located throughout the building.

9.10 Police/security
Some sports buildings and events will require a police presence, as part of the operational strategy for those events. The number of police and range of facilities will vary, depending on the type of event and licensing requirements. Some individual events may require a very small police presence, while others may require hundreds of police officers, in addition to the security staff employed by the building itself. The larger stadia may require detention rooms with two cells and associated toilets, mass arrest facilities for up to 60 spectators, a waiting and information room and refreshment rooms.

9.11 IT comms rooms
A dedicated IT comms room is likely to be required in all but a small clubhouse, with a controlled environment to protect the IT equipment. Larger facilities may require a number of IT comms rooms, which should be located throughout the building.

9.12 Equipment stores
Each sport will have a different requirement for the size and extent of equipment stores, ranging from simple sports equipment to large boats. The stores should be sized to accommodate storage racks for the equipment and may also need to include set-up space and workshops for maintaining and repairing equipment.

9.13 Groundskeeping
An area will be required by the groundskeeping staff to store and maintain the equipment required to manage the field of play. This may include vehicles, field equipment, tools, covers and pitch lighting, as well as a wash-down facility. Playing fields may also require irrigation tanks as part of the pitch maintenance strategy, which can take up a significant amount of space.

9.14 Waste management
The amount of waste generated at a modern venue can be considerable, despite recent trends for more sustainable packaging used in the food and beverage outlets. At a multi-level stadium, waste is generally collected on each tier of the seating bowl and then moved down to a central collection point in the service level for sorting, recycling and disposal. Larger facilities may require compactors to handle the level of waste generated in the building.

10 EXAMPLES OF SPORTS FACILITIES FOR VARIOUS SPORTS

As noted in the introduction to this chapter, sports facilities can come in many shapes and sizes, ranging from a simple recreation space, up to a complex, multi-functional building. The scales of facility can be categorised as follows.

10.1 Playing area
This sports facility simply comprises a playing area on which the sporting activity takes place, such as a football field marked out in

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

a park; lanes marked on rivers for canoeing; or the use of roads for marathons.

10.2 Playing area with clubhouse (training grounds)

This sports facility comprises a playing area and some accommodation that simply serves the needs of the participants, such as a cricket pavilion located adjacent to a cricket pitch; a boathouse placed next to a lake for rowing; or some changing rooms set alongside a rugby field.

10.3 Sport-specific venues

This sports facility comprises a specific playing area and a range of accommodation that will serve the needs of participants, spectators, media and facilities management for a specific sport. The shape of the playing area will often give a unique characteristic to the design of the sports facility, such as a grandstand running alongside the closing straight of a racecourse or motor-racing circuit; the V-shaped seating arrangement of a baseball park; or the undulating form of the seating bowl responding to the contours of the cycle track in a velodrome.

10.4 Multi-purpose venues (hosting concerts and events)

This sports facility comprises a playing area that can often be used for multiple events and provides a range of accommodation that will serve the needs of participants, spectators, media and facilities management for more than one type of sport or event. The shape of the playing area will often enable more than one sport to be undertaken within the facility, such as football and rugby in rectangular stadia; cricket and Australian football in oval stadia; multiple sports and events in an indoor arena; multi-sports in a sports hall or leisure centre; or a wide variety of water sports on an inland lake or sheltered harbour.

11 BIBLIOGRAPHY: (REFERENCES TO LEGISLATION AND REGULATIONS)

ADA and ABA: Accessibility Guidelines for Buildings and Facilities, 2006

Australian Football League: Laws of Australian Football, 2011

BS 6465 Part 1: Table 12 minimum provision of sanitary appliances for swimming pools, 2009

BS 8300: 2001 Design of buildings and their approaches to meet the needs of disabled people – code of practice: BSI, 2001

BS6465 Part 1: Minimum recommendations for cinemas, concert halls and similar buildings

BSEN 13200 – 1: Spectator Facilities, Layout Criteria for Spectator Viewing Area: BSI, 2003

CIBSE SLL Lighting Guide 4: Sport, Chartered Institute of Building Surveyors, 1990

Disability Discrimination Act 2005

Donald W Adie: Marinas, a Working Guide to their Development and Design, Architectural Press, 1975

ECB Facility Briefs and Guidance Notes for Indoor Sports Halls with Cricket Provision, TS3

FA, Guide to indoor and outdoor areas for small sided football, mini-soccer and futsal, 2005

Fédération Internationale de Gymnastique: Apparatus Norms, 2009

Federation Internationale De L'Automobile, Circuit Drawing Format, 2009

FIFA Football Stadiums Technical Recommendations and Requirements: Section 05, 2011

FIFA Guide to the artificial lighting of football pitches: FIFA, 2002 FIFA Technical Recommendations and requirements for the construction of New Stadia: Federation Internationale de Football Association, 2010

FITA Constitution and Rules, Indoor and Outdoor Archery Rules 2010

FIVB, Official Beach Volleyball Rules, 2009

Football Licensing Authority, DCMS: Guide to Safety at Sports Grounds, 2008, 5th Edition

Football Licensing Authority: Sports Grounds and Stadia Guide 1: Accessible Stadia

Football Licensing Authority: Sports Grounds and Stadia Guide 2: Concourses

Football Licensing Authority: Sports Grounds and Stadia Guide 3: Control Rooms

Football Stadia Advisory Design Council: Seating, Sightlines Conversions of Terracing Seat Types, 1991

Football Stadia Advisory Design Council: Stadium Roofs, 1992

FSADC: Seating, Sightlines, Conversion of Terracing, Seat Types: Football Advisory Design Council, 1991

FSIF/FLA: Accessible Stadia: Football Stadium Improvement Fund/Football Licensing Authority, 2005

Gaelic Football Association: Official Guide, 2010

IAAF Track and Field Facilities Manual, 2008

IBF, Official Baseball Rules, 2010

International Boxing Association: Technical and Competition Rules, 2010

International Hockey Federation: Guide to the Artificial Lighting of Hockey Pitches, 1997

International Judo Federation: Sports and Organization Rules, 2009

International Tennis Federation (ITF): Rules of Tennis, 2011

International Tennis Federation: Guide to the Artificial Lighting of Tennis Courts, 1991

IRB: Laws of the Game of Rugby Union, 2008

ISSF: Rules and Regulations, 2009

Geraint John and Helen Heard: Handbook of Sports and Recreational Building design, Volume 2, Indoor Sports: Architecture Press, 1995 Geraint John and Kit Campbell: Handbook of Sports and Recreational Building Design Volume 1 Outdoor Sports, 1993

Geraint John and Kit Campbell: Ice Rinks, Swimming Pools: Handbook of Sports and Recreational Design Volume 3, 1996

Geraint John, Rod Sheard and Ben Vickery: Stadia, A Design and Development Guide, Architectural Press, 2007

Planning Policy Guidance Note: Sport and Recreation: Department of Environment, 1991

R&A: Rules of golf and the rules of amateur status, 31st Edition, 2008–2011

Shields, Andrew, Wright, Michael: Arenas: A Planning, Design and Management Guide, London Sports Council, 1989

Sport England Design Guidance Note: Comparative Sizes of Sport Pitches & Courts, 2009

Sport England Design Guidance Note: Design Guide for Athletics, 2007–2012

Sport England Design Guidance Note: Design Guide for Badminton, 2005

Sport England Design Guidance Note: Design Guide for Cycling, 2003

Sport England Design Guidance Note: Design Guide for Fitness and exercise spaces Guidance Notes, 2008

Sport England Design Guidance Note: Design Guide for Indoor Sports, 2007

Sport England Design Guidance Note: Design Guide for Swimming Pools, 2008

Sport England Design Guidance Note: Pavilions and Clubhouses: Changing Rooms, 1999

Sport England Design Guidance Note: Sports Halls: Changing areas, 2011

Sport England Design Guidance Note: Sports Halls: Toilet Accommodation, 2011

Sports Council: Planning and Provision for Sport Selection Planning for Stadia, 1997

Sports Council: Toilet Facilities at Stadia, Planning Design and Types of Installation, 1993

The Event Safety Guide (Purple Guide), A guide to health, safety, and welfare at music and similar events, 2002

The Oxford Companion to Sports and Games: Oxford University Press, 1976

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

UEFA European Football Championship: Bid Requirements, 2012
UEFA Stadium Infrastructure Regulations, 2006
World Karate Federation: Competition Rules Kata & Kumite, 2009

12 CASE STUDY: RAVENSCRAIG REGIONAL SPORTS FACILITY (A SPORTSCOTLAND INITIATIVE)

Project information:

Client (Joint Venture):	North Lanarkshire Council Sportscotland Ravenscraig Ltd Motherwell College
Architect:	Populous
Structural Engineer:	Buro Happold
Services Engineer:	Buro Happold
Fire Engineers:	Fedra
Main Contractor:	Balfour Beatty
Location:	Ravenscraig, Motherwell, North Lanarkshire, Scotland
Gross Internal Floor Area:	18,300 m^2

Outline brief

The brief for the project was developed with the client team in consultation with their stakeholders. Motherwell College's interest in the project related to their sports science course for which classroom and access to training facilities was required.

The brief was for a multi-sports facility with both indoor and outdoor facilities capable of being used for competitive sport and training at the full range of levels from school to elite. The facility should be capable of accommodating 5000 spectators. It is hoped that the facility would be one of the training bases for one of the large national teams for the 2014 Commonwealth games.

Response to brief

The architect's aim was to create as much mix between the different sports and different levels of sports as possible, so that all the building's users could learn from each other. A key part of the strategy was to establish visible links within the building. A central spine was created that connected the three halls, which contain: a full-size indoor football pitch, athletics and a multi-sport hall, Figures 38.105–38.111. This central spine has two levels: changing and toilet facilities at the lower level, and cafeteria, classrooms and offices at the upper level with views into the halls. In order to accommodate the potential capacity of 5,000 for a large event, the hall has fire exits and ventilation to cater for 5,000 users, on the assumption that additional services including sanitary accommodation will need to be brought to site for the event.

General description of the building and site

The building is situated on a former steel mill site. The architecture of the building reflects this industrial past with its profiled metal cladding and pared-down internal finishes. The tilted forms of the building derive from allowing north light into the large halls to eliminate glare for competitors. This results in a distinctive profile to the building that sits well in the landscape.

The facility fits into the approved masterplan for the new town, part of the area planning brief. The new town is yet to be built. The facility incorporates an outdoor full size all-weather artificial football pitch, and 6 five-a-side pitches. These are all artificial grass pitches due to the extended period of use throughout the year and the reduced maintenance costs when compared to natural turf. There is also an external 1km running track, well lit, and surfaced with tarmac, that loops around the complex. There are also 450 parking spaces, of which 8 are reserved for families and 22 for disabled drivers, with options for car pool spaces.

Sports and events

Football, track and field athletics, badminton, volleyball, basketball, handball and netball are all played at the facility. As well as the outdoor pitches, there is a full size indoor football pitch which is a third generation (3G) artificial pitch, achieving a FIFA 2 star rating. It is used by local professional teams for training. There is a hall for athletics, with a rubber sports floor, equipped with a 135 m running track, long jump pits and throwing cages. It is predominantly used for training but is also used for low level competition.

The multi-sports hall hosts badminton, volleyball, basketball, handball and netball competition events on a sprung timber floor and has a 9.2 m vertical clearance to accommodate national level badminton events, but not international ones.

Technology

There are scoreboards in each of the halls, with camera technology in the athletics hall used for timing and scoring during competition. There is a central public address system for the building, along with CCTV. The extensive natural lighting of the halls is supplemented by motion-controlled artificial lighting. The football and athletics halls are naturally ventilated. There is a combined heat and power plant supplying heating and hot water, supplemented by radiant heating in the athletics hall. The football hall is treated as a 'garage' space so is not heated but well insulated for acoustic reasons, so is protected from extremes of temperature. In the multipurpose hall, the air handling system is controllable to limit drafts so that the flight of the shuttlecock is unaffected. Entry into the hall is gained by draft lobbies for the same reason. A fire engineering approach was developed for the building which required sprinklers to be installed in the spine building with automatic smoke vents in the roof combined with smoke reservoirs calculated to coordinate with the required escape times. The football hall also has automatic smoke vents, which have been designed to cater for the possible use as an event building for 5,000 people.

Viewing structures

Retractable tiered seating systems are installed in both the football and multi-sport hall, providing 400 seats in the former and 750 seats in the latter. Wheelchair positions are included with companions in both locations. Informal viewing is also possible from the 1st floor viewing gallery.

Accommodation

Eight changing rooms with toilet facilities are provided for players and two for officials with direct access to each hall and to the external pitches, all with exemplary DDA access. They are located in close proximity to break-out areas where results of training can be analysed and athletes can relax. For the training of elite athletes there is a strength and conditioning area, equipped with benches and free weights. There is also a medical room for sports injuries as well as a drug testing area. For the general public there is a gymnasium equipped with the usual combination of cardio (stationary bikes, rowing machines, treadmills) and weights machines. There are also two dance/general exercise studios with sprung timber floors. Behind the reception desk is a small shop. At the upper level, accessed by stairs and lift is the cafeteria, located above reception with panoramic views, classrooms, building management room, and satellite offices for the regional sports bodies and the facility managers.

Construction

The building has a steel frame, internal concrete block walls with steel ring beam with 3.5 m height for impact resistance. The floor of the spine building is finished with quartz acrylic resin providing a robust but attractive finish. Externally, the roof and walls of the building are clad with an aluminium standing seam system. The finish of the ceilings in the halls is the galvanised liner trays for the cladding system, but in the multi-sport hall, the liner is powder

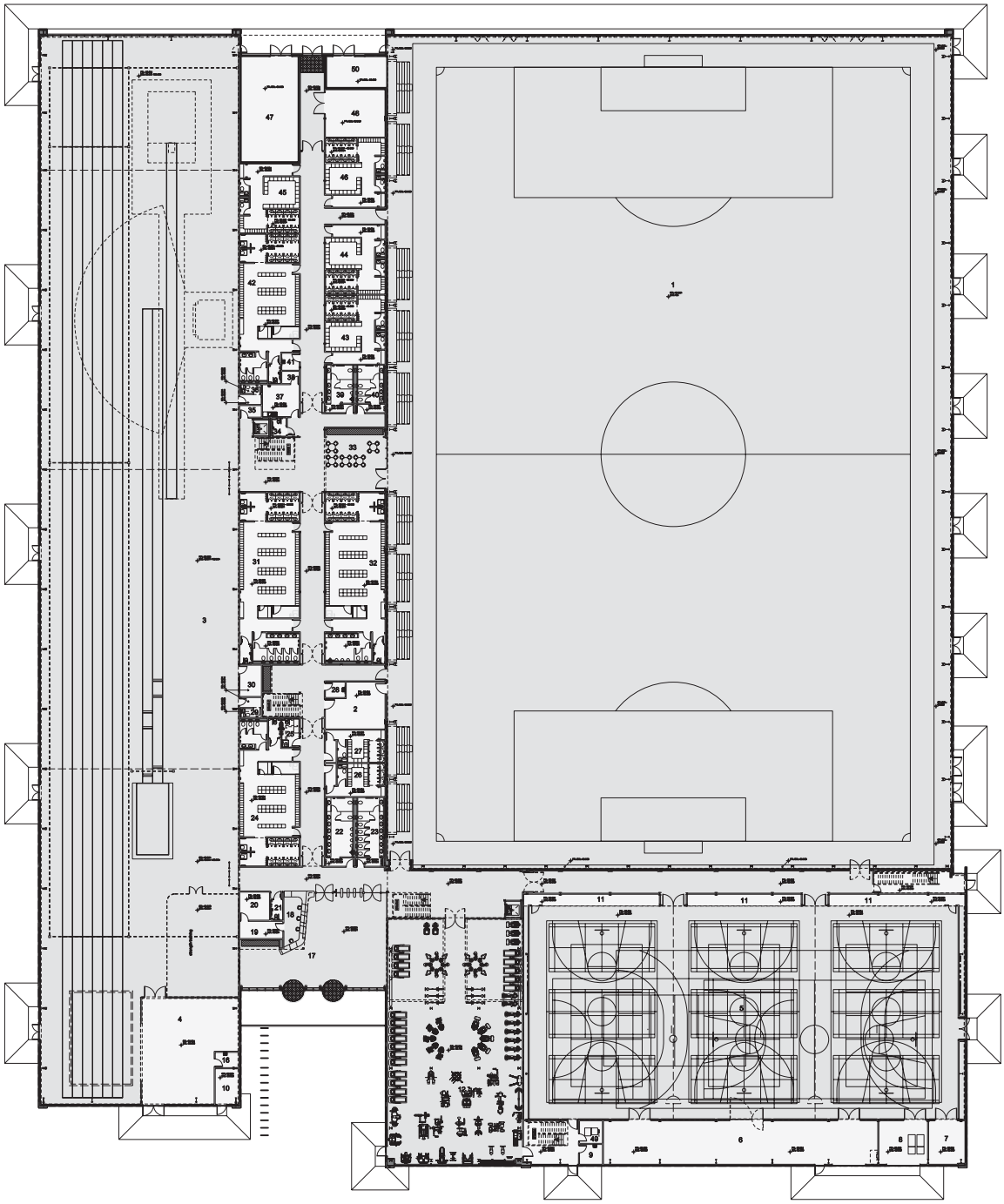
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



38.105 *1:1250 scale plan*

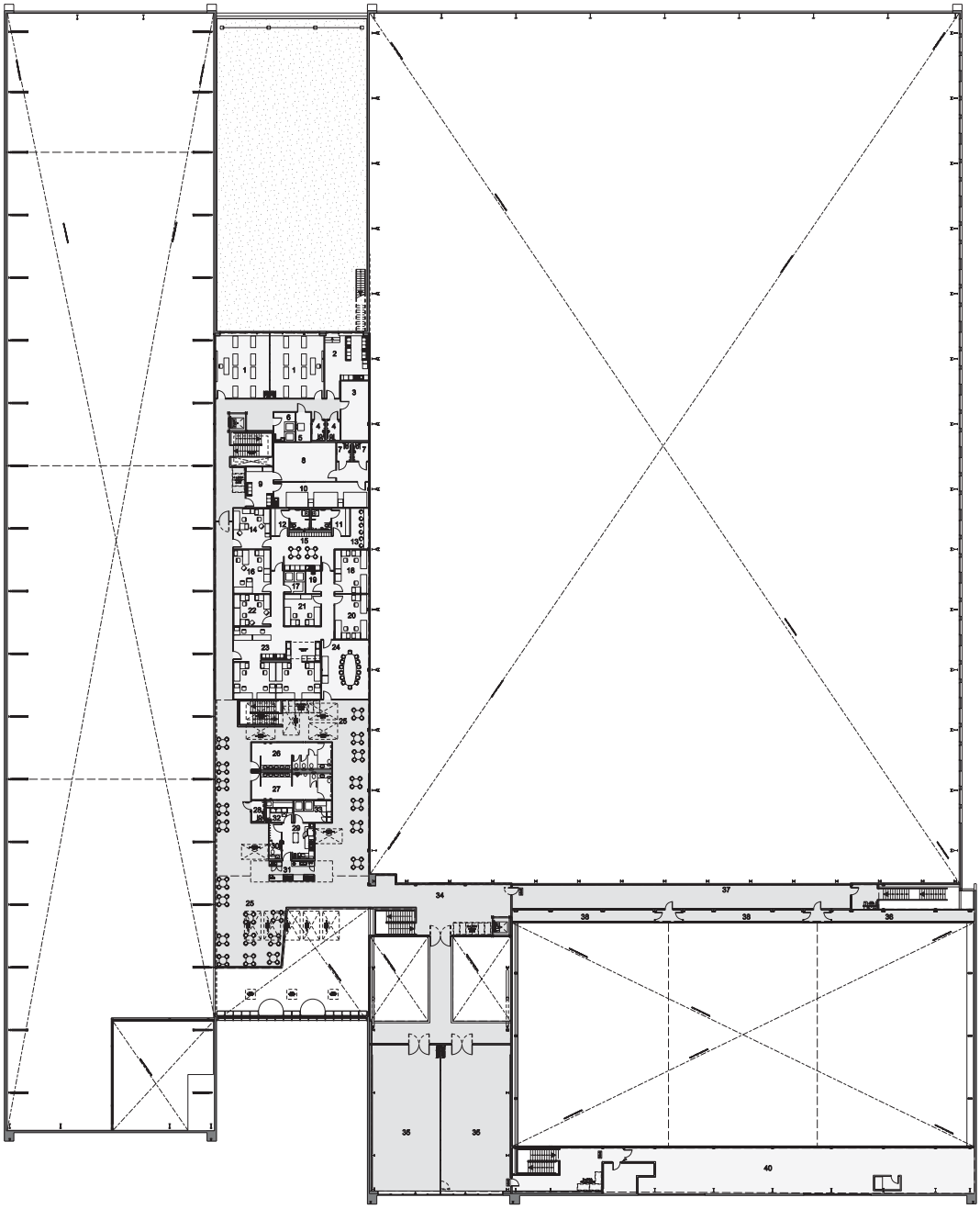
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



1	indoor football hall	7523.7 sqm	26	referee changing 1	29.2 sqm
2	indoor football hall store	39.9 sqm	27	referee changing 2	28.7 sqm
3	athletics hall	3222.5 sqm	28	cleaner's store	5.1 sqm
4	store for athletics hall	145.9 sqm	29	uni sex wc 1 (accessible directly from athletics hall)	6.0 sqm
5	sports hall	1512.5 sqm	30	coach office	11.0 sqm
6	sports hall store	195.2 sqm	31	open plan changing 2	153.8 sqm
7	mat store	25.7 sqm	32	open plan changing 3	153.7 sqm
8	tractor + maintenance vehicle bay	34.7 sqm	33	athletes interaction zone	61.8 sqm
9	cleaner's store	6.8 sqm	34	dda compliant public wc	4.3 sqm
10	fire control room	13.6 sqm	35	vending machine store	4.2 sqm
11	retractable seating bays	71.9 sqm	36	uni sex wc 2 (accessible directly from athletics hall)	6.0 sqm
12	strength conditioning area	529.0 sqm	37	first aid room	18.9 sqm
13	strength conditioning office	- sqm	38	store for first aid room	3.6 sqm
14	assessment room	- sqm	39	male public wc	19.8 sqm
15	strength conditioning store	- sqm	40	female public wc	19.8 sqm
16	cleaner's store	5.9 sqm	41	cleaner's store	5.0 sqm
17	reception	173.0 sqm	42	open plan changing 4	125.1 sqm
18	reception desk	22.5 sqm	43	team changing 1	60.0 sqm
19	reception admin	12.8 sqm	44	team changing 2	60.0 sqm
20	cash sorting / cash handling	13.0 sqm	45	team changing 3	60.3 sqm
21	dda compliant public wc	3.7 sqm	46	team changing 4	60.0 sqm
22	male public wc	28.6 sqm	47	plant room a	96.2 sqm
23	female public wc	27.8 sqm	48	plant room b	45.3 sqm
24	open plan changing 1	124.5 sqm	49	satellite comms room	6.9 sqm
25	assisted changing facility	8.0 sqm	50	plant room c	30.0 sqm

38.106 *1:500 scale floor plan 00 with legend*



1 Motherwell College class rooms	100.4 sqm	21 operations managers office	17.0 sqm
2 Motherwell College staff area	33.1 sqm	22 North Lanarkshire[4] football development office	17.1 sqm
3 Motherwell College storage space	24.2 sqm	23 reception / open plan office	81.3 sqm
4 Motherwell DDA compliant wc	8.0 sqm	24 meeting room	41.0 sqm
5 comms room	6.5 sqm	25 seating area cafe	368.6 sqm
6 riser cupboard	9.3 sqm	26 female public wc	31.6 sqm
7 medical area dda compliant wc	8.1 sqm	27 male public wc	31.6 sqm
8 medical area consultation office	35.3 sqm	28 DDA complaint public wc	3.9 sqm
9 medical area waiting area	16.2 sqm	29 kitchen	17.3 sqm
10 medical area treatment area	35.2 sqm	30 kitchen wc and cloakroom	5.5 sqm
11 male staff changing (incl. wc and shower)	13.3 sqm	31 servery	14.0 sqm
12 female staff changing (incl. wc and shower)	13.3 sqm	32 fresh food store	5.9 sqm
13 break out space	10.8 sqm	33 dry food store	9.0 sqm
14 maintenance and grounds office	21.9 sqm	34 gallary overlooking football hall	83.3 sqm
15 staff kitchen	14.4 sqm	35 dance studios/multi purpose room	269.1 sqm
16 Scottish Atheletics office	23.6 sqm	36 store for dance studios/multi purpose room	25.3 sqm
17 riser cupboard	6.9 sqm	37 gallary overlooking football fall (unheated)	114.4 sqm
18 Scottish Football Association office	21.8 sqm	38 gallary overlooking sports hall	64.7 sqm
19 cleaners store	5.0 sqm	40 plant room d	238.6 sqm
20 event managers' office	22.3 sqm		

38.107 *1:500 scale floor plan 01 with legend*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

levations

hort section



38.112 *Ravenscraig Regional Sports Facility. Architect: Populous. View into the internal football hall. (Photo: Andrew Lee)*



38.113 *Ravenscraig Regional Sports Facility. Indoor sports hall. (Photo: Andrew Lee)*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

39 Streets and spaces for people and vehicles

Updated by Ben Hamilton-Baillie (introduction, shared space and place-making) and Sustrans (cycling routes and parking)

CI/SfB: 12

Ben Hamilton-Baillie is the founder of Hamilton-Baillie Associates, and is a specialist in street design, safety and traffic movement. Sustrans is a charity enabling people to travel more by foot, bike or public transport

KEY POINTS:

- *Policy is moving away from a blanket segregation of traffic and pedestrians towards integration*
- *Defining preferred vehicle speeds is critical*
- *Commercial vehicles are getting larger and heavier*
- *Promoting walking and bicycling is of growing importance*

Contents

1 Introduction
2 Vehicles
3 Roads in general
4 Road design details
5 Cycle routes and cycle parking
6 Parking
7 Loading and unloading
8 Shared space
9 Place-making
10 Case study
11 Bibliography

1 INTRODUCTION

1.1 Role

Streets are defined as the public roads and spaces between private buildings in cities, towns or villages. Streets make up the great majority of the public space of any community. Their design, management and maintenance are critical to the economic and social quality of the built environment.

Streets are complicated spaces. They serve a wide range of functions from providing access and the foreground to buildings, to accommodating drainage and service channels. The principle functions fall into two categories:

- Space for transport and movement – streets provide the corridors for pedestrian and bicycle movement, vehicular traffic and public transport in all its variations.
- Space for exchange and interaction – streets provide the public space for formal and informal encounters and transactions, including trade, information, political activities, festivals and events, and day-to-day social intercourse.

1.2 Policy

The need to balance these two main functions of streets lies at the core of design policy developments over much of the past century. The arrival of automobiles at the outset of the twentieth century, and their huge impact on the spatial patterns and form of the built environment, has generated significant challenges for architects, urban designers and engineers. Designing spaces for people whilst coping with the practical realities of vehicles continues to require experimentation and creativity.

Policy and best practice in this area is in transition. In 1963, the publication of *Traffic in Towns*, often referred to as the *Buchanan Report* after the chair of the advisory committee responsible, set out a number of key principles for addressing the pressure from motor traffic. This argued that the two functions of streets, their traffic role on the one hand and their civic and social role on the other, were fundamentally incompatible and advocated a policy of segregation of traffic from the pedestrian role.

Traffic in Towns' legacy is notable for the introduction of concepts such as pedestrian precincts, ring-roads and high-level pedestrian walkways, and also the underpasses, overbridges, signals, barriers and bollards associated with physical separation.

By the end of the 1970s, a reaction to the principles of segregation was evident across many European countries. In The Netherlands, pioneers such as Joost Váhl experimented with mixed use, low speed residential streets giving rise to the *woonerf*, later introduced into the UK as 'home zones.' Hans Monderman, a traffic engineer responsible for road safety in the north of The Netherlands, explored ways to combine behavioural psychology and engineering to extend informal unsegregated street design into busier intersections and town centres. The term 'shared space' was coined in 2003 to describe the emerging paradigm of fully integrated, mixed-use streets, in contrast to conventional segregation (see section 8).

The publication of the *Manual for Streets (1 and 2)*, covering England and Wales, in 2007 and 2011 reflected this critical shift in street design policy. The Scottish Executive published similar guidance with *Designing Streets*, and the Irish Government has followed suit with *Design Manual for Urban Roads and Streets* (2013). Research and guidance by CABE, English Heritage and the CIHT has helped articulate the implications of a policy of integration, rather than segregation, of traffic from the social fabric of towns and cities.

2 VEHICLES

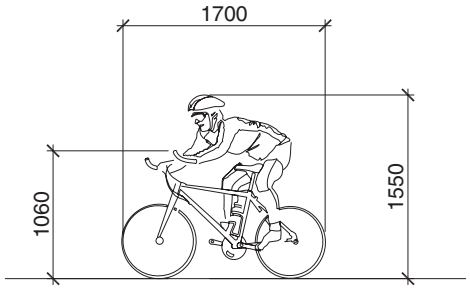
2.1 Scope

This section deals with data on:

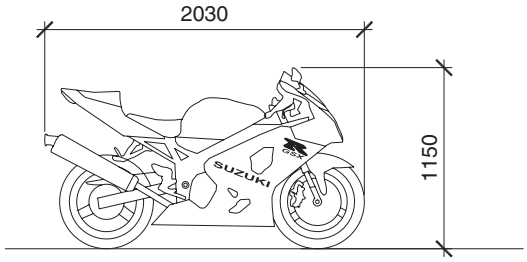
- Cycles.
- Motor-cycles and scooters.
- Automobiles: cars and small vans up to 2½ tonnes unladen weight.
- Commercial vehicles up to 10 tonnes unladen weight.
- Public Service Vehicles (PSVs): buses and coaches.
- 'Juggernauts', large commercial vehicles maximum 40t. This class includes those with draw-bar trailers.

2.2 Dimensions

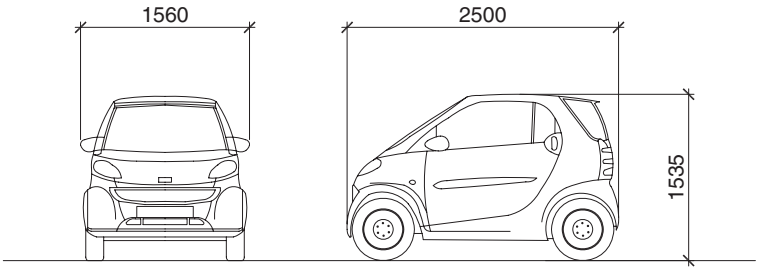
The dimensions of some examples of each class are given in Figure 39.1. In any specific case, the manufacturer's data should be consulted.



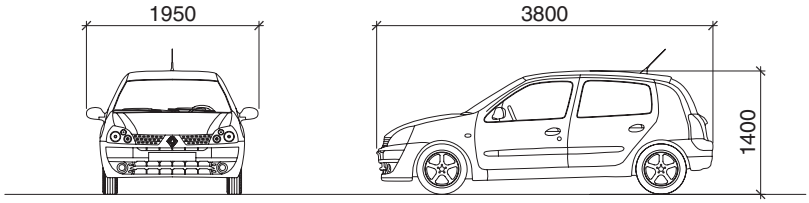
a *Bicycle*



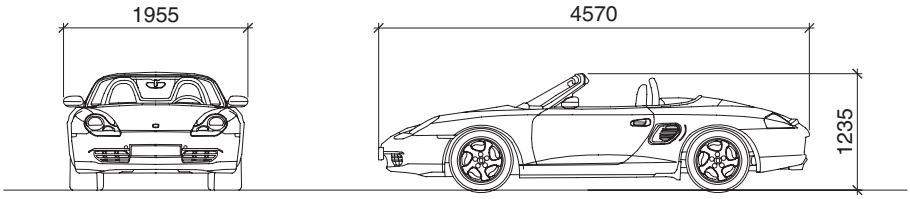
b *Motorcycle*



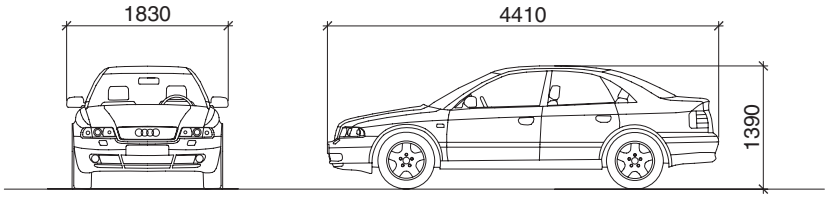
c *Small low emission two seater car*



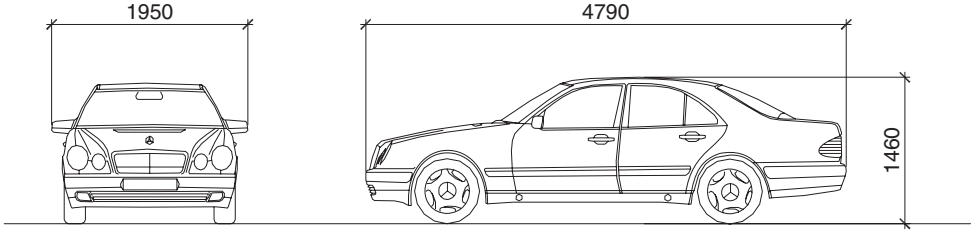
d *Small car*



e *Sports car*

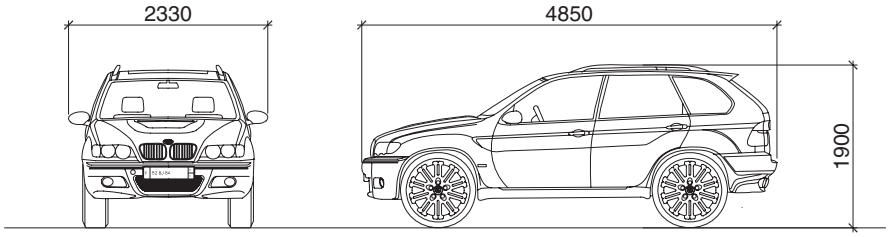


f *Family saloon car*

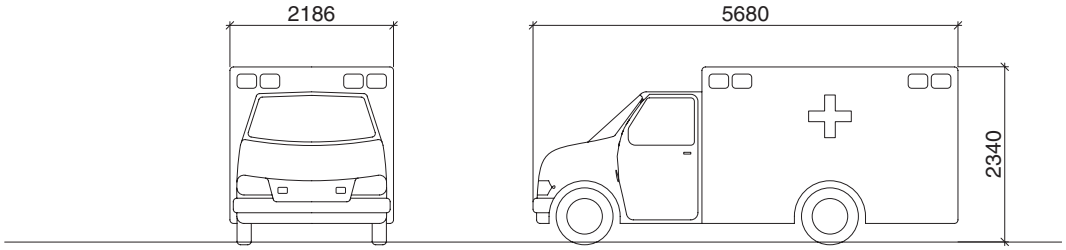


g *Luxury saloon car*

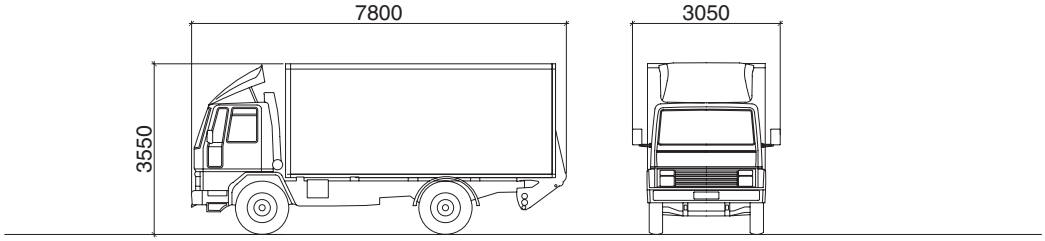
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



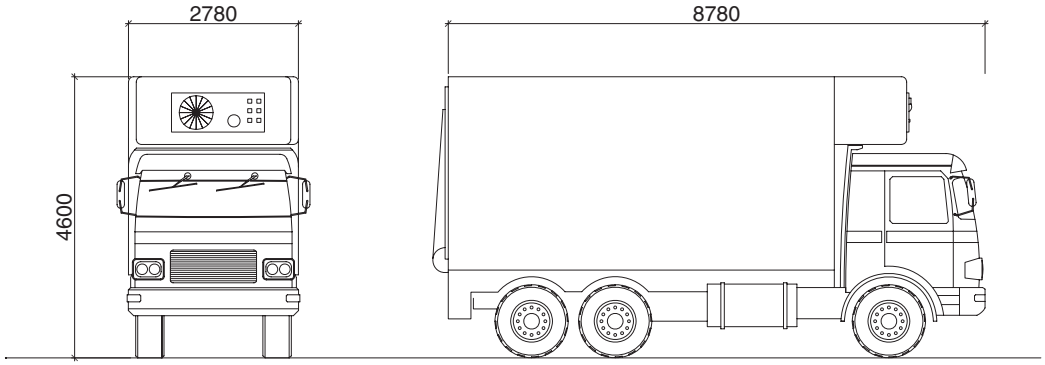
h *4 wheel drive car*



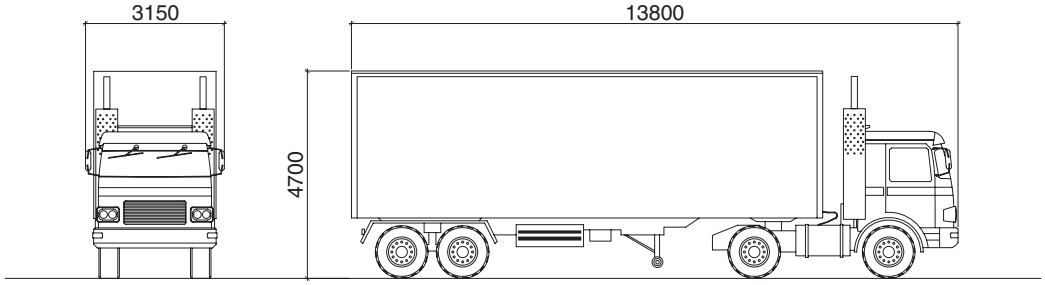
i *Ambulance*



j *2 axle rigid-body lorry*

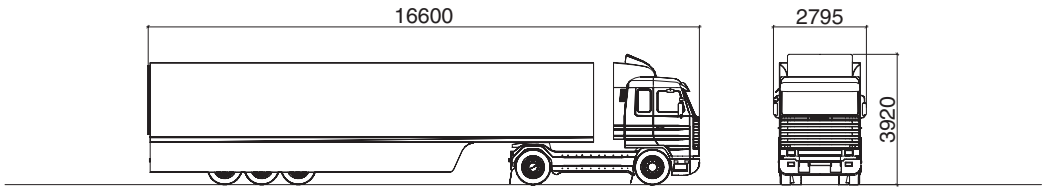


k *3 axle rigid-body lorry*

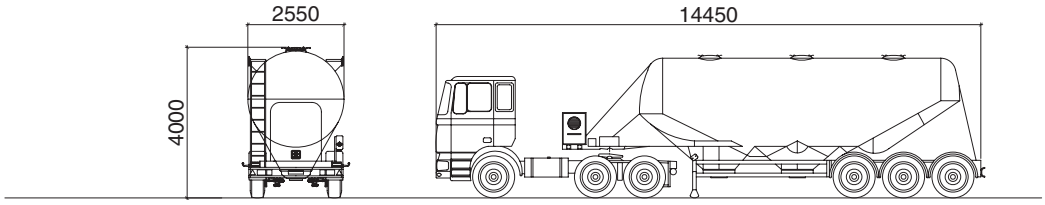


l *4 axle articulated lorry*

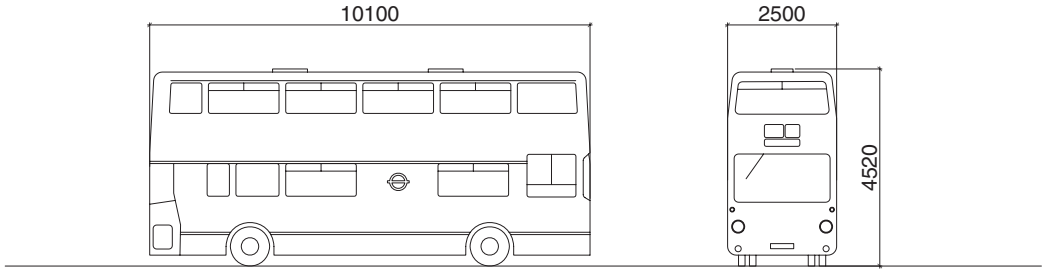
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



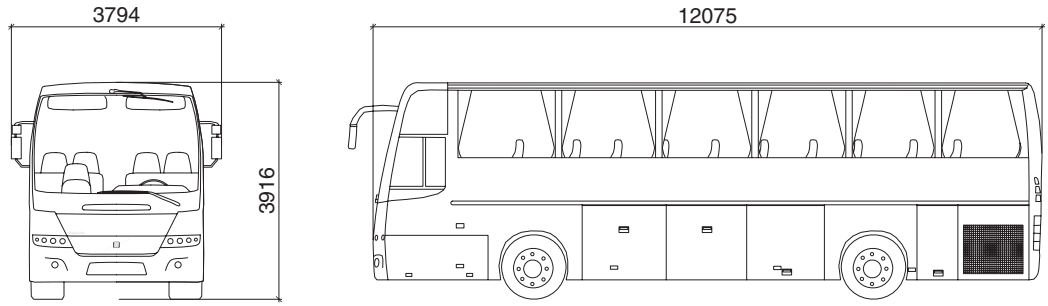
m *5 axle articulated lorry*



n *6 axle articulated tanker lorry*



o *Double-decker bus*



p *Passenger coach*

39.1 *Dimensions of typical road vehicles*

2.3 Unit construction

In the field of the larger commercial vehicles, unit construction is now almost universally employed. In this system a given chassis can be fitted with a variety of body shells for specific purposes and loads, mainly of standard dimensions. The body can be changed at will, permitting one body to be loaded while the chassis is on the road with another body delivering goods elsewhere.

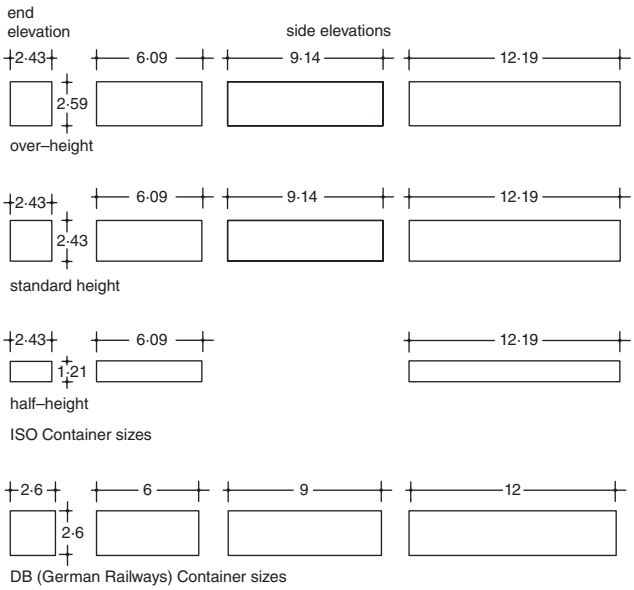
A particular example is the standard container, which is used on lorries, ships, railways or even as a storage unit in the open, Figure 39.2. As this system was first developed in the USA, the standard dimensions are imperial, but the German railways developed a parallel version.

2.4 Turning circles

Apart from the physical dimensions, it is necessary to know the critical characteristics of the vehicle in motion, particularly when manoeuvring while parking or preparing to load. These characteristics are complicated, and usually the manufacturer will quote solely the diameter of the turning circle, either between kerbs or between walls.

Manoeuvring diagrams have been published for various vehicles for the following operations:

- Turning through 90°.
- Causing the vehicle to face in the opposite direction by means of a 360° turn in forward gear.



39.2 *Dimensions of standard containers*

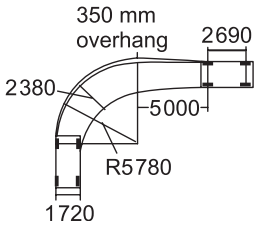
- Ditto in reverse gear.
- Causing the vehicle to face in the opposite direction by means of both the forward and reverse gears (three-point turn), in T-form.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

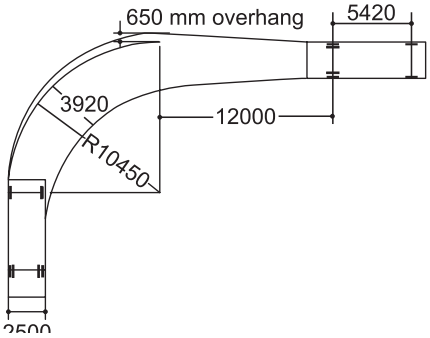
- Ditto in Y-form.
- Ditto in a forward side turn.
- Ditto in a reverse side turn.

Figure 39.3 shows the 90° turns for some of the common vehicles. The other diagrams will be needed for the design of turn-rounds in cul-de-sacs, etc. The use of the published turning circle sizes is not sufficient for the following additional factors:

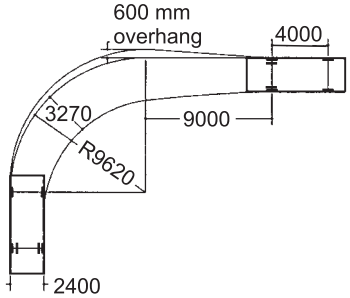
- The distance required for the driver to turn the steering wheel from straight ahead to full lock depends on the speed, which for the purposes of Figure 39.3 is between 8 and 16 km/h.
- The radius of turn differs between a right-hand and a left-hand turn.
- The path traversed by the rear wheels is different from that by the front wheels. In a commercial vehicle travelling at slow speed, the rear wheels follow a smaller arc to the front wheels, the amount depending largely on the distance between the axles. The divergence between the arcs of the wheels on the same side of the vehicle is termed the 'cut in', and value of this determines the total track width of the turning vehicle, always greater than when on the straight.
- While few vehicles have a measurable side overhang of the body beyond the wheel track, many have considerable overhang at front and rear. This is important at the front: the extra width beyond the wheel tracks described by the body is known as 'cut-out'. Allowance should be made for front and rear overhang when designing turn-rounds, etc. by having no vertical obstructions within 1.2 m of the carriageway edge.



a *private car*



b *pantechnicon*



c *refuse collection vehicle*

3 ROADS IN GENERAL

3.1 Introduction

This chapter will generally deal only with roads and facilities within development sites, such as industrial parks and housing estates. Public roads are not normally the concern of the architect, but Table I gives the recommended carriageway widths for most road types.

The broad hierarchy of roads is:

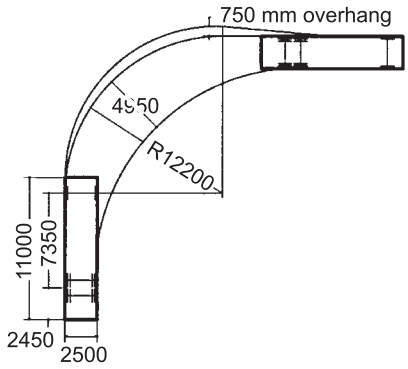
- motorways and trunk roads
- distributors (primary, district and local)
- access roads.

Definitions:

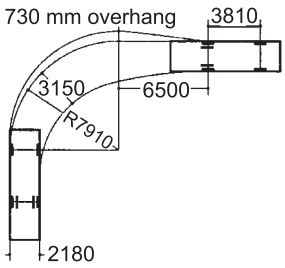
Carriageway: the area of road surface used by moving vehicles.

Carriageway width: the distance between the kerbs forming the carriageway edges.

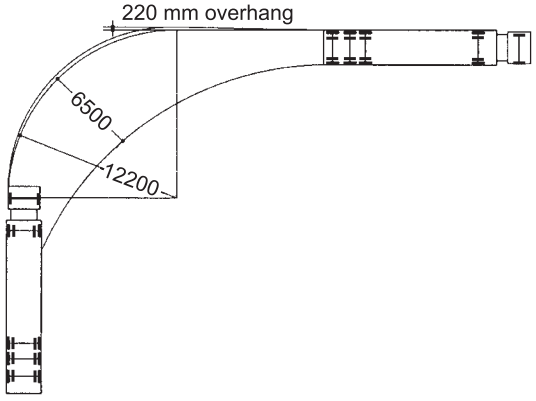
Dual carriageway: a road with a central reservation, each separate carriageway carrying traffic in the reverse direction lane: a width



d *medium commercial vehicle*



e *fire appliance*



f *largest commercial vehicles*

39.3 *Geometric characteristics of typical vehicles turning through 90°*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table I Recommended carriageway widths

Road type	Recommended carriageway width (m) between kerbs or edge lines	
Primary distributor	One-way, four lanes	14.6
	Overall width for divided carriageway, two lanes each way with central refuges	14.6
	Two-way, four lanes total, no refuges	13.5
	One-way, three lanes	11
	Two-way, three lanes (recommended only for tidal flow)	9
	One-way, two lanes	7.3
District distributor	One-way, two lanes	7.3
	One-way, two lanes if the proportion of heavy commercial traffic is fairly low	6.75
	Two-way, two lanes	7.3
Local distributor and access road in industrial district	Two-way, two lanes	7.3
Local distributor and access road in commercial district	Two-way, two lanes	6.75
	Minimum two-way, two lane back service road used occasionally by heavy vehicles	5
Local distributor in residential district	Two-way, two lanes used by heavy vehicles minimum	6
Access road in residential district	see text and Figure 39.5	
	Where all vehicles are required to be able to pass each other	5.5
	Where a wide car can pass a pantechnicon	4.8
	Where two wide cars can pass each other, but a pantechnicon can only pass a cyclist	4.1
	Where a single track only is provided, as for a one-way system, or where passing places are used	
	for all vehicles	3
	for cars only (drives)	2.75
Rural roads	One-way, four lanes	14.6
	One-way, three lanes	11
	Two-way, three lanes	10
	One-way, two lanes	7.3
	Two-way, two lanes	7.3
	Motorway slip road	6
	Minimum for two-way, two lanes	5.5
	Minimum at junctions	4.5
	Single-track between passing places	3.5
	Overall at passing place	6

of carriageway capable of carrying a single line of vehicles, usually delineated with white-painted dashed lines on the carriageway surface.

Lane width: since the maximum vehicle width permitted is 2.5 m, and the minimum clearance between parallel vehicles at 30mph is 0.5 m, the minimum lane width is 3 m. However, vehicles travelling at speed require greater clearance and large vehicles need greater widths on curves, so faster roads have wider lanes

Cycle track or cycle path: a completely separated right-of-way primarily for the use of bicycles

Cycle lane: a portion of a roadway which has been designated by striping, signing, and pavement markings for preferential or exclusive use by cyclists

Shared roadway: a right-of-way designated by signs or permanent markings as a bicycle route, but which is also shared with pedestrians and motorists

Footway: an area of road devoted solely for the use of pedestrians, including those in wheelchairs or with prams, and running alongside the vehicular carriageway. In Britain the footway is also called the 'pavement', in the USA the 'sidewalk'.

Footpath: a facility for pedestrians not forming part of a road.

3.2 Roads in residential areas

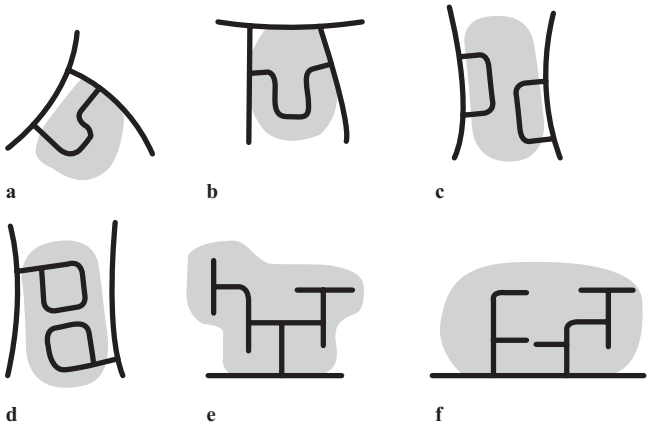
This section focuses mainly on roads in residential areas and in housing estates. However, the principles are the same in industrial and business areas, only the details will differ.

Environmental areas

An 'environmental area' is surrounded by distributor roads from which access to the properties within is gained solely via the access roads within it. The access road network is designed with the following in mind:

- Road access to within 25 m (or 15 m in certain cases) of each house.
- Road access to all private garages, whether within curtilages or in garage courts; and to all parking areas.
- Through traffic from one distributor road to another, or to another part of the same road (avoiding a traffic blockage) is either impossible, or severely discouraged.
- Necessary tradesmen, e.g. 'milk-rounds', calling at all or most properties in sequence, are not unreasonably diverted.
- In general, traffic is not allowed to proceed too fast, but visibility at all times is at least the stopping distance for the intended speed (not the legal) limit.

Figure 39.4 illustrates typical access road layouts.



39.4 *a and b are through roads, so tortuous as to discourage through traffic; c and d are non-through systems, but avoid the need for hammer-head turnrounds; e is a cul-de-sac system, but will have substantial traffic at the entrance; f is to be preferred on this count, although both systems pose problems for permeability*

Types of access road

Access roads in residential areas are of three types:

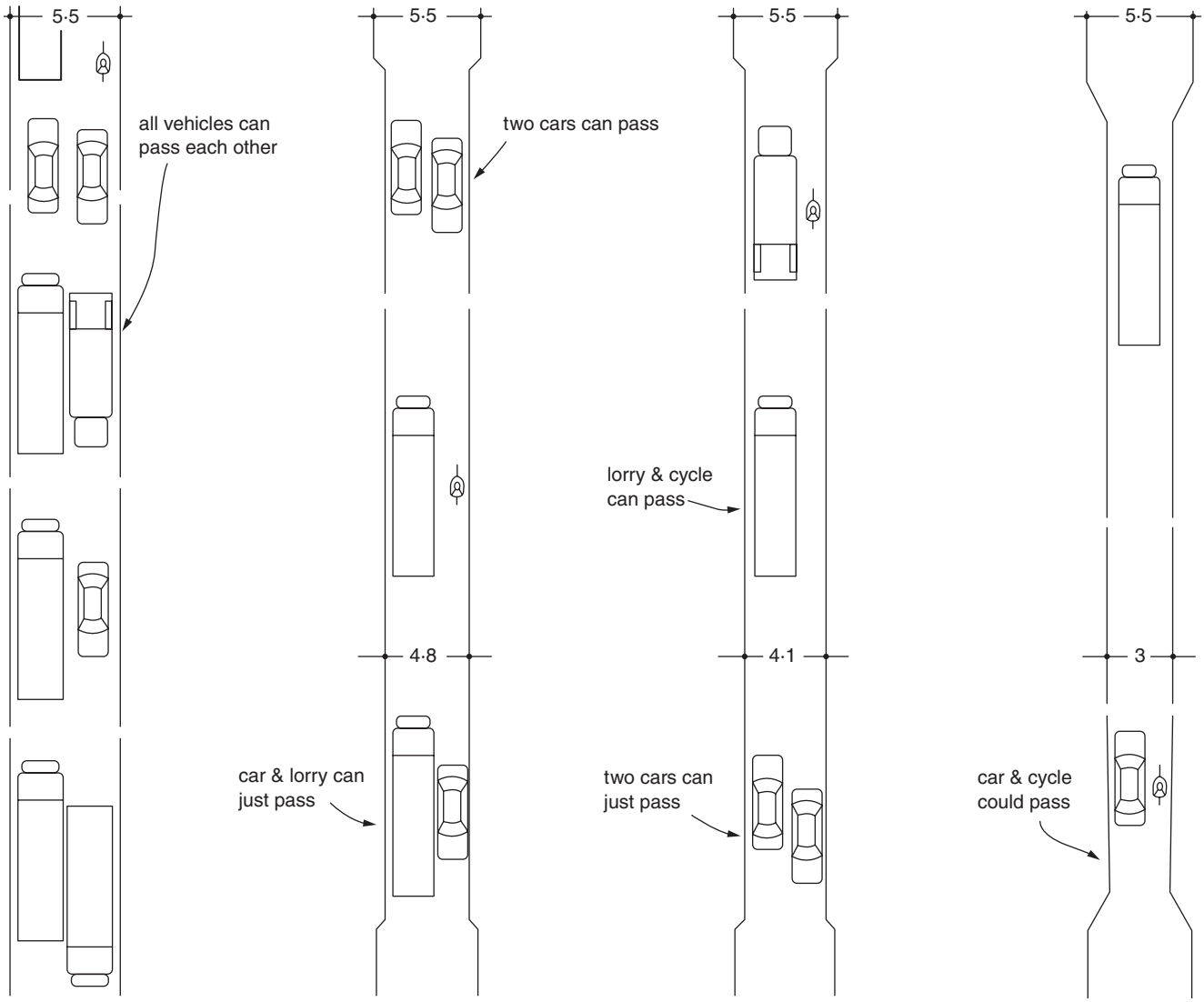
- *Major access roads (or transitional)*. These are short lengths of road connecting a distributor road with the minor access road network, the latter at a T-junction. They are normally 6 m wide, have no direct access to property along their length and serve from 200 to 400 dwellings.
- *Minor access or collector roads*. These form the backbone of the network, will serve up to 200 dwellings and be 5.5 m wide with only one footway. Occasionally a single track 'car way' 2.75 m wide is used for access to about 50 dwellings, in conjunction with a separate footpath system.
- *Shared private drives, mews courts, garage courts and housing squares*. Generally these facilities serve up to 20 dwellings, and are designed for joint pedestrian/vehicle use with hard surfaces, no upstand kerbs and no footways. Access to them from the collector roads is marked by some device such as a short ramp or rough surface material, with the purpose of slowing down the traffic.

Designed controls

Conventionally roads were designed so that cars could be parked on both sides, and two cars could still pass. This encouraged use by vehicles trying to avoid congestion on main roads, with excessive speed and consequent nuisance and danger to the inhabitants. Figure 39.5 shows the characteristics of the various carriageway widths.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



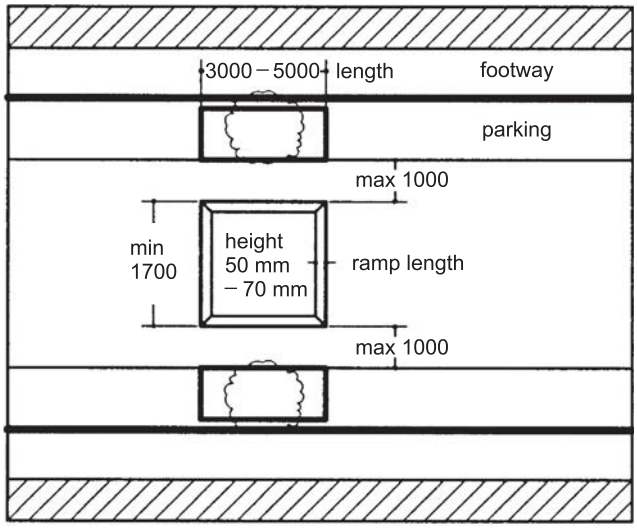
39.5 *Characteristics of various carriageway widths on two-way roads*

While legal penalties can apply to misuse of these roads, these require enforcement resources which are rarely available. It is therefore the designer's responsibility to build-in the discouragement required. Closures, narrowing and speed humps are now used in existing roads; but these have unwanted side-effects such as complications for ambulances, fire engines and even local buses. In new developments it should be possible to avoid these measures and still provide sufficient restraints.

Figures 39.6 to 39.8 show typical arrangements of humps. The slowing effect of various ramps is detailed in Figure 39.9. Figures 39.10 and 39.11 give the Department of Transport requirements for hump dimensions.

There are considerable disadvantages to the use of humps. Vehicles, such as delivery vans, that are continuously using roads with humps find that maintenance costs on tyres, wheels and suspensions are significantly increased. Buses and ambulances find that their passengers experience discomfort and even danger. An alternative slowing device to the hump is the 'chicane', examples of which are shown in Figure 39.12.

Once garages and visitors' parking spaces are provided, kerbside parking may be discouraged by minimising the width of the road carriageway. However, occasional access by large furniture vans (and, unfortunately, fire appliances) will be necessary; and regular visits by refuse collection vehicles have to be as trouble-free as possible. For example, local authorities dislike culs-de-sac with end turning areas permanently obstructed by parked cars, and may well insist on residents bringing their refuse to the entrance of the road.

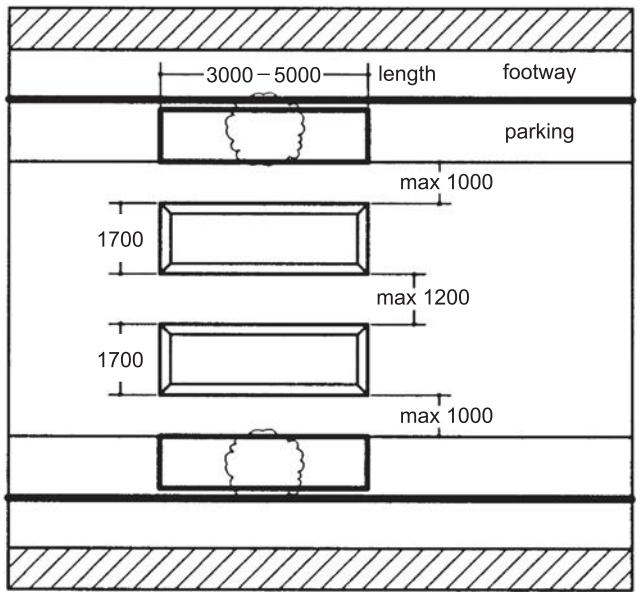


39.6 *Cushion hump*

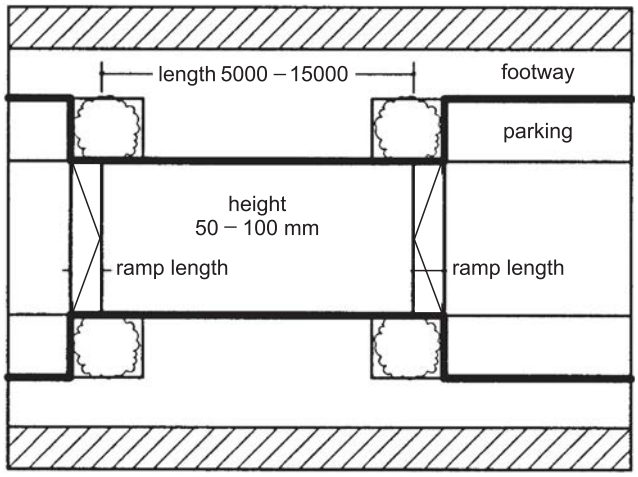
Refuse vehicles and delivery vans blocking narrow roads cause annoyance to other residents trying to pass; consider having at least two routes of access/egress for most parts of the area.

3.3 Roads in industrial parks

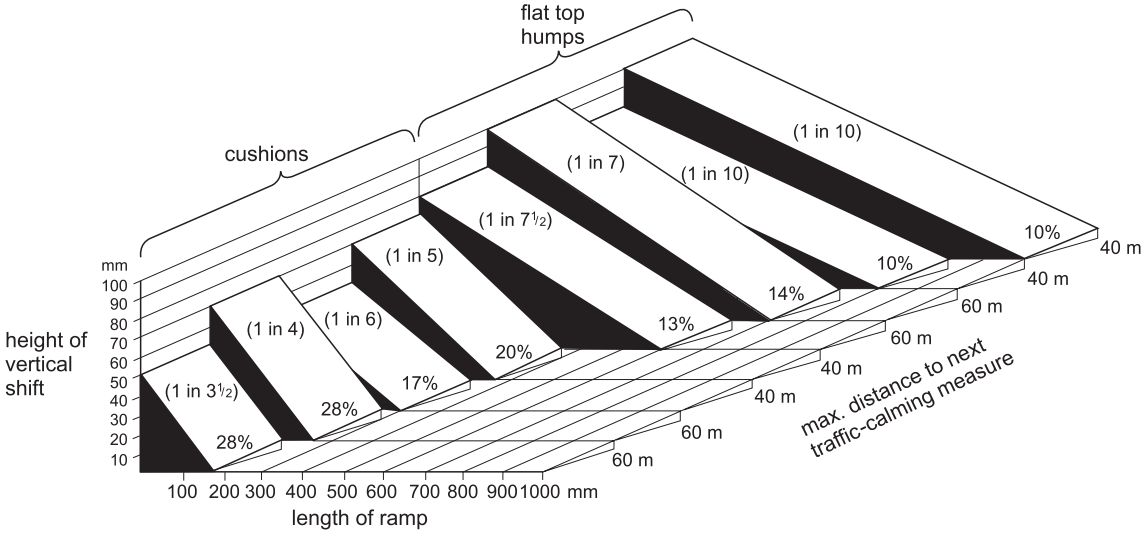
These must provide for use by the largest vehicles, but otherwise pose the same problems as roads in housing estates. Layout should



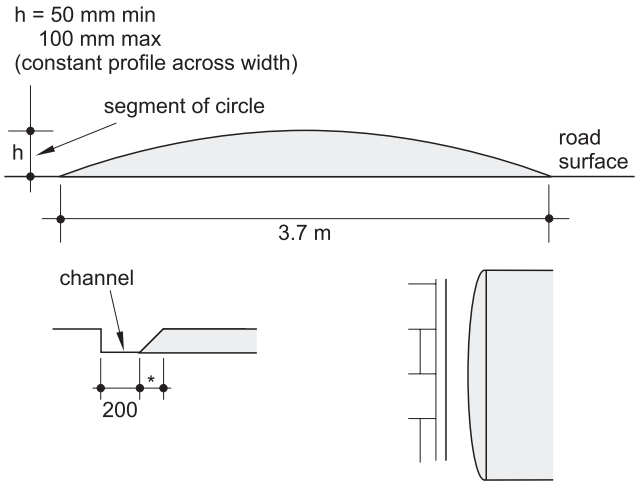
39.7 *Double cushion humps*



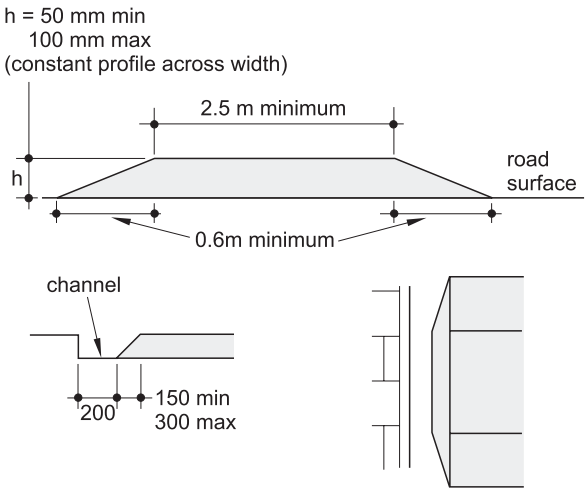
39.8 *Flat top hump used as a pedestrian crossing*



39.9 *Results of research into ramp dimensions for 85 percentile speed of 32 kph (20 mph)*



39.10 *Dimensions of round toproad hump from the Highways (Road Hump) Regulations 1990*



39.11 *Dimensions of flat-top hump from the same source*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

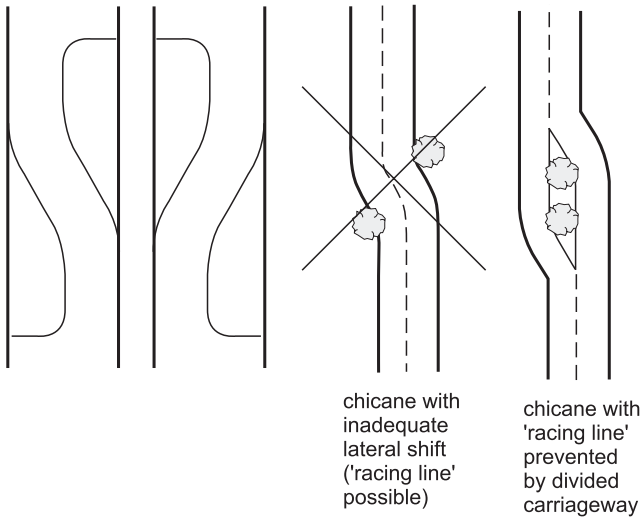
discourage traffic using the roads as a cut-through, and should also ensure that the speed of the legitimate traffic is kept low. This is not a simple matter, as corner radii cannot be too sharp when heavy vehicles constitute a substantial proportion of the traffic.

4 ROAD DESIGN DETAILS

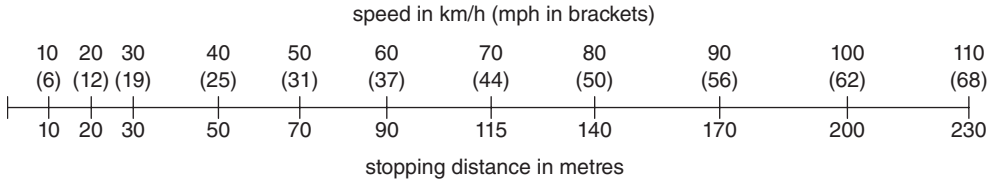
4.1 Visibility and stopping distance

It is an axiom of road design that the driver should be able to see a distance at least as far as the distance he or she needs to stop in. If the object seen is also a moving vehicle, the sight distance must allow both vehicles to stop before colliding.

Figure 39.13 gives the design stopping distances for speeds up to 110 km/h (approx 70 mph). These distances are about $2^1/_4$ times the stopping distances given in the Highway Code for vehicles with good brakes in ideal conditions. This is to allow for reduced brake performance, poor weather conditions and impaired visibility. When emerging from a side road onto a through road the driver must be able to see a vehicle on the through road a distance of that vehicle's stopping distance. When crossing a footway the driver should be able to see 2.4 m along it. Where small children are to be



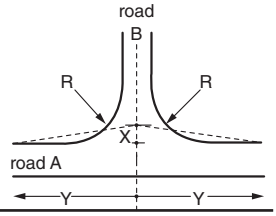
39.12 *Chicane types of traffic slowing device*

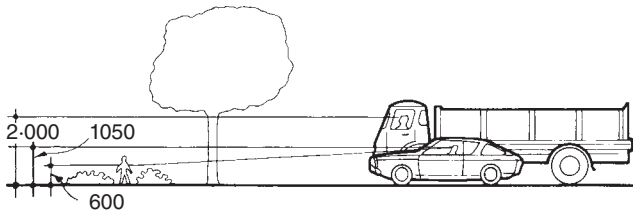


39.13 *Design stopping distances*

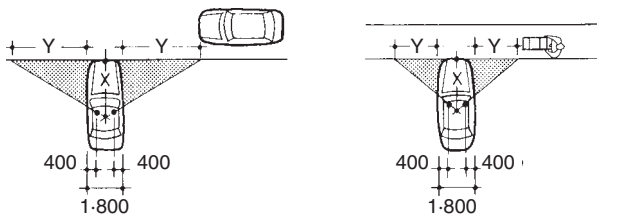
Table II Recommended standards in junction design

Junction type		Radius	Minimum junction	Opposite		Sightlines(m)
Road A	Road B	(m) R	spacing (m) adjacent	X		Y
Local distributor	Any other road	10	80	40	5	60 in 30 mph zone 80 in 40 mph zone 100 in 50 mph zone
Minor access road	Major access road	6			2.4	40
Minor access road	Minor access road	6	25	8	2.4	40
Minor access road	entrance to mews or garage court	4.2	25	8	2.4	40
Single track road	entrance to mews or garage court	8 & 5 Offset	25	8		Junctions must be intervisible
Mews or garage court	entrance to mews or garage court	4.2			2.4	10





39.14 *Required heights for unobstructed visibility*



39.15 *Required distances for unobstructed visibility*

expected this visibility should be to within 600 mm of the ground; but where there are no small children (such as in industrial areas) 1050 mm will be sufficient. Figures 39.14 and 39.15 indicate the areas that must be free of obstruction, and Table II gives some recommended standards in residential areas.

4.2 Curves

As mentioned in Section 3.4, when a vehicle travels round a curve the road width it occupies is greater than the track width on the straight. Table III combined with Figure 39.16 indicates the magnitude of this – the width of carriageway should be increased on curves to compensate.

4.3 Corners

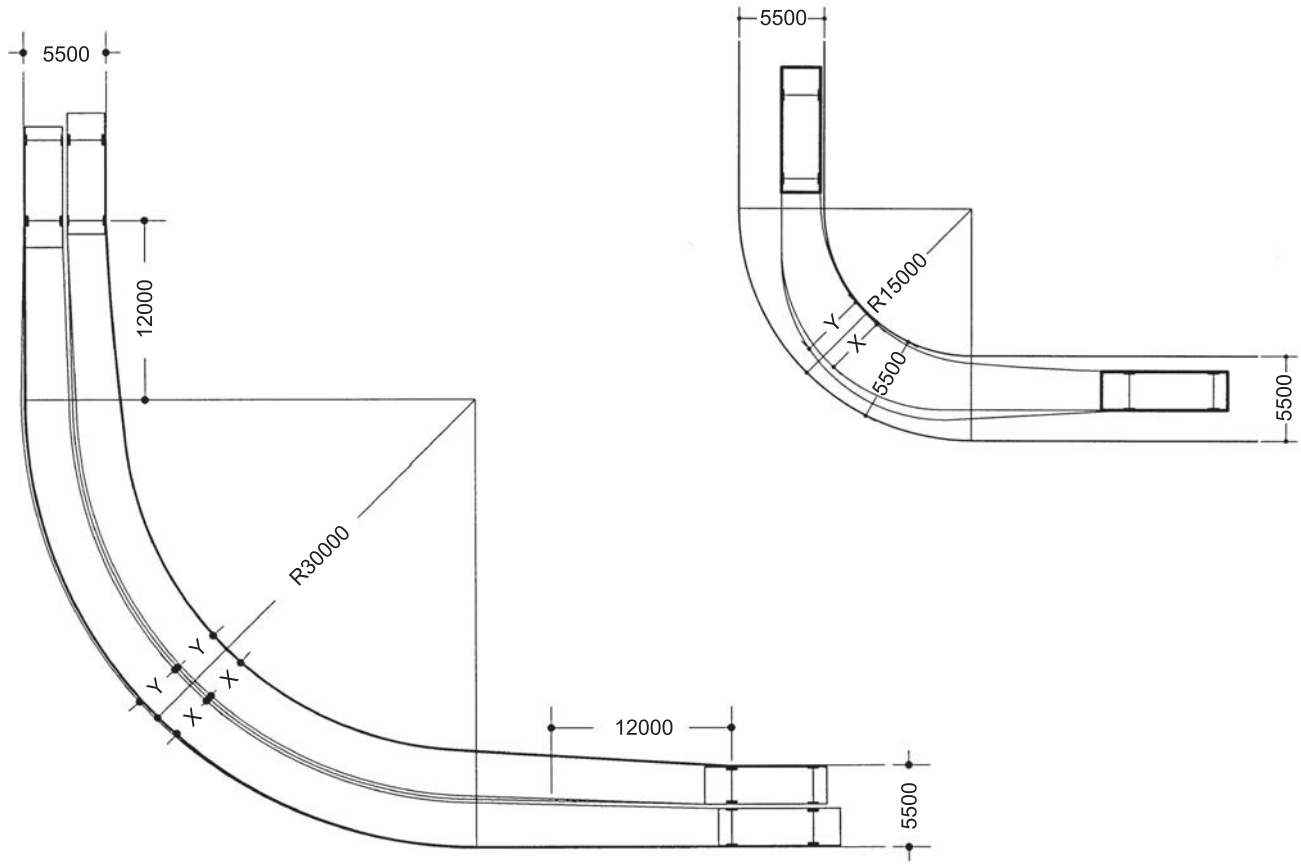
Since the internal radius of turn of a large commercial vehicle is about 8 m, it will be seen that a kerb radius of 10 m will be needed for such vehicles to maintain a constant distance from the kerb while turning the corner, also allowing some spare for the distance covered while turning the steering wheel. A kerb radius of 10 m in

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table III Outside turning radius of front axle (m)

Minimum radius			15		30		45		60		75–400		400+		
R	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	
10.45	3.92	4.57	3.44	3.89	2.96	3.19	2.80	2.95	2.73	2.84	2.68	2.77	2.53	2.54	Pantechnicon
9.62	3.27	3.87	2.94	3.33	2.66	2.85	2.58	2.71	2.53	2.63	2.50	2.58	2.42	2.43	Refuse vehicle
7.91	3.15	3.88	2.67	3.06	2.42	2.61	2.34	2.47	2.30	2.40	2.27	2.35	2.19	2.20	Sightlines(m)
5.78	2.38	2.73	1.96	2.10	1.84	1.91	1.80	1.85	1.78	1.81	1.76	1.78	1.73	1.74	Private car

X = Maximum width of wheel path
Y = Maximum width of wheel path plus overhang



39.16 *Widening on bends; dimensions X and Y are given in Table III*

all cases would mean large areas of carriageway at junctions, and would be inappropriate in scale in many places, particularly in residential areas. Where traffic volumes are low there is no reason why the occasional large vehicle should not encroach on the opposite side of the road, provided that clear visibility is maintained so that vehicles affected by the manoeuvre can take avoiding action in time. Figure 39.17 illustrates the effects of using radii of 10, 6 and 4 m.

4.4 Turn-round areas

Where conventional arrangements are used in turn-round areas in mews courts and housing squares, the minimum standards in Figure 39.18 can be employed. Some local authorities require more generous minimum standards for their refuse collection and fire-fighting vehicles. In cases of doubt, use the specimen vehicle track diagrams in Figure 39.3.

4.5 Gradients

Acceptable gradients are hard to define. What would be quite normal in the Peak district would be considered horrendous in Lincolnshire. Consider the likelihood of snow and icy conditions in winter, when anything greater than about 12 per cent becomes impassable without snow tyres or chains. Most general-purpose roads are now constructed to 7 per cent or less. Ramps to lorry loading bays and car parking garages are limited to 10 per cent. Some car parks in basements or multi-storey have gradients up to 15 per cent (and occasionally beyond). These steep gradients require vertical transition curves at each end to avoid damage to vehicles. Also, steep gradients either up or down should be avoided close to the back of pavement line or road edge, as it is difficult to see clearly, or to take preventative action if needed.

4.6 Verges

Where there is no footway, a soft verge of 1 m width should be provided for the accommodation of services (water, gas, electricity, communications, etc.) and to allow for vehicular overhang.

5 CYCLE ROUTES AND CYCLE PARKING

5.1 Scope and guidance

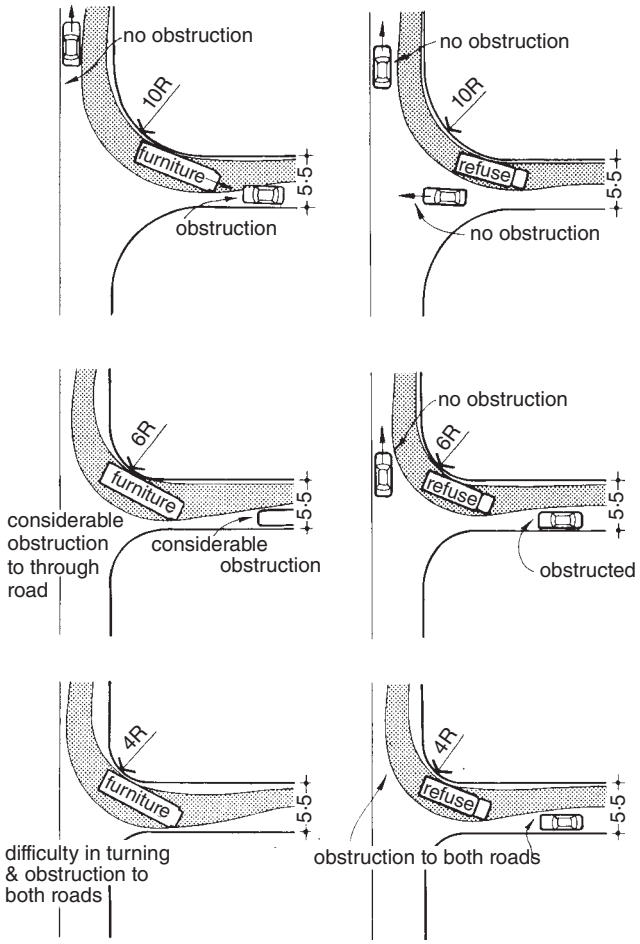
This section mainly applies to off-road cycle provision. Guidance on this, and the complexities of on-carriageway and junction cycling provision, is found in the Department of Transport's Local Transport Notes 2/08 and 1/12, and in Transport for London's London Cycling Design Standards.

5.2 Gradients

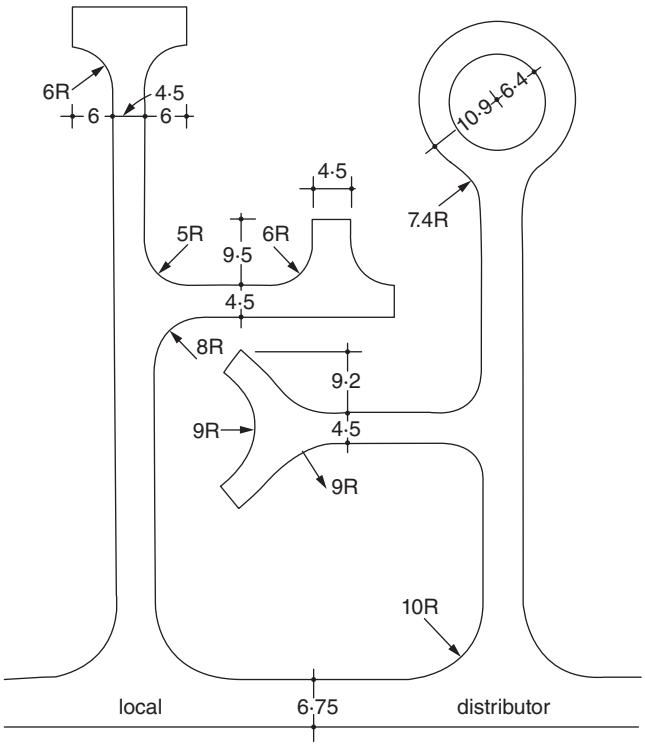
Cyclists will avoid steep gradients. Studies show that if gradients exceed 5 per cent there will be a sharp drop in the length of uphill

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

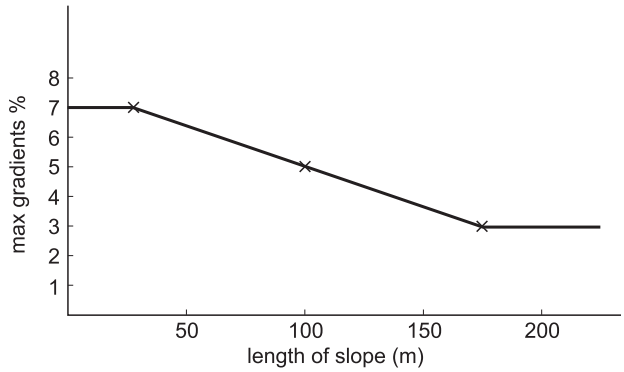


39.17 *Junction design; the effect of kerb radius on traffic flow at the T-junction of two 5.5 m wide roads*



39.18 *Typical recommended dimensions for use in urban areas*

grade that cyclists will tolerate. Figure 39.19 illustrates commonly accepted maximum uphill grades based on length of grade; downhill gradients of 6.5 per cent are acceptable. Note that this does not apply to ramps to subways and foot/cycle bridges where the maximum gradient should normally be 5 per cent.



39.19 *Acceptable gradients for bikeways*

5.3 Width

Factors to consider when determining widths for bikeways must include:

- the dimensions of the cyclist and the bicycle;
- manoeuvring space required for balancing;
- additional clearance required to avoid obstacles;
- gradient – where this is steep, additional width is helpful;
- whether on lightly used routes, a substandard width facility is better than none.

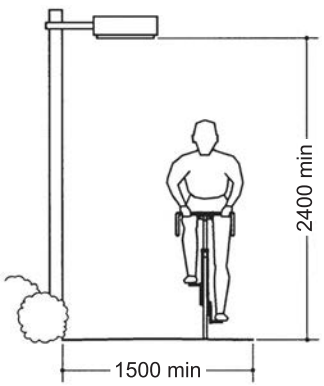
Local Transport Note 1/12 summarises minimum widths for off-road cycle tracks as below:

- unsegregated shared use: 3m preferred (effective);
- pedestrian path unbounded on at least one side: 1.5m (actual);
- pedestrian path bounded on both sides: 2m (actual);
- one-way cycle track: 2m preferred (effective);
- two-way cycle track: 3m preferred (effective).

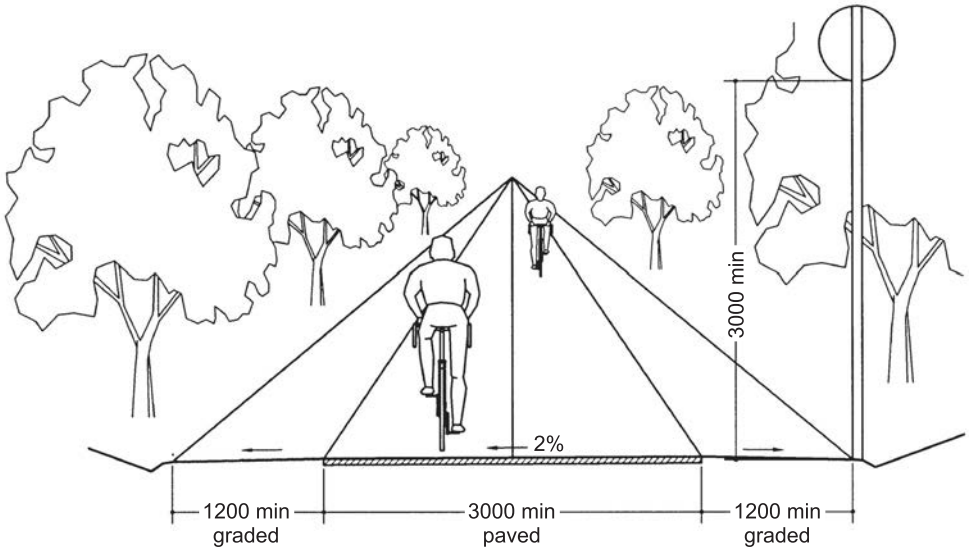
Additional clearance is required when there are edge restraints to maintain effective widths:

- flush or near-flush surface: no additional width needed;
- kerb up to 150mm high: add 200;
- vertical feature from 150–600mm high: add 250;
- vertical feature above 600mm high: add 500.

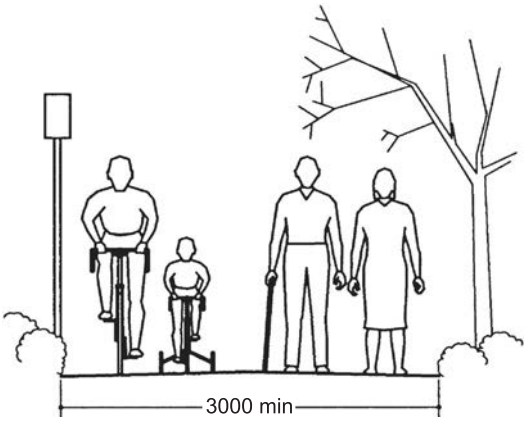
In almost all cases two-way travel will occur on cycle paths regardless of design intentions; appropriate widths should be provided. Various paths are shown in Figures 39.20, 39.21 and 39.22,



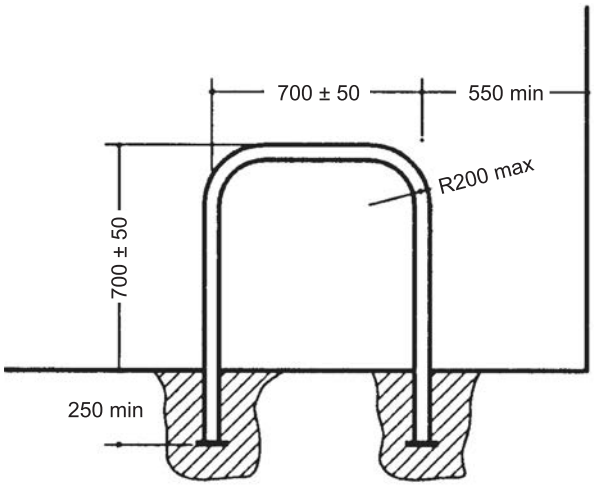
39.20 *Single-track cycle path*

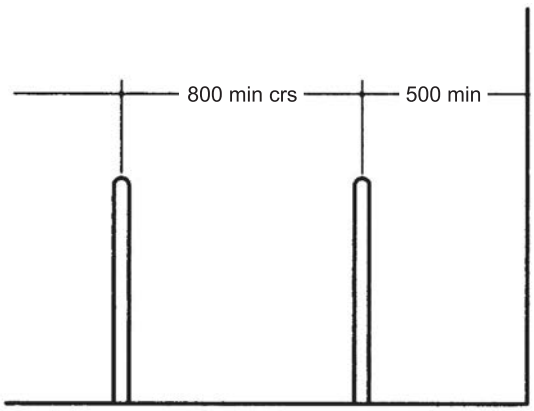


39.21 *Two-way bicycle path on separated right of way*



39.22 *Cycle path shared with pedestrians*





39.23 *Basic Sheffield parking stand*

5.4 Surfacing

A separate bikeway should have a high quality smooth surface and have a thickness capable of supporting maintenance vehicles. Asphalt, concrete, gravel and stabilised earth are materials commonly used. Machine-laid surfaces are preferred for cycle tracks as it is often difficult to achieve a satisfactory surface that is comfortable for cyclists. Unbound surfaces are not recommended unless on very quiet routes.

5.5 Drainage

Surfaces should have a crossfall of between 1 and 2.5 per cent to provide positive drainage. Drainage grilles should have their slots at right angles to the cyclists' line of travel and be designed and located to minimise danger.

5.6 Cycle parking

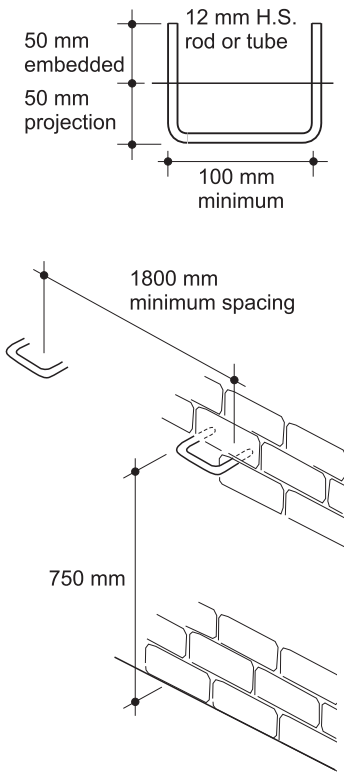
This should be located as close to destinations as possible without interfering with pedestrian traffic; and where visual supervision, lighting and shelter from inclement weather can be achieved. It is essential to provide facilities for securely locking the bicycle frame and the front wheel to something immoveable. The favourite is the Sheffield stand, Figure 39.23, or in certain situations, wall bars, Figure 39.24. In extreme cases, lockers large enough to contain a bicycle can be provided. Figures 39.25 to 39.28 show arrangements where larger numbers of cycles are expected. See Section 6 for suggested scale of cycle parking provision.

6 PARKING

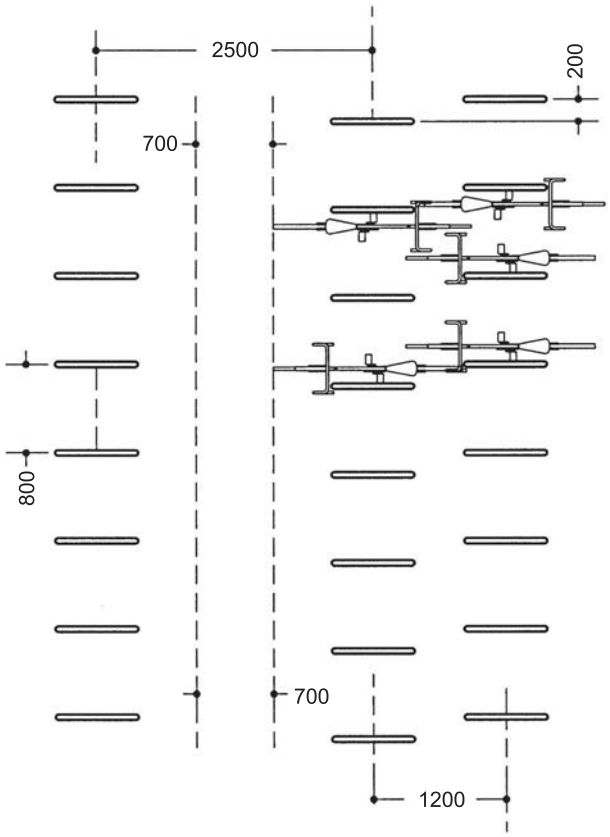
6.1 General

A clear parking policy for each area is an essential. Many facilities now provide little or no parking in order to discourage the use of private transport. This is only effective if it is clearly impossible to park on the adjacent roads, and if there is adequate public transport available. Consider also the needs of disabled people.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

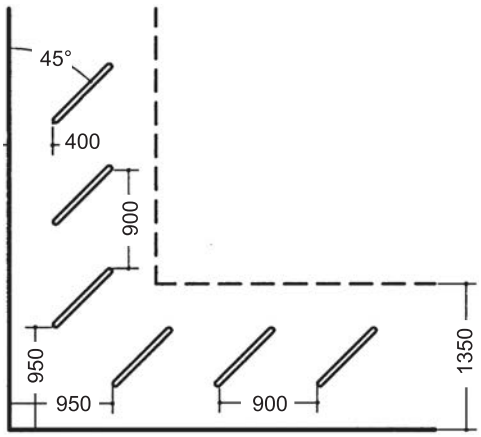


39.24 *Wall bar, suitable for small parking spaces where short-term parking is required*

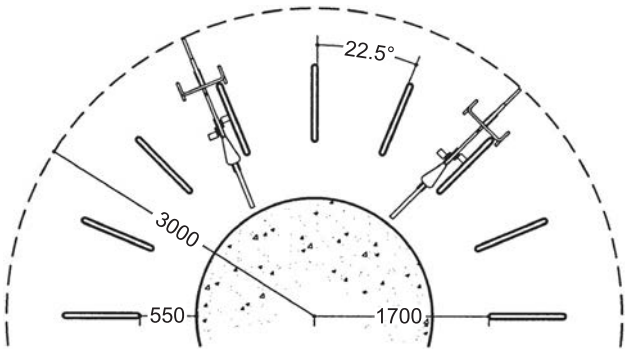


39.25 *It is important that arrays of Sheffield stands make best use of space. Attempts at closer spacing than shown will not succeed due to blocking of some positions by carelessly parked cycles*

There are no statutory requirements and few guidelines for the scale of parking provision. Table IV gives recommendations, but each specific case should be examined to determine



39.26 *An arrangement in an angle between two walls*



39.27 *Circular array with a capacity for 32 cycles*

expected requirements. Some planning authorities now restrict parking provision for cars in order to give a measure of restraint to traffic.

Table IV also includes recommendations for the scale of bicycle parking. These are quite generous so as to encourage greater use of bicycles. However, account should be taken of the local conditions – in places where there are substantially more bicycles than average, greater provision should be made.

6.2 Domestic garages

The domestic garage is the basic provision for residential areas. This can be:

- within the envelope of the house or block of flats;
- a separate detached building;
- one of a number in a garage court.

Figures 39.29 to 39.35 show a number of typical arrangements.

6.3 Car parks

Once the scale of provision has been decided, the form will depend on the size and shape of the available area, and also on the type of vehicle expected. Figures 39.36 and 39.37 give examples of various arrangements, but again, these should be taken purely as a guide. This type of car park assumes that vehicles arrive and leave in a random fashion. In some situations, such as sporting events, a dense arrangement can be adopted which means that all vehicles have to leave approximately in the sequence in which they arrived.

Figure 39.38 shows various types of multi-storey garage. No dimensions are shown as these vary with the site. An additional type, not illustrated, incorporates a mechanical stacking system operated by attendants. In practice, this rarely shows any advantage over conventional types.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table IV Parking and loading/unloading requirements

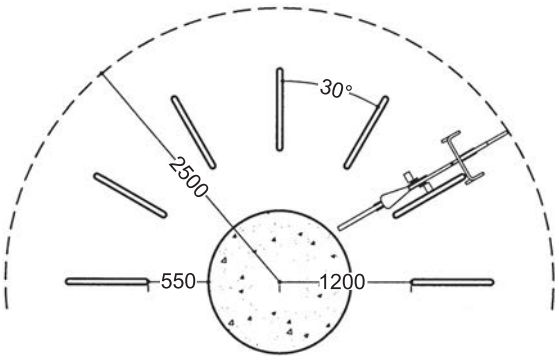
Type of building	Car parking provision	Loading/unloading provision		Cycle parking
Normal housing	Residents: one garage space for each occupancy, (preferably within the curtilage)	Refuse collection vehicle within 25 m of each disposal point (dustbin position). Some authorities require vehicle within 15 m. Where communal containers (paladins) are used, maximum distance 9 m		
	Visitors: where houses are served directly from a road, driveways provide a minimum of one car space within curtilage of each			
	Where visitors cannot park within curtilage, one off-street space per four dwellings	Furniture removal vehicle as near as possible, not further than 25 m		
Minimum-cost housing	Space should be provided, if not laid out, to allow for one resident's or visitor's parking space per dwelling, provided public transport is available	As above		
Old people's housing	One garage space per two dwellings	As above		
Sheltered housing	Resident and non-resident staff: one car space per two members present at peak period	As above, plus provisions for special passenger vehicle with tail lift, etc.		
	Visitors: use empty staff places, but provide one additional place per five dwellings	Minimum provision for daily loading/unloading 50 m		
Shops	Staff: one car space (preferably in enclosed yard behind shop) for each 100 m^2 gross floor area or, if known, one space per managerial staff plus one for every four other staff	See diagrams of loading bays. General minima as follows:		1 per 200 m^2 with minimum of 4
		Gross floor space not exceeding: 500 m^2	Minimum space required: 50 m^2	
	Customers: one space for each 25 m gross floor area.	1000	100	
	In superstores with gross floor area exceeding 2000m^2 allow one space per 10m^2. (Not appropriate when goods sold are obviously bulky, e.g. carpets, boats)	2000 each additional 1000 m^2	150 50 m^2	
Banks	Staff: one space for each managerial or executive staff, plus one per four others	Minimum 25 m^2		2
	Customers: one space per 10 m of net public floor space in banking hall			
Officers	Staff: one space for each 25 m of gross floor area, or one space for each managerial and executive staff, plus one space per four others	General minima: Gross floor space not exceeding:	Minimum space required:	1 per 200 m^2 with minimum of 4
	Visitors: 10% of staff parking provision	100 m^2 500 1000 each additional 1000 m^2	50 m^2 100 150 25 m^2	
Production buildings (factories)	Staff: one car space per 50 m of gross floor area	See loading bay diagram. Provision to be commensurate with expected traffic		1 per 500 m^2 with
	Visitors: 10% of staff parking provision	General minima as follows: Gross floor space not exceeding:	Minimum space required:	minimum of 4
		100 m^2 250	70 m^2 140	
Storage buildings (warehouses)	Staff: one space per 200 m^2 of gross floor space	500 1000 2000 each additional 1000 m^2	170 200 300 50 m^2	1 per 1000 m^2 with minimum of 4
Hotels, motels and public houses	Resident staff: one space per household	General minima as follows:		1 per 10 beds with
	Non-resident staff: one space for each three staff members employed at peak period	Gross floor space not exceeding: 500 m^2	Minimum space required: 140 m^2	minimum of 4
	Resident guests: one space per bedroom	1000	170	
	Bar customers: one space for each 4 m^2 of net public space in bars	2000 each additional 1000 m^2	200 25	
	Occasional diners: no additional provision required			
	If conferences are held in the hotel, space required should be assessed separately at one space for each five seats			
Restaurants and cafés	Resident staff: one space per household	General minima as follows:		1 per 25 m^2 with
	Non-resident staff: one space per three members employed at peak period	Dining floor space not exceeding: 100 m^2	Minimum space required: 50 m^2	minimum of 4
	Diners: one space for each two seats in dining area	250	75	
	(For transport cafes, the space should be a lorry space of 45 m, and the arrangement should be such that vehicles can enter and leave without reversing)	500	100	
Licensed clubs	Resident staff: one space per household	Minimum 50 m^2		1 per 25 m^2 with minimum of 4
	Non-resident staff: one space for each three members employed at peak period			
	Performers: one space for each solo performer and/or group expected at peak			
	Patrons: one space per two seats, or one space per 4 m^2 net public floor space			
Dance halls and discotheques	Staff: one space per three members at peak period	Minimum 50 m^2		1 per 25 m^2 with minimum of 4
	Performers: three spaces			
	Patrons: one space per 10 m of net public floor space			
Cinemas	Staff: one space per three members at peak period	Minimum 50 m^2		1 per 100 seats with

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

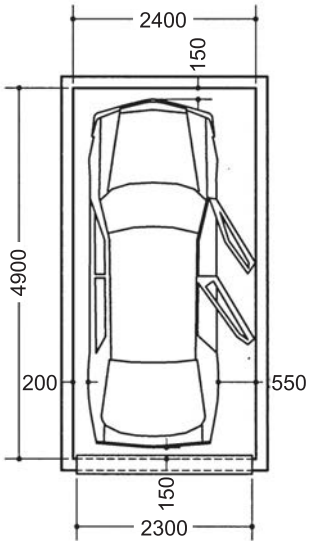
Table IV (continued)

Type of building	Car parking provision	Loading/unloading provision		Cycle parking
	Patrons: one space per 5 seats	Space required within site by main entrance for two cars to pick up and set down patrons		minimum of 4
Theatres	Staff: one space per three members at peak period Patrons: one space per 10 m^2 of gross dressing room accommodation Patrons: one space for each three seats	Minimum 100 m^2 Space required within site by main entrance for two cars to pick up and set down patrons		1 per 100 seats with minimum of 4
Swimming baths	Staff: one space for every two members normally present Patrons: one space per 10 m pool area	Minimum 50 m^2		1 per 4 staff
Sports facilities and playing fields	Staff: one space per three members normally present Players: one space for each two players able to use the facility simultaneously, provided public transport is reasonably close. Otherwise two spaces for each three players Spectators: provide only if more than three times the number of players	Minimum 50 m^2		1 per 4 staff
Marains	Staff: one space per three members normally present Boat-users: two spaces for each three mooring-berths. (If other facilities are included, e.g. restaurant, shop etc., provide additional spaces at 50% normal provision for each additional facility)	Minimum 50 m^2		1 per 4 staff
Community centres and assembly halls	Staff: one space for each three members normally present Patrons: one space for every five seats for which the building is licensed	Minimum 50 m^2		1 per 4 staff
Places of worship	Worshippers: one space per ten seats in space for worship	Minimum 50 m^2 Space provided within site close to main entrance for two cars to set down and pick up worshippers		1 per 60 seats minimum 4
Museums and public art galleries	Staff: one space per two members normally on duty Visitors: one space per 30 m^2 of public display space	Minimum 50 m^2		1 per 300 m^2 minimum 4
Public libraries	Staff: one space per three members normally on duty Borrowers: one space for each 500 adult ticket holders with a minimum of three spaces. If there are separate reference facilities, provide additional spaces at one for each ten seats	Minimum 50 m^2		1 per 300 m minimum 4
Hospitals	Staff: one space for each doctor and surgeon, plus one space for each three others Outpatients and visitors: one space for each three beds	General minima as follows: Gross floor space not exceeding: 1000 m^2 2000 4000 6000 every additional 200 m^2	Minimum space required: 200 m^2 300 400 500 100 m^2	1 per 12 beds
Health centres, surgeries, clinics	Staff: one space per doctor etc. Patients: two spaces per consulting room	Sufficient for requirements specified, including if necessary space for special vehicle for non-ambulant patients	4	
Special schools, day-care centres and adult training centres	Attenders: in many cases these will be transported to the centre. For certain centres for the physically handicapped, allow one space for special or adapted self-drive vehicle per four attenders	Accommodation for special passenger vehicle Space provided within the site for cars and/or buses to set down and pick up	1 per 6 staff	
Nursery and primary schools	Staff: one space per two members normally present Visitors: two spaces Hard surface play area used for parking on open days etc.	Minimum 30m^2	1 per 6 staff	
Secondary schools	Staff: one space per two members normally present Visitors: schools with up to 1000 pupils – four spaces, larger schools – eight spaces. Hard surface play area used for parking on occasion	Minimum 50 m^2 Space provided within site for school buses to set down and pick up	1 per 6 staff 1 per 3 students	
Sixth form colleges	Staff: one space per two members normally present Visitors: colleges with up to 1000 pupils – five spaces, larger schools – ten Hard surface play area used for parking on occasion	Minimum 50 m^2	1 per 6 staff 1 per 3 students	
Further education colleges and retraining centres	Staff: one space for each member normally present Students and visitors: one space for each three students normally present	Minimum 50m^2	1 per 6 staff 1 per 3 students	

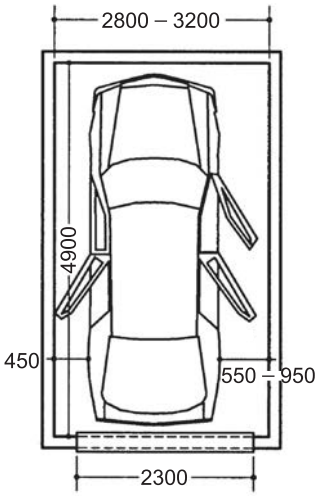
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



39.28 *Circular array with a capacity for 24 cycles*

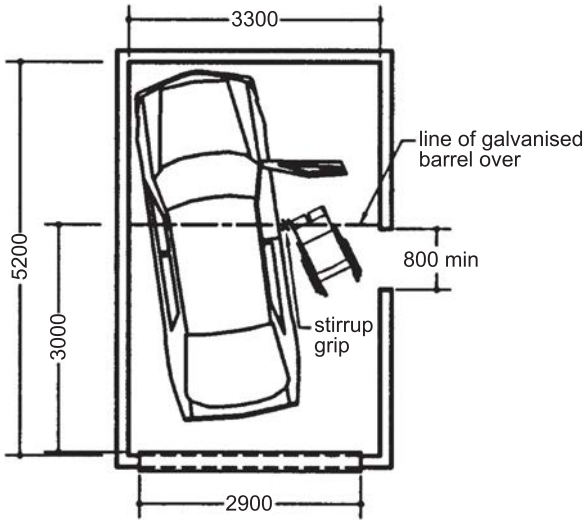


39.29 *A domestic garage of minimum dimensions*

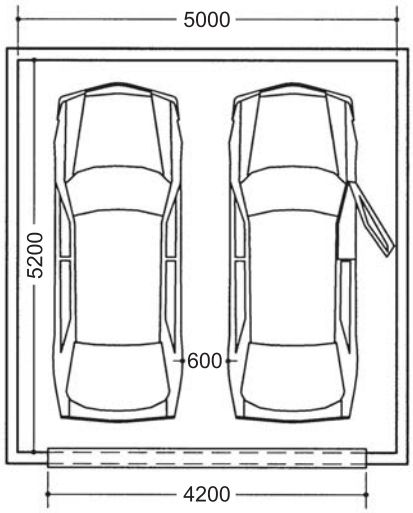


39.30 *A more generous garage permitting passenger access*

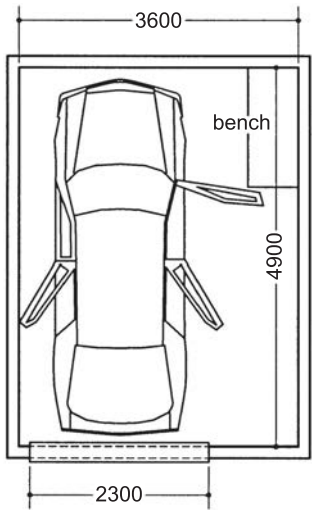
Wherever public or private parking facilities are provided, appropriate arrangements for disabled people, whether drivers or passengers, should be made. Disabled parking bays should be as close as possible to the place that the user needs to go, and preferably under visual supervision to discourage misuse by others. Bays should be at least 800 mm wider than standard, to permit manoeuvring of wheelchairs for transfer, and any kerbs should be ramped.



39.31 *Garage for a driver who is a wheelchair user (for an ambulant disabled driver, a width of 2.8 m is adequate)*



39.32 *A garage for two cars*

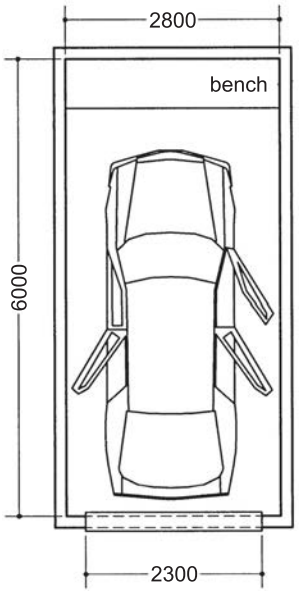


39.33 *A garage of minimum length but width sufficient for a workbench*

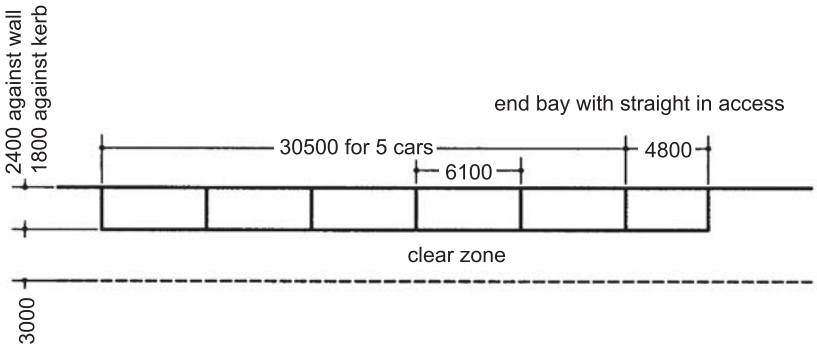
7 LOADING AND UNLOADING

Figures 39.39 to 39.44 show requirements for loading, unloading and parking large vehicles.

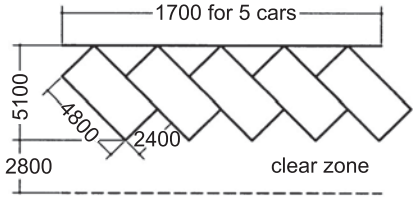
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



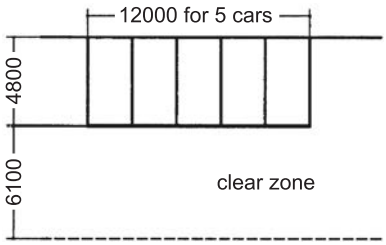
39.34 *A garage with a workbench at the end*



a *in-line parking 20.1 m² per car against kerb, 23.8 m² against wall*

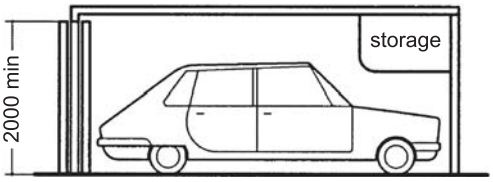


b *echelon parking at 45° (other angles can be used): 22.1 m² per car or 19.2 m² where interlocking in adjacent rows*

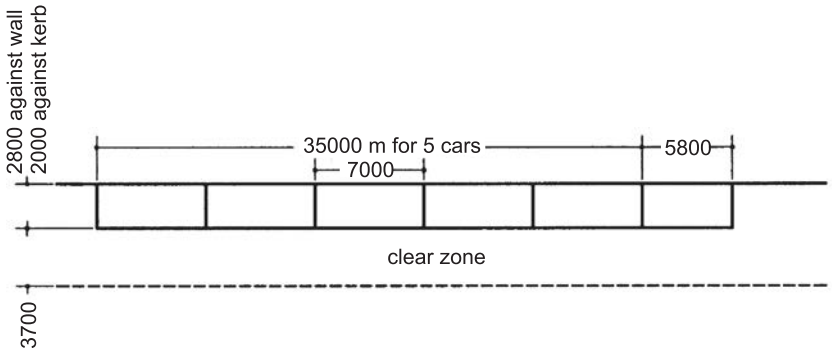


c *head-on parking, 18.8 m² per car*

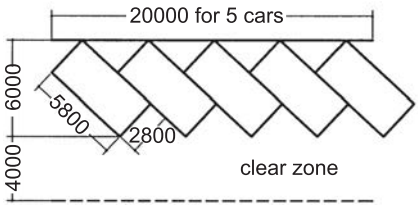
39.36 *Basic parking dimensions. Standard European parking bay or stall 4.8 × 2.4, allow 24 m² per car, including half the clear zone but no access gangways*



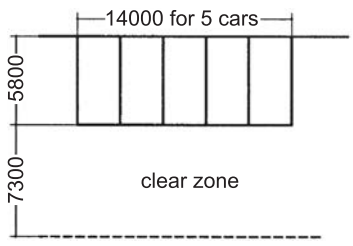
39.35 *Cross-section through a garage showing raised storage area*



a *in-line parking 27.0 m² per car against kerb, 32.6 m² per car against wall*



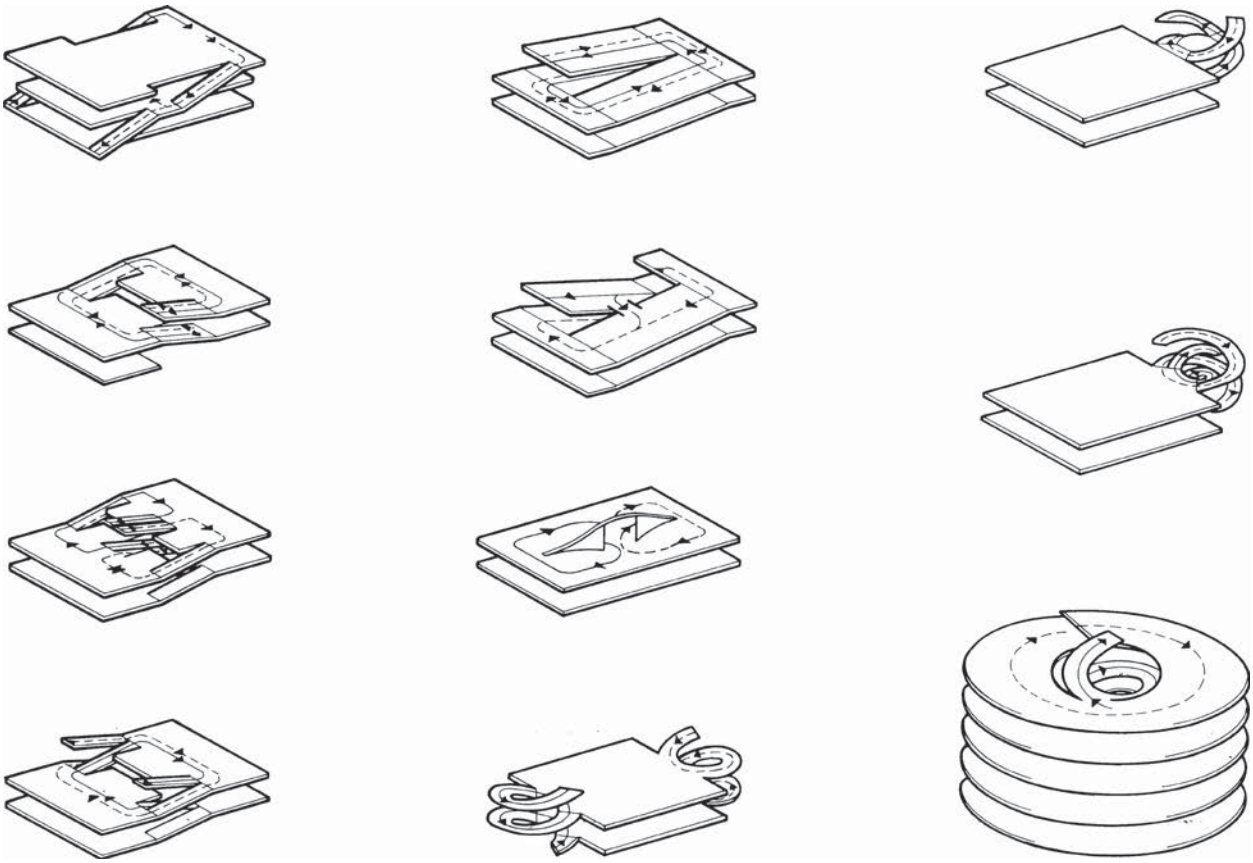
b *echelon parking at 45° (other angles can be used): 32.0 m² per car or 28.0 m² where interlocking in adjacent rows*



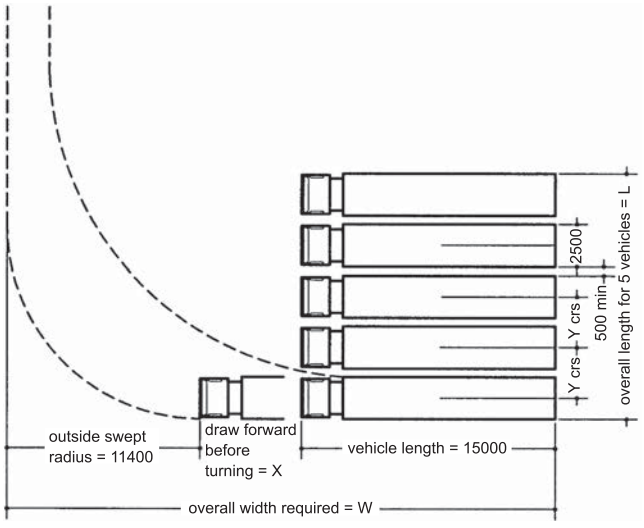
c *head-on parking, 26.5 m² per car*

39.37 *Basic parking dimensions. Large European parking or American bay or stall 5.8 × 2.8, allow 33 m² per car, including half the clear zone but no access gangways*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

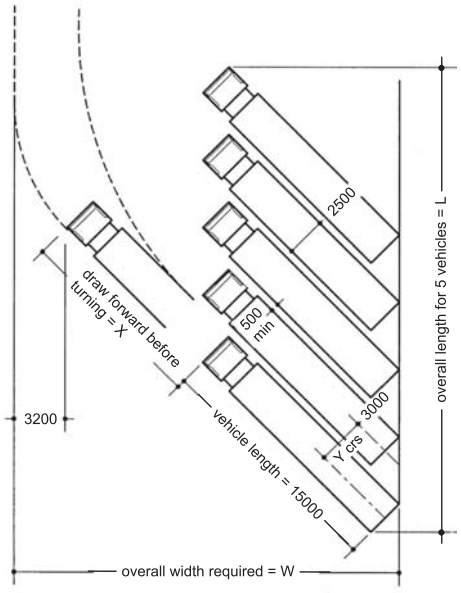


39.38 *Types of multi-storey car parks*



X draw forward	Y centres	W o/a width	L o/a length for 5	Area per vehicle (m²)
1	5.0	27.4	22.5	123
2	4.4	28.4	20.1	114
3	4.0	29.4	18.5	109
4	3.7	30.4	17.3	105
5	3.4	39.4	16.1	101
6	3.0	32.4	14.5	94

39.39 *Lorry parking and loading bays: diagonal (45°) for the largest vehicles*



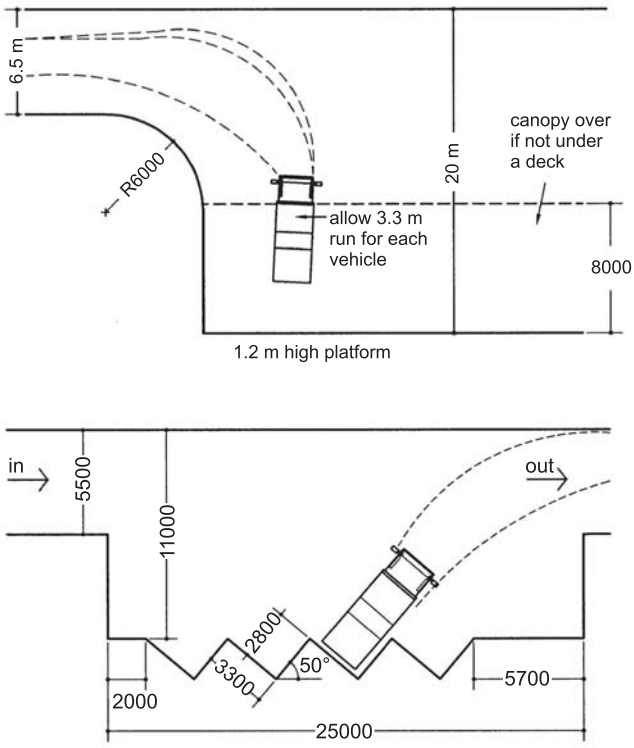
X draw forward	Y centres	W o/a width	L o/a length for 5	Area per vehicle (m²)	
				gross	net*
4	4.8	18.4	39.5	145	113
5	4.5	19.1	37.8	144	111
6	4.2	19.8	36.1	144	108
7	3.9	20.5	34.4	141	105
8	3.6	21.2	32.7	139	101
9	3.4	21.9	39.6	138	100
10	3.2	22.6	30.5	138	98
11	3.1	23.4	29.9	140	99
12	3.0	24.1	29.3	141	99

*Excluding the empty triangles at each end.

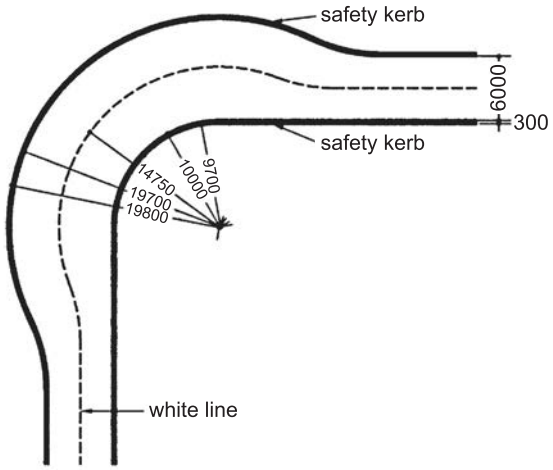
39.40 *Lorry parking and loading bays: diagonal (45°) for the largest vehicles*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

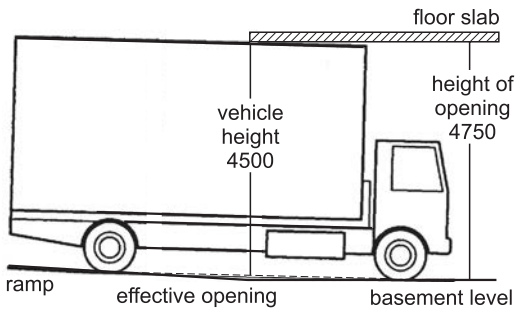
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



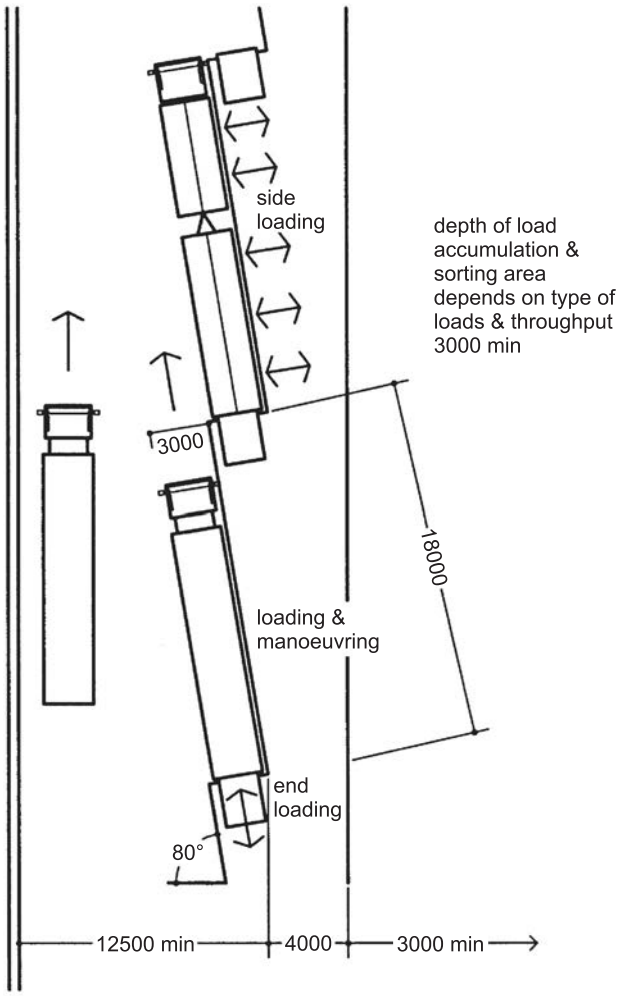
39.41 *Minimal loading docks appropriate for limited number of vehicles per day, extremely high land costs or other physical restraints*



39.43 *Ramp on a sharp curve, such as access to a shopping centre loading dock. Maximum gradients 10 per cent on straight, 7 per cent on inner kerb*



39.44 *Headroom criteria for covered loading docks*



39.42 *Finger dock, where manoeuvring depth is limited and side loading is required as well as end loading. Very fast turnround times are possible although capacity is small*

8 SHARED SPACE

8.1 Principles

The emerging principles behind the concept of shared space for the design of streets and public spaces relies on a clear distinction between two worlds, that of the highway and of public space. Both demand fundamentally contrasting characteristics. On the one hand, the high-speed, single-purpose, regulated and standardised world of the highway, on the other, the low-speed, multi-purpose, contextual and socially defined qualities of the public realm. The contrasting characteristics can be summarised in Table V.

Behavioural psychologists have noted that drivers' speed and responses are largely determined by perceptions of time, and our expectations of progress. In the highway world, high-speeds are part of 'system time', based on anticipation of arrival at a destination at a particular time. By contrast, public space is governed by 'context time', where interest in people and surroundings triggers the brain to expect and demand low speeds to allow time for interpretation and localised responses.

Table V Characteristics of highway and public realm

The Highway	Public Realm
Single purpose	Multiple purposes
Regulated and controlled by the State	Governed by social protocols
High speed	Low speed
Segregated	Integrated
Predictable, consistent, certain	Unpredictable, intriguing, ambiguous
Standardised	Contextual
Interpreted through signs and markings	Multi-layered human communication



39.45 *Shared space at Exhibition Road in South Kensington, designed by Dixon Jones with Project Centre and Hamilton-Baillie Associates for the Royal Borough of Kensington & Chelsea*

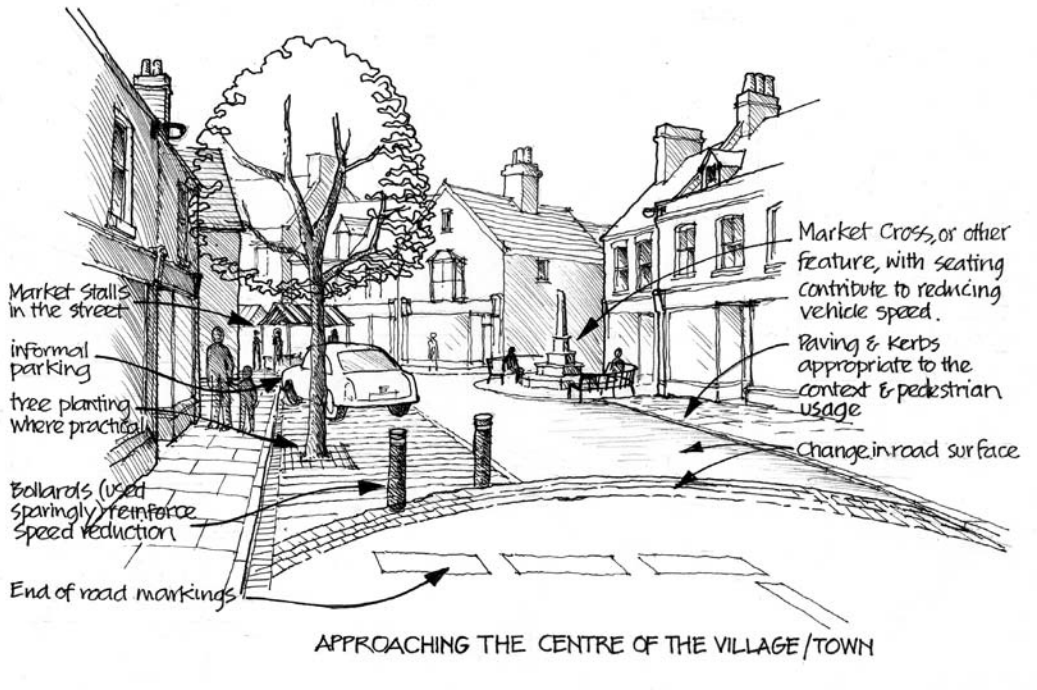
Shared space is a term used to describe the shift towards the use of 'context time' to achieve the safe and efficient integration of vehicular traffic into the streets and spaces that constitute the public realm, Figure 39.45. In practice this requires a combination of design elements and an understanding of the spatial and dimensional implications of low-speed design. Key themes are set out in Sections 8.2–8.6.

8.2 Gateways or transition spaces

The interface between the two worlds of the highway and public space calls for careful treatment, for example at the entry point into a town or village. This requires clarity and consistency. The change of scale from high-speed to low-speed can be achieved through a combination of tighter dimensions, materials, lighting, planting and landscaping, public art and place-making. Consistency between highway measures and the town's architecture and morphology is essential. The transition, Figure 39.46, from highway to shared space requires road markings such as centre lines to end, and the introduction of lower-height, place-specific lighting in place of standard highway masts.

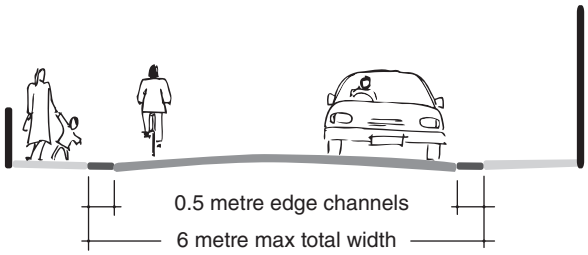
8.3 Visual narrowing

Driver speeds are largely determined by perceptions of carriageway widths. Reducing the apparent width of the vehicular carriageway is one element in creating the necessary low-speed environment for shared space. An edge strip installed parallel to the kerb, in a material close in tone, texture and colour to the footway, can



39.46 *Village transition (Hamilton-Baillie Associates)*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



39.47 *Cross section showing narrowing of carriageway width perception (Hamilton-Baillie Associates)*

successfully reduce the perceived width of carriageway, Figure 39.47. For low speeds, a two-way carriageway of around 6 m can be reduced to an apparent width of 5 m with the inclusion of twin edge strips of 500 mm.

8.4 Edge friction

Vehicle speeds are also determined by the richness of information and activity in the driver's peripheral vision. Where high speeds are expected on highways such as motorways, the edge conditions are maintained as empty and blank as possible. By contrast, low speed environments can be created by enriching the carriageway edge with as much activity, variation and interest as possible. Vertical elements such as trees or lamp columns can combine with spill-out from shops or pavement activity to create edge friction.

8.5 Central medians

One method of increasing edge friction is to introduce a central strip to separate the opposing carriageways. Such a strip can be helpful in minimising the crossing distance and number of negotiations pedestrians have to undertake, allowing a street to be crossed in two phases. A median strip, Figure 39.48, can be of any width, but it is often helpful to allow 2 m in order to accommodate transverse bicycle parking or tree planting. Lighting columns can be well placed on a median strip, providing a useful change in arrangements at the transition point.

8.6 Junction design

The move from segregated towards integrated traffic design allows for greater creativity in the design of intersections, which often lie at the heart of the community. All too often such spaces are dominated by traffic infrastructure. Junctions work more efficiently the lower the approach speed of vehicles, and the less interference is generated by pedestrian crossings. Lower design speeds remove the need for signal control, saving long-term capital and revenue costs for the local highway authority. Shared space junction design strategies include:

- Creating low approach speeds. This will often require the introduction of entry lobbies some 80–120 m distant from the main junction in order to establish appropriate driver expectations.
- Inclusion of a central feature, such as an obelisk, statue, fountain, tree or lamp around which traffic can circulate. Where the available space is limited, a simple roundel or geometrical pattern in the junction can be helpful.
- Avoiding the formality of a mini-roundabout. This helps maintain place qualities and increases driver awareness of fellow street users. The use of tracking software to establish the turning capabilities of large vehicles can be helpful, although lower speeds can allow much tighter dimensions than standard programs allow. A 25 m diameter circle is usually the minimum required to allow large HGVs to turn through 180º.
- For busy intersections, it is helpful to set pedestrian courtesy crossings back 5 m from the junction entry point, in order to allow a vehicle to be free to negotiate solely with other drivers on entering a junction. This set back has to be balanced with minimising any deviation in pedestrian desire lines.



39.48 *Median strip in the centre of Oxford*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

9 PLACE-MAKING

9.1 Benefits

The art of place-making is key to successful urban design and planning and traffic management. Simple measures can help transform a featureless linear street into a rich sequence of places, punctuating and enriching the driver's understanding of context. The positioning of a tree, fountain or lamp in the centre of an intersection can help create a place, or merely the inclusion of a notional frame around a space using setts, blocks or contrasting paving. Special lighting and the disposition of street furniture are also valuable ingredients in place-making.

9.2 Streets and buildings

Conventional segregated highways bear no relationship to the buildings they serve or the activities such buildings generate. Integrated street design seeks to establish a close relationship between the context of a street's surroundings and the design of the street itself. Thus a street might vary its design and form in response to the presence of a school, a park, a pub, a church or a major building. Finding creative ways to establish such conversations is central to current good practice in street design.

9.3 Pedestrian movement

Good street design begins with establishing a clear picture of the likely pedestrian flow patterns, the 'desire lines', established by key pedestrian attractors. Research by Space Syntax and others has highlighted the need to avoid sharp changes in directions in order to provide the legibility and confidence pedestrians demand. Barriers such as guard-rails, high kerbs, bollards and highway clutter should be avoided wherever possible. Pedestrian crossings should be positioned where desire lines suggest pedestrians will wish to cross traffic. Most often this will not be orthogonal to the flow of traffic (as in conventional formal crossings), but is more likely to reflect the diagonal movements associated with pedestrian movement.

Lower speeds in shared space allow for greater use of 'courtesy crossings' – the use of paving material and lighting to highlight to drivers where people are likely to wish to cross. Keeping the width of carriageway where pedestrians cross to an absolute minimum (3 m per lane) is critical in minimising the disruption to traffic flows and encouraging easy pedestrian movement.

9.4 Designing for cyclists

A guide to good design and infrastructure for cyclists is provided in Section 5. Where speeds are sufficiently low to minimise the differential between motor traffic and cyclists, informal sharing of the carriageway becomes more feasible. The presence of cyclists is helpful in establishing the informal negotiations and mutual awareness central to shared space. Where one-way streets for motor traffic cannot be avoided, measures should be introduced to allow two-way flows for cyclists. Off road, traffic-free links and connections form a critical part in a comprehensive network for cyclists. Only where speeds or traffic volumes are over-dominant in a given street or space should separate lanes be marked out on carriageways or on shared-use footways, where widths should not be lower than 1.2 m.

9.5 Designing for people with disabilities

Current street design continues to seek creative means to allow and foster universal access to as much of the built environment as possible. Establishing low speeds is the most critical factor above all in achieving such universal access. The quality of experience and confidence of people with disabilities requires an environment that fosters an awareness and alertness of drivers towards individual circumstances. Elements such as courtesy crossings, supplemented tactile or physical measures to ease navigation and orientation, combined with a clear understanding of the importance of landmarks, sound, paving surfaces, lighting, sunlight and many other clues, can minimise the barriers facing those with disabilities.

9.6 Street furniture

Street furniture and planting can be central to successful place-making, and can help establish the overall design approach appropriate to the context. The arrangement, positioning and design of the benches, litter bins, lighting columns, bicycle parking and other items of street furniture are best considered as an integral part of the overall design, rather than left until last. Wherever possible, any necessary signing can be designed into the street furniture to minimise clutter.

10 CASE STUDY – POYNTON

10.1 Introduction

Poynton is a small market town between Stockport and Macclesfield in Cheshire. It is a crossroads settlement, centred around the intersection of the busy north-south London Road, with the east-west Chester Road. Park Lane, the town's main high street, runs eastwards from the main intersection of Fountain Place.

In 2007, the decline in economic activity had become critical for the future of the town, with over half of its high street shops standing vacant.

10.2 Traffic blight

This retail decline was partly associated with the poor quality of street design and layout in Park Lane. But the more significant factor was the bifurcation of the residential community caused by the heavy traffic and wide, impersonal carriageways of the signal-controlled junction at Fountain Place. As a result, one half of the town's residential area, including its railway station, was physically and psychologically divided from Park Lane. Heavy congestion and delays associated with the traffic signals had generated poor air quality, and traffic speeds were a concern. The magnificent parish church, designed by Alfred Waterhouse and very popular for local weddings, had an especially poor connection to the town.

10.3 New street design

Street design, and a radical approach to traffic management, were central to the master plan for the regeneration of Poynton designed by Hamilton-Baillie Associates and completed in 2012, Figure 39.49. This included a redesigned Park Lane premised on low-speed, continuous flow traffic. Visual widths of carriageways were reduced to 2.6 m, combined with an informal central median strip. The signal-controlled pedestrian crossing was removed, and a number of diagonal courtesy crossings were introduced. New lighting, street furniture and a coherent arrangement for shop fronts completed the design.

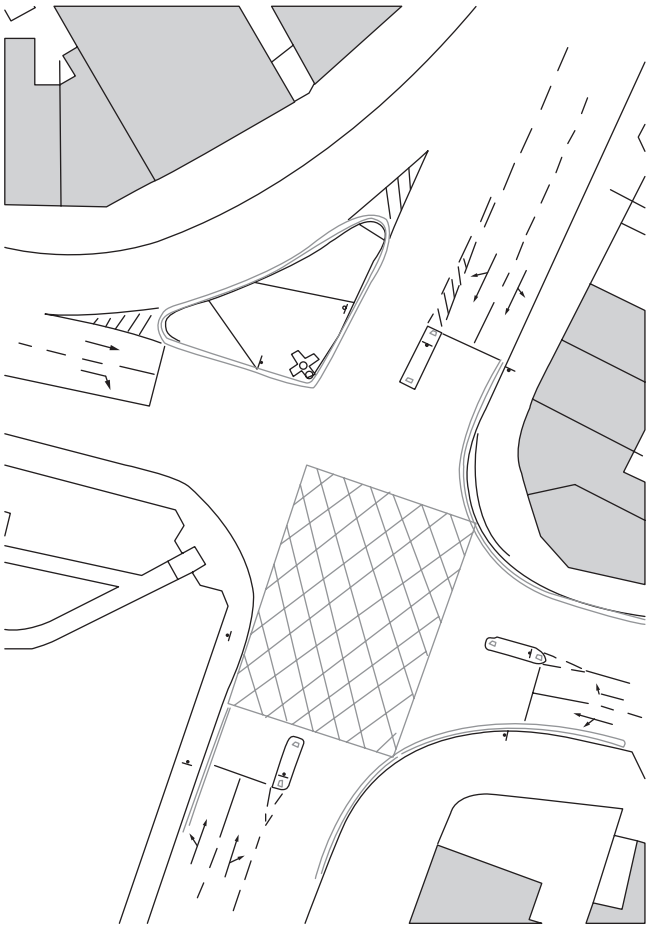
10.4 Fountain Place

The second phase of the £4 million project involved re-establishing a town centre and a sense of place at the Fountain Place junction, Figure 39.50. This was the first time that shared space principles had been applied to a major junction with such high volumes of traffic. Removal of the traffic signals and the introduction of low-speed, shared space arrangements allowed significantly greater space to be allocated for pedestrians, including a key space outside the church gate. All road markings, signs and signals were removed, and new gateways were created on each of the four approaches to the junction. Fountain Place was laid out as two interconnected circles in a granite block paving pattern, marked by informal roundels, to reinforce the sense of place, Figure 39.51.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



39.49 *Hamilton-Baillie Associates' masterplan for Poynton, including a median strip and a new junction at Fountain Place to the left*



39.50 *Fountain Place's signal-controlled junction layout before its redesign*



39.52 *Fountain Place pictured after its redesign, with significantly less congestion*



39.51 *Fountain Place's new junction layout*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

10.5 Impact

Within 10 months, all remaining vacant shops had been successfully let, and footfall has increased by around 80 per cent. Congestion levels fell more dramatically then expected, Figure 39.52, and journey times for vehicles passing through Poynton have reduced by 35–50 per cent. Road traffic accidents and injury rates, at the time of writing, showed a marked improvement on the signal-controlled arrangement.

11 BIBLIOGRAPHY

Baldwin & Baldwin (eds). The Motorway Achievement – Volume 1 Visualisation of the British Motorway System: Policy and Administration. Thomas Telford, 2004

Colin Buchanan, et al., *Traffic in Towns*, HMSO, 1963

CABE, *This Way to Better Streets*, 2007 www.designcouncil.org.uk

CIHT, *Streets and Transport in the Urban Environment*, 2014

Cambridge City Council, *Cycle parking guide for new residential development*, 2010

Construction Industry Council, *Integrated Transport and Land Use Planning*, 2002

Croney & Croney, *The design and performance of road pavements*. McGraw Hill, 1998 (3rd edition)

Department of Environment, Transport and the Regions, *The Highways (Road Humps) Regulations 1999*

Department for Transport, *Inclusive Mobility*, 2005

Department for Transport, *Local Transport Note 2/08 – Cycle Infrastructure Design*, 2008

Department for Transport, *Local Transport Note 1/12 – Shared Use Routes for Pedestrians and Cyclists*, 2012

Department for Transport, *Manual for Streets*, 2007

Department for Transport, *Manual for Streets 2*, 2011

Department for Transport, *Shared Space Local Advice Note 1/11* 2011

Department for Transport, Local Transport Note 1/08 -*Traffic design and Streetscape, 2008*

Dorset AONB, and Ben Hamilton-Baillie, *Traffic in Villages: A Toolkit for Communities*, 2011

English Heritage, *Streets for All*, 2006

D. Engwicht, *Mental Speed Bumps*, Enviropress, 2005

Jan Gehl, *Life between Buildings*, Danish Architectural Press, 2001

Jan Gehl, *Cities for People*, Island Press, 2010

Hill et al., *Car Park Designers' Handbook* (X401). Thomas Telford 2005

B. Hillier & J. Hanson. *The Social Logic of Space*. Cambridge University Press

Irish Government, Dept. Transport, Tourism & Sport, *Design Manual for Urban Roads and Streets*, 2013

Allan B Jacobs, *Great Streets*, MIT Press, 1995

Jha, MK et al. *Intelligent Road Design*. WIT Press, 2006

Lamm et al., *Highway Design and Traffic Safety Engineering Handbook*. McGraw Hill 2000

The Scottish Government, *Designing Streets*, 2010

Sustrans, *The National Cycle Network – Guidelines and Practical Details, 1996*

Transport for London, *London Cycling Design Standards*, www.tfl.gov.uk

H.G. Váhl & J Giskes, *Traffic calming through integrated urban planning*, Amarcande, 1988

Tom.Vanderbilt, *Traffic*: *Why We Drive the Way We Do*, Penguin, 2008

This page intentionally left blank

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

40 Studios for sound and vision

David Binns

CI/SfB 528

David Binns is the senior partner of Sandy Brown Associates, architects and acoustic consultants

KEY POINTS:
- *Avoidance of extraneous sound is essential*
- *Production staff need both full observation and easy access to the studio floor*

Contents

1 Introduction
2 Studio types
3 Planning
4 Services
5 Acoustics
6 Statutory requirements

1 INTRODUCTION

1.1 Scope

A TV studio is an area in which activities are performed specifically for observation. (Television cameras are also used outside studios for surveillance in stores, banks and so on.) A sound studio may be used for live broadcasts such as news bulletins, but is most likely to be required for making recordings.

1.2 Broadcasting studios

The greatest differences between studios will be in the ancillary areas rather than the studio *per se*. These differences reflect the nature and attitudes of the client: the BBC in the UK, for instance, is a public service organisation whereas the independent companies are not (although they must adhere to standards set by the Independent Broadcasting Authority).

1.3 Independent and educational studios

There are now many small independent studios, operating for private commercial use, for making programmes under contract and for making educational and instructional videos. Some are attached to higher-education institutions.

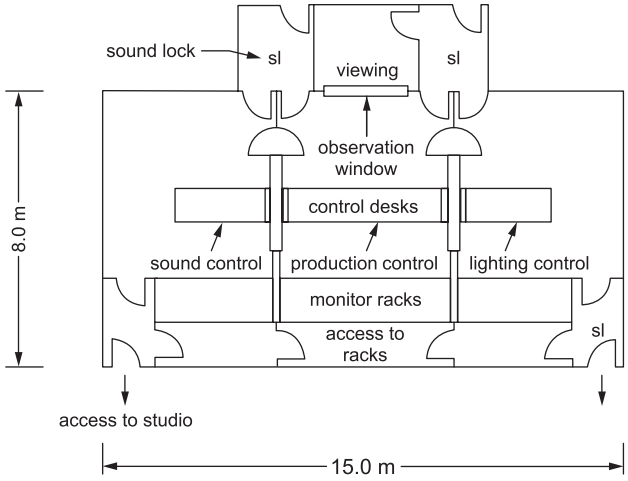
2 STUDIO TYPES

2.1 Sound studios

Small sound studios may be used for such purposes as local broadcasting and for recording advertisements and jingles for commercial radio. Figure 40.1 shows the scheme for such a facility. Where larger spaces are required, for example for recording orchestral music, studios primarily designed for TV might well now be used. The principles behind both sound and TV studios are similar, although sound studios are more likely to have direct vision windows.

2.2 Multi-purpose TV production studios

Previously, TV studios differentiated between music and drama. Now, all are multi-purpose largely due to economic pressures. They have accepted acoustically 'dead' conditions, reverberation or presence being added electronically. Greater use of zoom lenses in preference to camera tracking means microphones are located further from performers, necessitating low reverberation times and background noise levels. Camera tracking requires a floor laid to very precise tolerances (currently ±3 mm in 3 m). The floor



40.1 *Relationship diagram for sound recording studio suite*

is normally heavy duty linoleum sheet laid on an asphalt mastic screed; it requires a specialist floor laying contractor to achieve these fine tolerances.

Studio length-to-breadth ratio should be in the region of 1:1.5. The minimum practical floor area for a small commercial TV studio would be 60 m^2 with static cameras. TV station studios range between 200 and 400 m^2. The studio height is determined by the clear space required below the lighting grid (a function of the longest camera angle). The minimum height for a small studio is 4 m; in the larger studios 11 m to the grid with a clear height above of 2.5 m, making something over 13.5 m overall. In these studios an access gallery is required *at grid level approximately 4.5 m above studio floor level.* This is normally to avoid obstruction of access doors and observation window. Access to the galleries from studio floor level is mandatory and direct access to lighting grid level is desirable.

A cyclorama or backdrop cloth is suspended below lighting grid level. It should be at least 1.25 m away from the walls to allow a walkway around the studio and is on a sliding track with radiused corners to enable it to be stored.

2.3 Interview and announcers' studios

These studios range in size from 30 to 60 m^2 with a height of 4 to 6 m. Static cameras and a simple form of lighting grid combined with floor lighting stands are used.

2.4 Audience participation studios

Some productions require audience participation and fixed theatre-type seating on terraces is provided. In smaller studios this is demountable, so storage space has to be provided. Audiences place more stringent demands on the planning of a TV complex, as segregated access and emergency escape routes have to be provided (see Chapter 15, Auditoria).

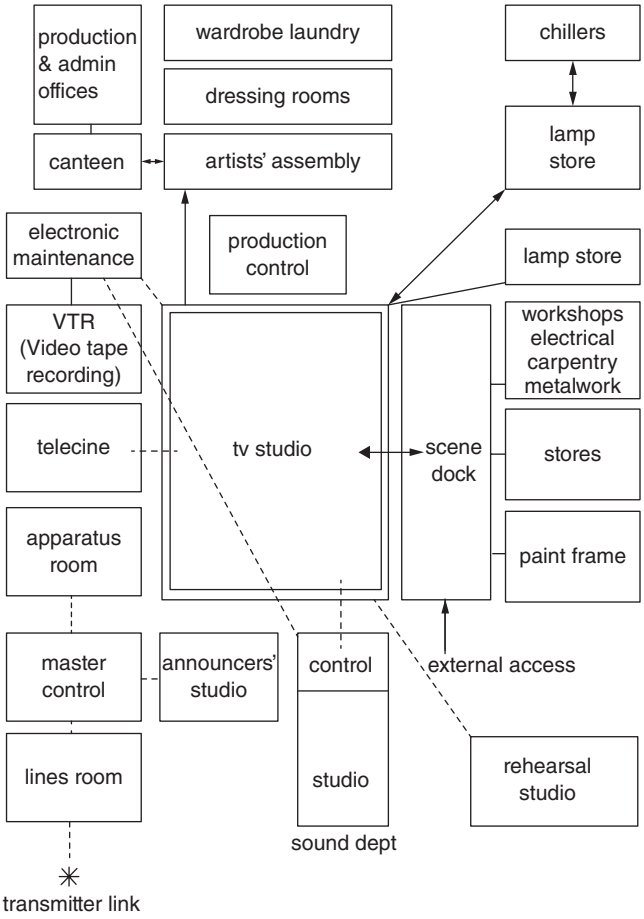
3 PLANNING

3.1 Layout

A typical layout for a TV broadcasting studio complex is shown in Figure 40.2. Larger installations will have workshop facilities

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



40.2 *TV studio complex; block planning diagram*

adjacent to the scene dock and if flats and backdrops are made on-site a paint frame will need to be the full height of the cyclorama curtain. Further details of such facilities will be found in Chapter 15.

Equipment areas

Ancillary equipment areas will include separate areas for VTR (video tape recording) and telecine (transference of filmed material to video). The machine operator should be able to hear sound track and cues above the noise of other machines in the room which are usually enclosed in open-fronted cubicles with heavily acoustically treated walls.

Master control room

Adjacent to these equipment areas will be the master control room, which is the last monitoring link in the video and audio chain before transmission. Here programme material, either recorded (VTR and telecine) or live from the studios, will be linked with continuity from the announcer's studio.

Dressing rooms

Artists' facilities adjoining the studio will include dressing rooms with associated wardrobe and laundry, rest and refreshment areas (see Chapter 15).

Rehearsal spaces

Separate rehearsal spaces are required as there is considerable pressure on studio floor time (much of which is used in setting and striking scenery, and setting up lighting and cameras for productions). These need not be the full studio size as several sets will occupy the studio floor and scenes are rehearsed individually, often in remote assembly halls.

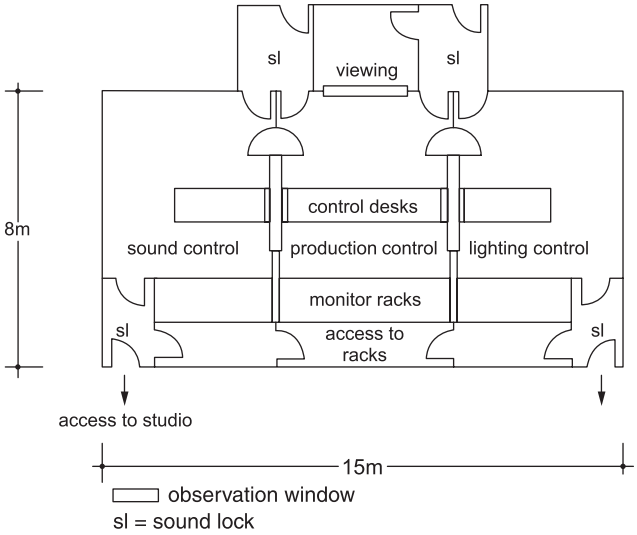
Service spaces

In addition to the areas detailed in Figure 40.2, space will be required for a sub-station, emergency generator and tape stores. The small commercial and education studios which do not broadcast will have simpler planning arrangements.

3.2 Control suites

TV control rooms do not now overlook the studio they monitor for the following reasons:

- The cyclorama track and studio scenery are likely to interfere with the producer's view; production decisions are made off monitor screens.
- The chroma of glass in the observation windows must be adjusted to confirm colours reproduced by TV monitors. This is done using an applied tinted finish which requires frequent replacement.
- Windowless production suites do not need to be elevated, hence production staff have direct access to the studio floor. A typical control suite layout of this type is shown in Figure 40.3.



40.3 *Layout of a production control suite with no direct visual access to studio*

Minimum clear height in the control room, including a false ceiling for services, is 4 m.

Separate control areas for production, lighting, and sound are required with 25 dB insulation between each and visual contact via observation windows. A viewing area for visitors separate from that for production staff is desirable.

The disadvantage of such a layout is that the producer has no direct visual contact with the floor manager or performers.

4 SERVICES

4.1 Lighting

Television studio lighting is highly specialised. The large production studio will have a remotely operated lighting grid, whereas the small studio will have a simple pre-set system.

Lamp support systems

There are three basic types of lamp support systems:

- The most elaborate is a grid of 'railway' tracks covering the whole studio. On these tracks run carriers which have a telescopic arm holding the lamp. The arm is motor driven (either electrically or hydraulically) and lowers the lamp to studio floor level for setting and adjustment. Each lamp can be separately panned, tilted and dimmed remotely. An additional overhead rail at the perimeter of the grid will carry carts on to which the 'monopole telescopes' and lamps can be run off the grid to a lamp store. Where several studios exist this rail will interconnect them all via a central lamp store. The latest grids are equipped with

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

an electronic memory to enable a whole production of lighting settings to be stored.

- A simpler form has lighting bars which can be raised or lowered electrically or manually fixed direct to the studio. The bars take several forms from the 'lazy scissors' principle to a simple bar on cables and pulleys.
- The third and simplest type is a fixed barrel grid. As in the second type no space is required above this grid for access as lamps are clamped direct to the bars and set from studio floor level.

Lighting to equipment and control areas needs to be carefully studied to avoid reflections and provide correct levels for viewing. Special fittings are often required.

4.2 Air conditioning

Air conditioning presents the designer with a number of unique problems: the large volume, the high heat loads generated by lamps, low background noise levels and the need to provide comfortable conditions in parts of the studio obscured in all but one plane by scenery. Low air speeds have to be used to achieve the noise levels. The most successful system has been the 'dump' system where cooled air is fed from a large plenum chamber above grid level and returns via natural convection of heat from the lamps to a similar exhaust plenum at an even higher level. Plant rooms, unless remote from the studios, require structural isolation to prevent vibration transmission (see Section 5.3); adequate space must be allowed for attenuation. Mechanical engineers are familiar with duct-borne noise problems, but do not normally investigate noise break-in through duct walls or the architectural acoustic problems. The architect should make certain that this forms part of the specialist consultant's brief.

4.3 Technical wiring

Extensive provision has to be made for power, audio and video wiring connecting the studio to control suites and equipment areas. Camera cables are approximately 50 mm in diameter and have a minimum bending radius of 0.5 m. Power wiring, which may include low-voltage power, has to be run in separate trunking from audio wiring to avoid interference. Trunking is often concealed within the acoustic finishes and all perforations of the studio enclosure have to be sealed airtight to avoid sound transmission.

4.4 Other services

Large production studios will require compressed air, gas, water (including drainage) and a smoke-detection system, in addition to electrical services.

5 ACOUSTICS

5.1 Identify standards

The standards to be achieved should be identified by the specialist consultant and agreed with the client at the outset. The two main sources are the BBC and the ISO (International Standards Organisation).

5.2 Airborne sound insulation

For every location a full one-third octave band, site noise level survey must be carried out to determine the design of the enclosing structures. Additionally, all internal transmission loss defined by frequency should be established and can be extended to provide the mechanical engineer with the requirements for in-duct crosstalk attenuation. For this it will be necessary to establish the maximum permissible noise levels from all sources in each room.

5.3 Vibration isolation

The noise and vibration levels of all mechanical plant should be studied and the architect must identify who should be responsible for defining maximum permissible levels and designing to achieve them. Structure-borne sound transmission, particularly on the upper levels of framed buildings, may necessitate the 'floating' of plant rooms and noise-protected areas.

This involves isolating the walls, floor and roof from the surrounding structure. The walls are built off a secondary floor bearing on steel spring or rubber carpet mountings designed to a maximum natural frequency not exceeding 7 to 10 Hz. Footfall impact noise often requires floors to be carpeted with heavy underfelt or in extreme cases, the floating of studios.

5.4 Reverberation time

Figure 40.4 relates reverberation time to volume for television studios. Calculation will indicate the amount and type of absorption required. Details of a typical wide band modular absorber are shown in Figure 40.5. Approximately 200 mm should be added to the clear studio height and to each wall thickness to accommodate the acoustic treatment. Sound control rooms need to be similarly treated, with the other production control rooms and technical areas made as dead as possible.

5.5 Background noise levels

Maximum permissible background noise levels are shown in Figure 40.6. These should be related to the external ambient levels and to noise from air-conditioning plant. In certain situations where plant rooms are adjacent to noise-sensitive areas, maximum permissible noise levels at intake and extract louvres should be specified to limit this noise breaking back in through the external skin, particularly at windows.

5.6 Special details

Acoustic doors and sound lock

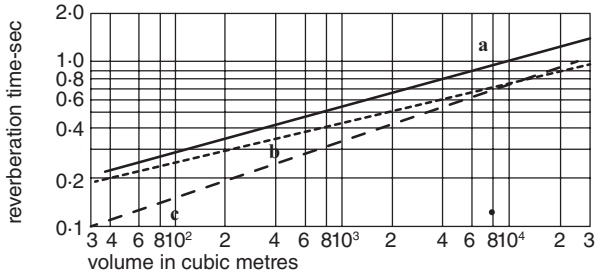
Typical details for an acoustic door and an observation window are shown in Figures 40.7 and 40.8. All noise-sensitive areas should be approached via a sound lock lobby consisting of acoustic doors, with either end of the lobby treated to be acoustically dead. The mean sound transmission loss of each door is 33 dB and sealing is effected by means of magnetic seals.

Scenery doors

The transfer of scenery into the studio requires an opening in the region of 5m high by 5m wide with a sound reduction index between 50 and 60 dB. This door will almost certainly be of steel construction. Hinged doors have been used but the forces required to ensure that the edge seals close airtight produce operational difficulties. A 'lift and slide' door is more satisfactory. An electric or hydraulic drive opens and closes the door while radius arms lower it inwards and downward to compress the edge seals all round. This type of door does not require an upstanding threshold as does the hinged door, and this is a considerable operational advantage.

6 STATUTORY REQUIREMENTS

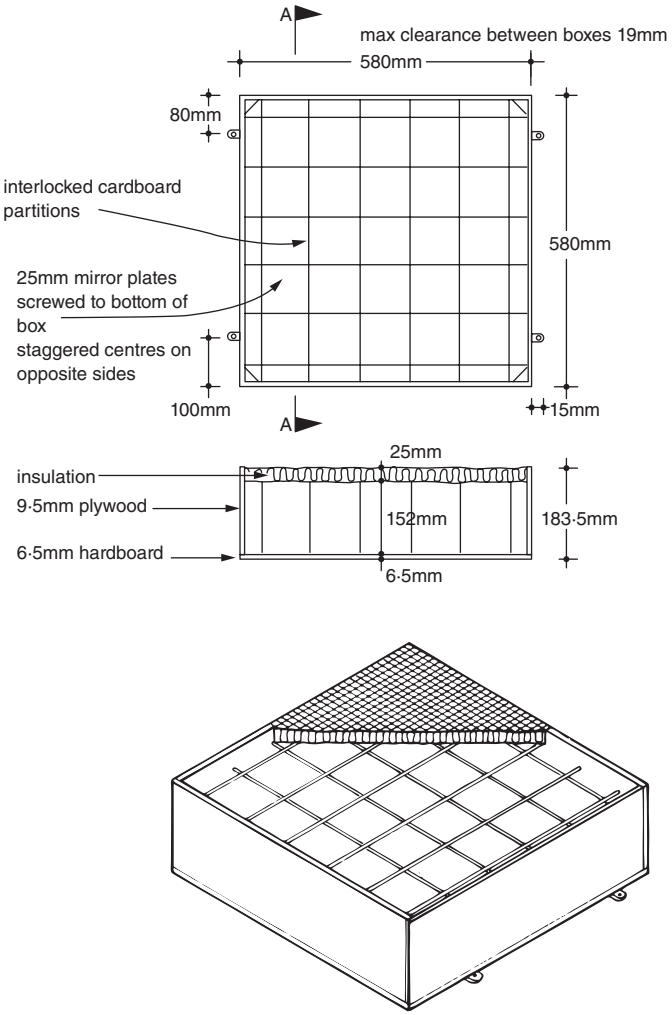
Careful examination should be given at the planning stage to means of escape and fire resistance. Statutory requirements vary considerably



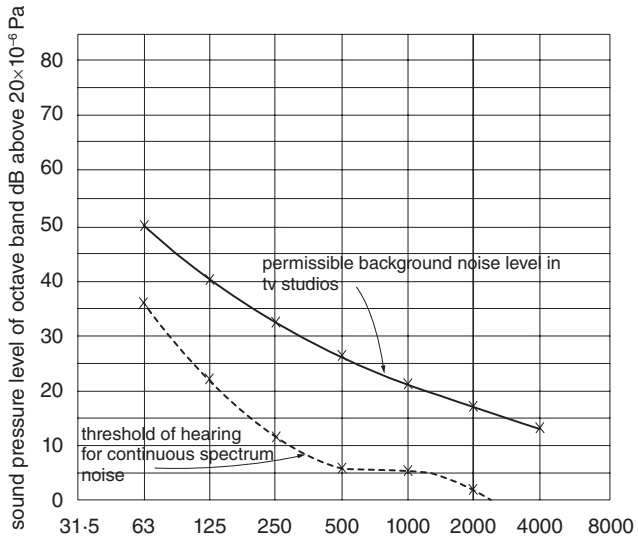
a *highest acceptable reverberation time* **b** *optimum reverberation time*
c *lowest practicable reverberation time*

40.4 *Reverberation times for TV studio*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

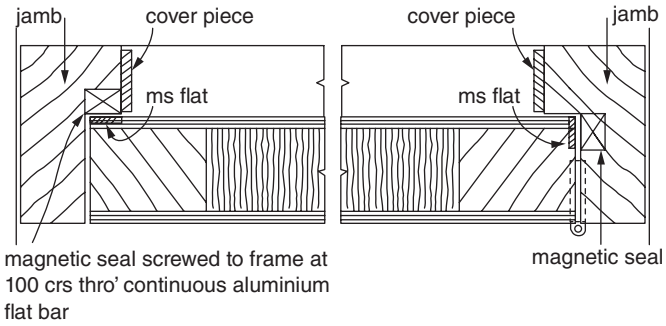


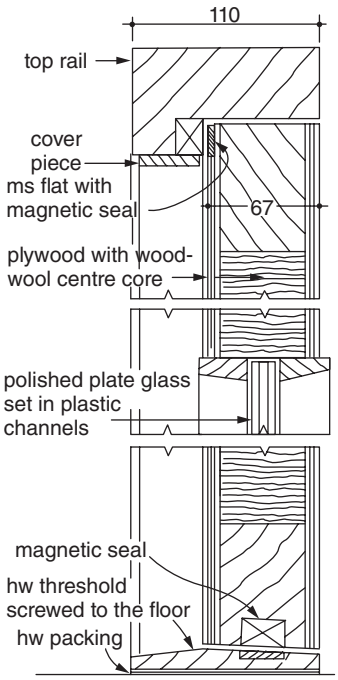
40.5 *Modular sound absorbing unit*



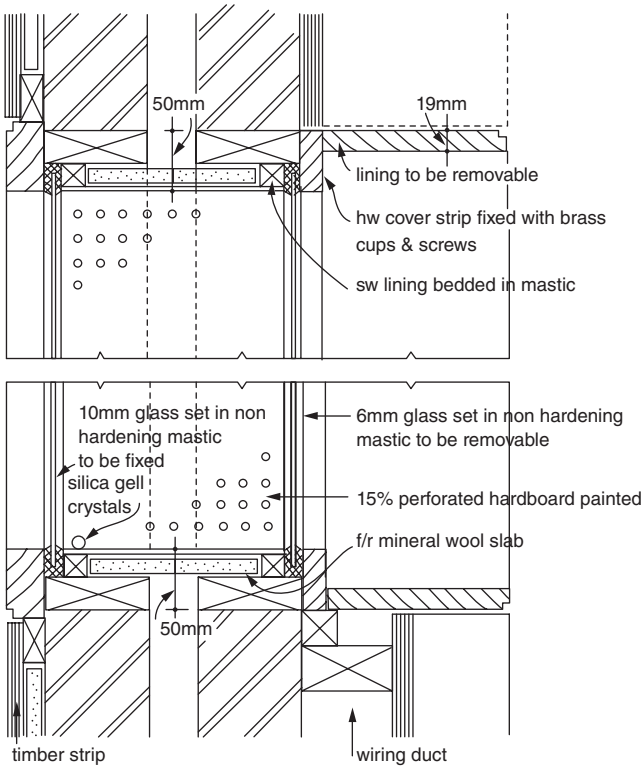
40.6 *Background noise levels*

in all parts of the world, but the most stringent are those operated in the UK where Class O flame spread may be required for all finishes and up to a four-hour fire separation for the studio walls. This necessitates double steel roller shutters on all perforations through walls. Smoke vents are sometimes required and these must be designed to match the sound insulation of the roof.





40.7 *Acoustic door construction*



40.8 *Observation window*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

41 Transport terminals and interchanges

Airports updated by Andrew Perez with additional contributions by Richard Chapman. Railways by Declan McCafferty.

CI/SfB 114, 124, 144

Andrew Perez is a principal at Grimshaw Architects. Declan McCafferty is a partner at Grimshaw Architects. Richard Chapman is director of Airport Design Consult Ltd

KEY POINTS:

- *Airport terminals are now major public buildings with increasingly diverse functions*
- *Intermodality between all forms of transport is a critical consideration*
- *Moving large numbers of passengers safely, simply and efficiently are key components of a successful terminal and interchange design*

Contents

1 Introduction
2 Airports
3 The terminal building
4 Departures – landside
5 Departures – airside
6 Arrivals – airside
7 Arrivals – landside
8 Levels and volumes
9 Aircraft and apron requirements
10 The changing airport
11 Case study
12 Railway stations
13 Bus and coach stations
14 Trams and light rail
15 Bibliography

1 INTRODUCTION

Air travel is now available to many more people than ever before in its relative short history. As a result, airport terminals are now major public buildings and accommodate diverse functions from the social to the commercial as well as processing departing and arriving passengers. These buildings can be part-theatre, part-urban plaza, part-museum, part-shopping mall and part-leisure centre. Serving as gateways, both literally and figuratively, these buildings have become important emblems for nations as well as major transport processors. As their size, critical, social and commercial mass increase, airport terminals become ideal centres for major transport interchanges, capturing large movements of people, many of whom may not necessarily be travelling by air.

2 AIRPORTS

2.1 History

The airport terminal has been an established building type for only ninety years since London's first airport at Croydon, but many typologies have evolved. The rapid development of air travel has meant that buildings have swiftly become obsolete and needed either replacement or reconstruction.

A notable early example is the original terminal at Gatwick Airport, Figure 41.1 that offered passengers in 1936 a direct and sheltered route from railway to terminal and from terminal to aeroplane. It was therefore an early true transport interchange facility.

2.2 Airport terminal planning

There are two major influences on airport and terminal size:

- passenger demand;
- airline traffic scheduling.

2.3 Airport terminal capacity and size

Passengers per year and passengers per hour are the key factors in terminal design. Large peak concentrations will produce a high hourly demand in relation to the annual traffic. A substantial constant traffic level will produce a high annual rate in relation to the hourly demand.

Global air travel is growing on average by 5–6 per cent every year and estimates suggest that passenger numbers will continue to increase by 3–5 per cent annually for the foreseeable future.

Sophisticated mathematical models can be used to represent the flow of passengers. Where appropriate, standards are applied to various future times such as five and ten years ahead.

The term *standard busy rate* (SBR) is used in terminal design, and is the number of passengers predicted in the thirtieth busiest hour of scheduled use. This means that for 29 hours in the year the facilities will not match up to the requirement, but reasonable standards and economy are balanced.

Other factors to be considered are:

- *Aircraft movements*: number of arrivals and departures per hour, aircraft sizes, number of stands for each size or range of sizes, passenger load factors.
- *Baggage quantities*: number of pieces per passenger, by class of travel and traffic type.
- *Visitors*: number of accompanying visitors with departing and arriving passengers by class of traffic type.
- *Employees*: number and proportion for airport, airline, concessionaire, control authorities, etc. and proportion of males and females.
- *Landside transport*: number of passengers, visitors and employees arriving by private vehicles and by public transport (bus, coach, hire car, taxi, train, light rail, etc.).

A very simple rule of thumb for approximating terminal floor area is:

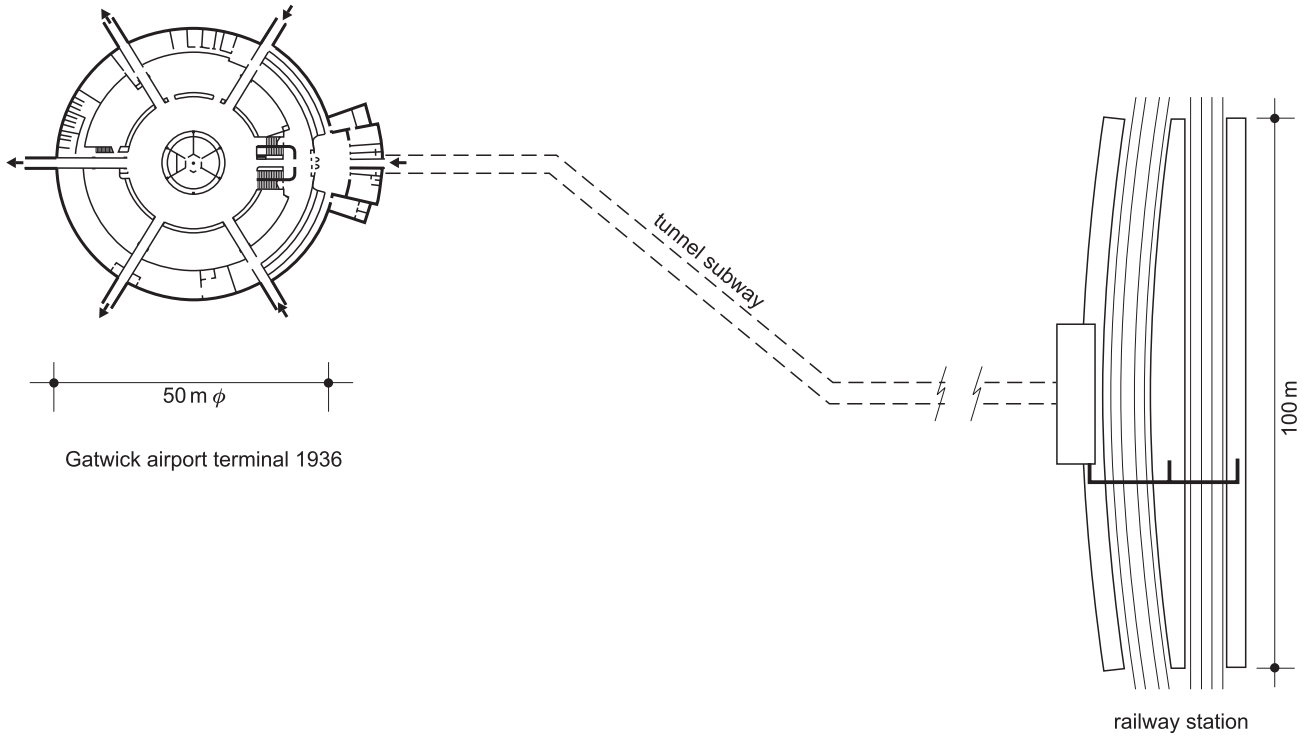
- For every one million passengers per annum (mppa) the terminal expects to process, multiply by this by 10,000 m^2.

So, a terminal planned to process some 30 mppa will be approximately 300,000 m^2 total gross floor area.

2.4 Type of traffic

There are three main types of traffic:

- *International*: involves customs and immigration procedures.
- *Domestic*: does not involve customs and immigration procedures so can be simpler buildings.
- *Combined international/domestic.*



41.1 *Gatwick Airport Terminal, 1936*

2.5 Type of passenger

There are two main types of passenger:

- *Origin and Destination (O&D):* Fly to the terminal, which is the final destination.
- *Transfer*: Fly to the terminal which is not their final destination, connecting with another flight to travel onward to the final destination. This can be either international-to-international connections or domestic-to-international (or vice versa) connections.

2.6 Type of airport

There are two main types of airport:

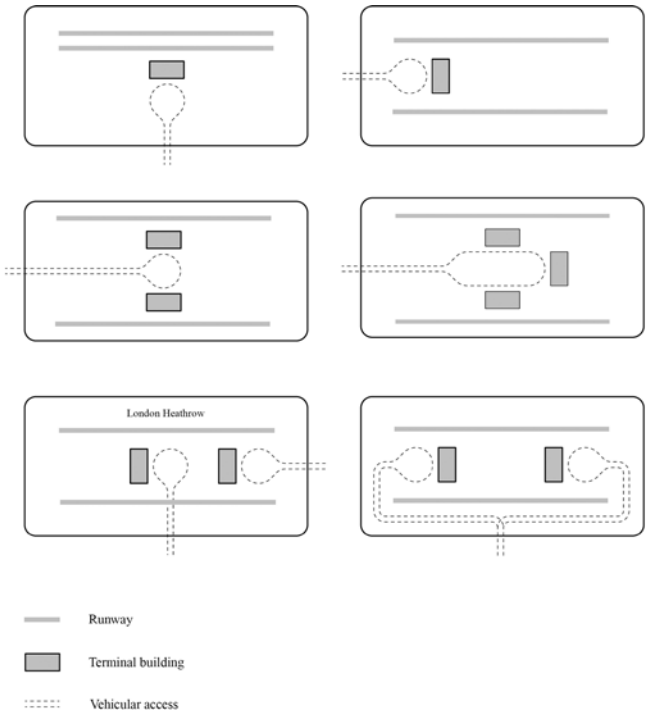
- *Point to Point:* Airports with no transfer passengers i.e. passengers directly fly to this airport as their final destination.
- *Hub*: Airports with a percentage of passengers transferring to an onward flight to their final destination.

2.7 Passengers versus planes

Major airport terminals require large multi-runway airfields. The challenge for terminal buildings is to exist within these complex environments and remain accessible, functional and amenable for passengers and staff. Whereas an air traffic controller may judge the success of an airport in terms of short taxiing distances and the number of air traffic movements per hour, a passenger would use quite different criteria for measuring success. These are all focused on the terminal building itself such as general comfort, ease of use, legibility of wayfinding, and the range and variety of services offered. As designers we must remember that terminal buildings are designed for passengers first. The plane must not rule. However airfield configuration is a major influence on the positioning, footprint and configuration of the terminal buildings.

2.8 Position of the terminal building

Many if not most airfield configurations are pre-existing or reconfigured as a legacy from earlier times. Key fixes for any airfield configuration are the length and alignment of the runway(s). These two factors, along with public vehicular access, will be major drivers in determining where exactly the terminal will or can be positioned within the airfield. Various examples are shown in Figure 41.2.



41.2 *Examples of terminal building/airfield relationship*

2.9 Footprint of the terminal building

Emblematic shapes, evocative geometries, all seen from the air, do become indelible images representing particular airports. Easily identified, these can in themselves form part of the airport's, and indeed the city's identity. However, these forms are not a result of simple shape-making. Three key drivers forge the terminal building footprint:

- *the available site boundary.* This is the plot which the terminal building can occupy within the airfield without interfering with any aircraft movements on the ground.
- *the number of contact aircraft stands serving the terminal directly (rather than remotely via a coach).* This number of

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

required aircraft stands is represented in lineal metres and this figure is known as the stand frontage. The total stand frontage is therefore the building perimeter required to be made available for adjacent plane parking.
- *maximum walking distance within the terminal.* Set a reasonable maximum walking distance for passengers (IATA suggests 650 metres from the exit of security).

These three parameters will then inform the shape of the terminal footprint. There is also a fourth parameter – limits set by airfield operating parameters such as the obstacle limitation surface and runway approach slopes. This will not necessarily influence the terminal footprint but will set vertical height limits for the terminal. Figure 41.3 describes this process of 'shaping' the footprint.

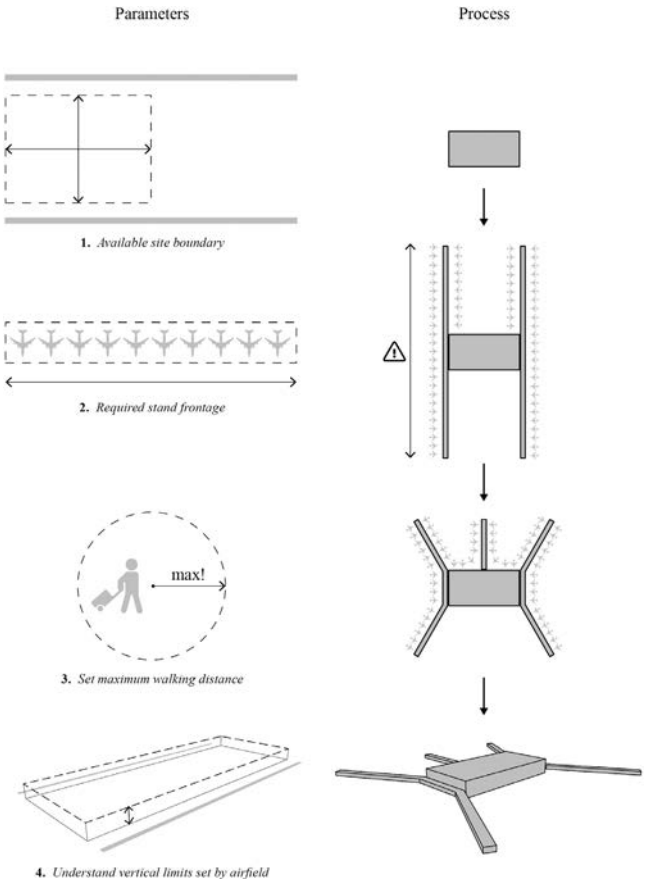
2.10 Configuration of the terminal building

There are however several configuration types possible, both centralised or de-centralised, Figure 41.4. A centralised terminal, Figure 41.5, is where all the main processing functions are located in one zone. In a de-centralised terminal, these functions are distributed along the terminal building or even in separate buildings.

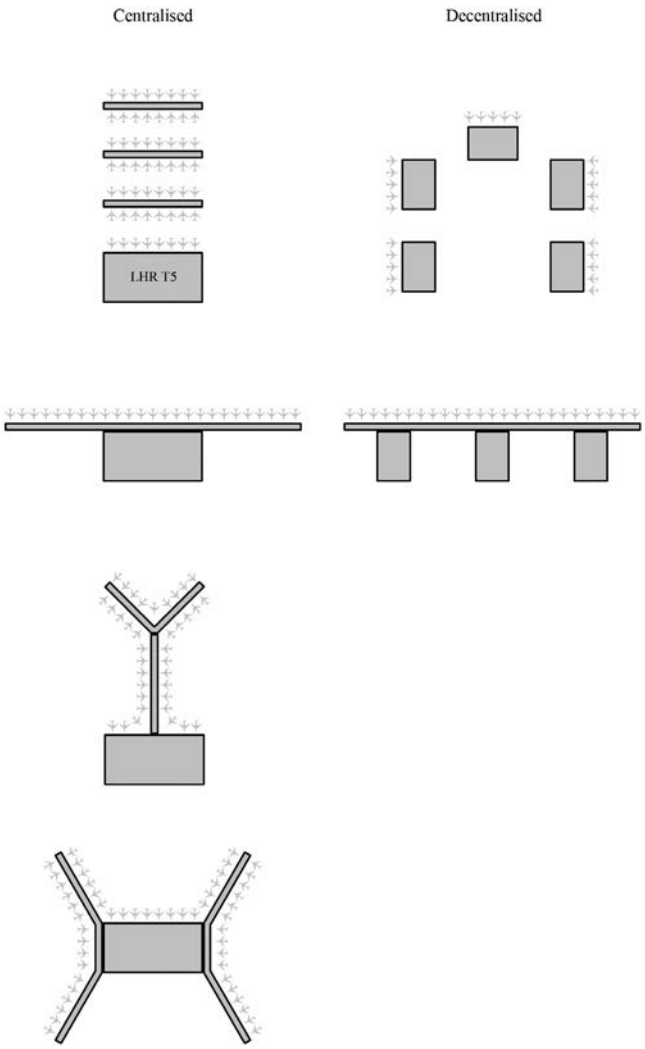
Key factors influencing configuration type may be:

- *Physical space*: space may not be available.
- *Airfield needs*: separating piers from processor may optimise air traffic movements, reducing taxiing distance.
- *Economic:* a large single terminal may be expensive to build but a network of smaller terminals may be more expensive to operate.
- *Flexibility*: the need for phasing and future expansion dependent on passenger forecasts.

Another factor to consider is size. A single terminal building processing in excess of 60mppa will need to be so large that it will be



41.3 *Factors influencing the terminal building footprint*



41.4 *Typical terminal building configuration*

at the limits of operating as a single terminal. The sheer scale of such a building will require passengers to walk very long distances. While this can be mitigated by the use of automated people movers (APM), this can add complexity to the passenger journey. Also, as airports find the need to expand in response to increased traffic numbers, it may be easier in terms of maintaining an uninterrupted operation to build smaller but more terminals.

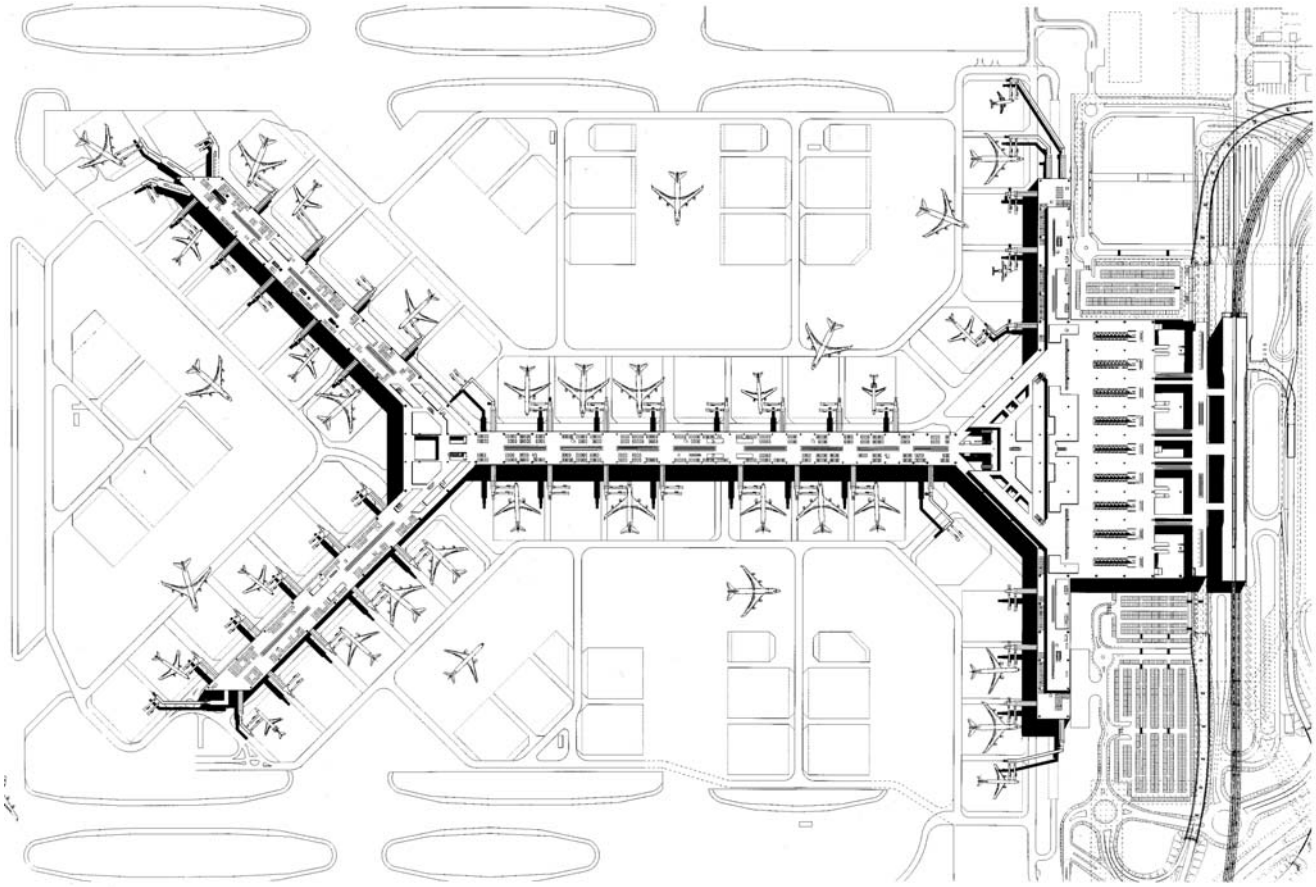
This approach has the benefit, particularly for hub airports, of conveniently accommodating airlines and/or airline alliances in dedicated terminal buildings. This co-location of airlines of the same alliance simplifies passenger wayfinding and greatly assists with reducing transfer times, as most transfers tend to occur within alliances. However, multi-terminal hub airports like Heathrow face the challenge of moving transfer passengers from terminal to terminal, easily and quickly.

Efficient and speedy connection between terminals and the piers served by them is the key to the success of a hub airport, enabling transferring passengers to safely make their onward connecting flight, ideally in as short a time as possible. This Minimum Connect Time (MCT) is key. The shorter the guaranteed MCT, the greater the number and variety of connections with other flights that the passengers will be able to connect to, offering more choice to more destinations.

Finally, it is worth noting that there are three key stakeholders in the running of any airport:

- owner/operator
- airline(s)
- regulator.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



41.5 *Chek Lap Kok airport, Hong Kong (Foster + Partners)*

The relationship between these three may vary from country to country, and its nature and dynamic may also influence the optimum configuration of the terminal building(s).

3 TERMINALS

3.1 A processing machine

Terminal buildings are effectively machines processing two main movement flows; one for passengers, and one for their baggage. Both of these flows move in two opposing directions with departing and arriving (passengers) and outbound and inbound (baggage). In hub airports there is an additional 'cross' flow or re-directed flow, that being for transferring passengers and their baggage.

3.2 Passenger flows

Passenger flows are governed by a series of processes that are required for security and border control, Figures 41.6 and 41.7.

The processes dictate the sequence, direction and order of the flows, but each process also represents a space in which it takes place, and it is the series of these spaces that comprises the complete passenger journey through the terminal building, Figure 41.8.

The adequate sizing of these spaces is critical to accommodate the volume of the passenger numbers so that the flows keep moving and bottlenecks are avoided, and also to provide a degree of passenger experience and comfort.

The exact degree of passenger experience and comfort can vary dependent on the Level of Service (LoS) that is to be provided by a particular terminal.

IATA Airport Development Reference Manual identifies the following Levels of Service:

A Excellent level of service; condition of free flow; excellent level of comfort.
B High level of service; condition of stable flow; very few delays; high level of comfort.
C Good level of service; condition of stable flow; acceptable delays; good level of comfort.
D Adequate level of service; condition of unstable flow; acceptable delays for short periods of time; adequate level of comfort.
E Inadequate level of service; condition of unstable flow; unacceptable delays; inadequate level of comfort.
F Unacceptable level of service; condition of cross flows; system breakdown and unacceptable delays; unacceptable level of comfort.

These Levels of Service translate into space standards and are represented in the form of an area (m^2) provided per person for the major terminal zones, such as check in, security, baggage reclaim, etc. The higher the LoS, the more space provided per passenger.

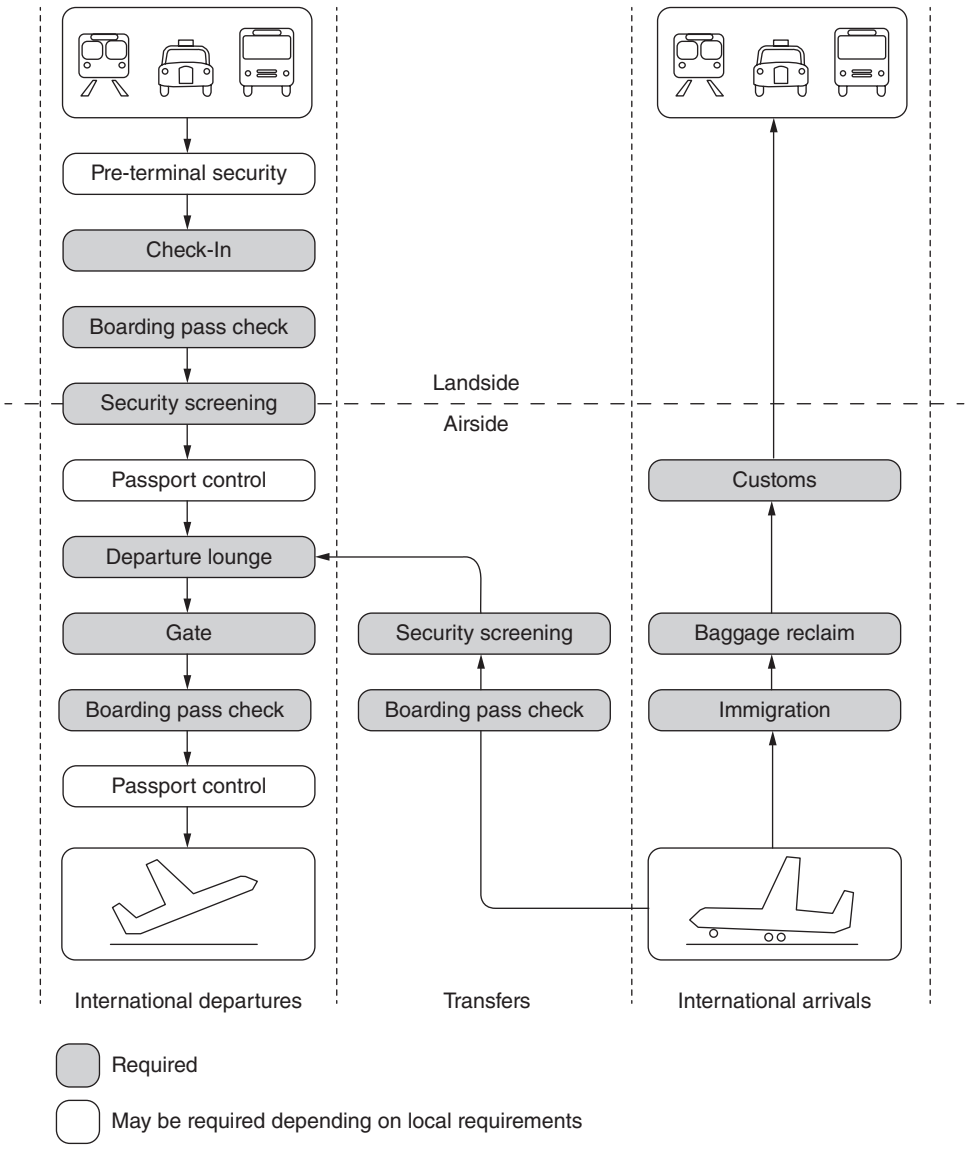
4 DEPARTURES – LANDSIDE

4.1 Departures vehicle drop-off forecourt (also known as kerbside)

Factors to consider:

- *Security*: consider a suitable vehicular bomb-blast stand-off distance for uncontrolled private vehicle traffic. Typically this is 30 m from the terminal façade to the first lane of traffic.
- *Commercial*: the whole forecourt or at least the private car section may be incorporated into the short-term or nearest car park. This will require motorists to pay for the privilege of parking close to the check-in area.
- *Baggage*: baggage trolleys should be available for passenger use. For heavy package tours traffic, with coaches setting down large pre-sorted amounts of baggage, a dedicated area and route to the baggage areas may be desirable.
- *Airline needs*: in large terminals shared by many airlines, signed sections of forecourt may be appropriate.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



41.6 *International passenger process flow*

- *Predicted changes*: allow for predictable changes in traffic mix which may affect the modal split (the percentages of passengers arriving by car, bus, train).

Quantities to be assessed:

- *Hourly passenger flows*: in the case of a combined departures and arrivals forecourt a planned two-way rate will be relevant.
- *Estimated dwell time*: an average of 1.5 minutes may be allowed for cars and taxis.
- *Modal split*: Often influenced by local custom/preference.

Typical space calculation based on 2000 originating passengers/hour:

- Number of passengers/hour at kerbside for cars + taxis: 1000.
- Number of passengers per car or taxi: 1.7.
- Number of cars and taxis: 1000/1.7 = 588 per hour.
- Time spent at kerb by each vehicle: 1½ minutes.
- Number of cars and taxis at one time: 588/40 =16.
- Length of kerb per vehicle: 7 m + 10 per cent.
- Length of kerbside for cars and taxis: 105.6 m.
- Overall rule of thumb: 1.2 m of total kerbside (including public transport) per 10 passengers/hour.

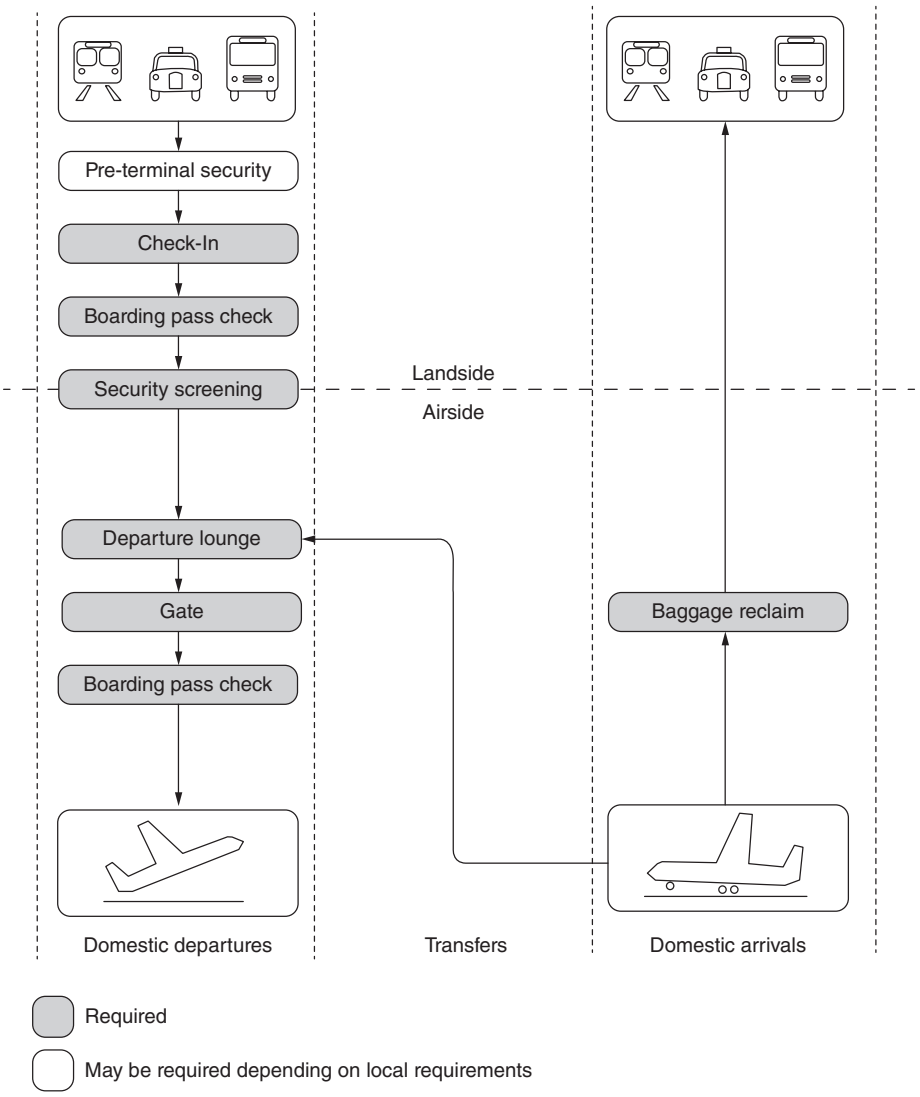
Figure 41.9 describes a typical landside forecourt arrangement.

4.2 Departures concourse

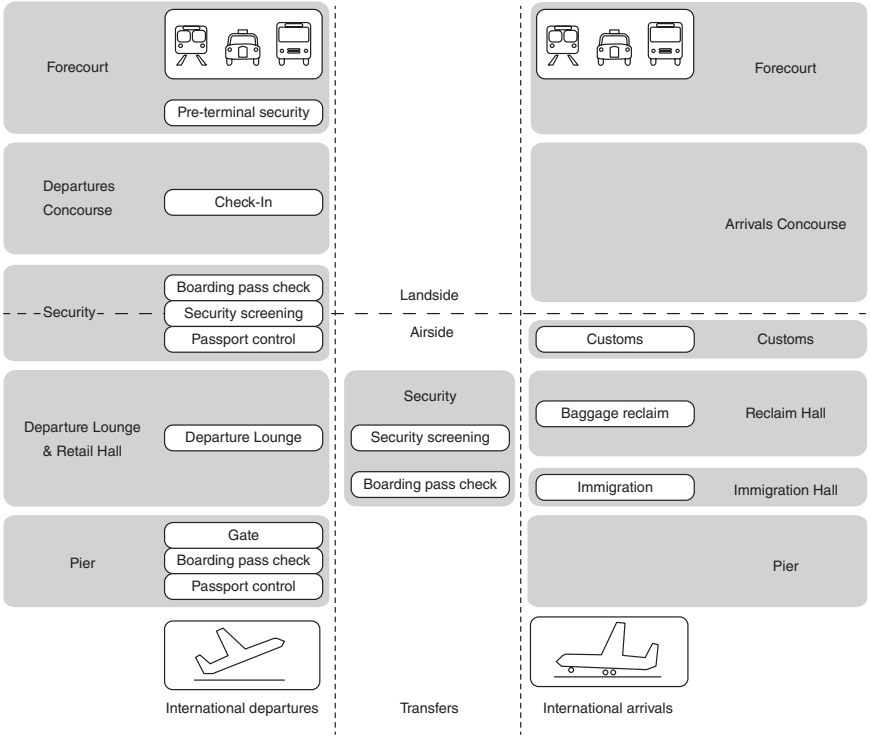
Key factors to consider:

- *Security:* entry to the concourse is generally not controlled but can be via a pre-security check that requires all persons entering the terminal to be searched, both passengers and visitors alike. This is required in some countries, for example Russia, India and Turkey.
- *Commercial*: shopping and catering facilities will be appropriate here, together with bureau de change (international terminal only) and including food and beverage provision for persons not travelling but seeing passengers off.
- *Baggage*: all circulation areas should make allowance for baggage trolleys.
- *Government controls*: access to airside for staff.
- *Airline needs*: airlines require ticket sales desks and offices.
- *Information systems*: public display of information on flights and information desk. There may be an opportunity to provide flight information in the forecourt (if covered) which allows passengers to orientate themselves prior to entering the terminal.
- *Predictable situations*: provision may be needed for exceptional conditions occasioned by delayed flights, with additional seating and extra catering space. This is usually a large food and beverage outlet that is designated for this purpose should delays occur.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

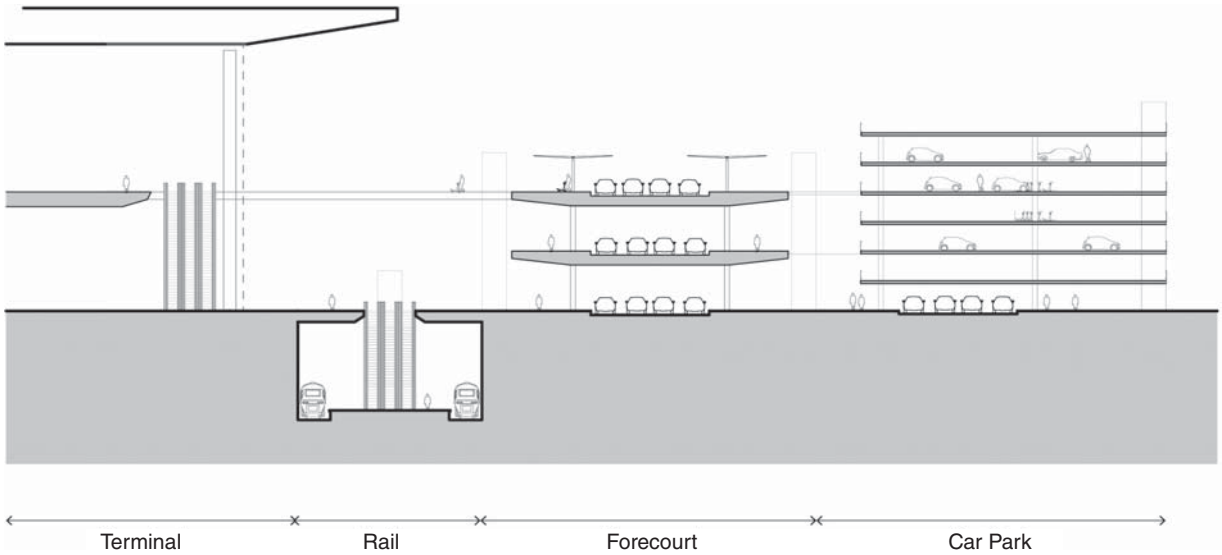


41.7 *Domestic passenger process flow*



41.8 *Passenger process flow and associated spaces*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



41.9 *Typical landside forecourt arrangement*

There are several quantity factors to be assessed:

- Hourly passenger flows: two-way flow will be relevant where there is to be a combined departures and arrivals area.
- Visitor ratio: a common ratio in the West would be 0.5 to 0.2 visitors per passenger (with even lower ratios for certain domestic traffic) but 2.5 to 6 or even higher in the East or Africa.
- Estimated dwell time: a common time would be 20 minutes.

Typical space calculations based on 2000 originating passengers/hour are as follows:

- Number of people per hour: 3000 (0.5 visitors/passenger).
- Number at one time (peaking factor, say 50 per cent in 20 minutes): 1500.
- Space per person: 2.7 m^2 (LoS 'A'); 2.3 m^2 (IATA LoS 'B')
- Area required: 3450 m^2. Some area may be in shops and catering spaces.

4.3 Check-in

Traditionally, at check-in passengers showed their tickets, had seats allocated and if necessary had large items of baggage weighed (and possibly security screened) for registration and loading into the aircraft hold. However, in recent times the check-in process has undergone great change, with most passengers now checking in online from home. This means that many passengers arrive at the terminal having already checked-in and printed a boarding pass with a seat allocated.

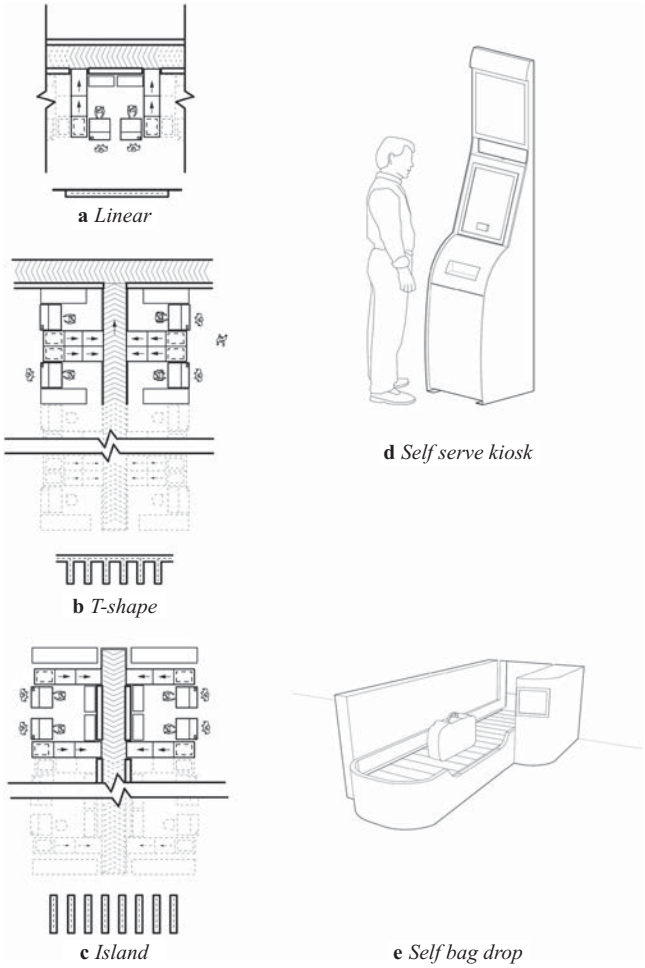
Whereas previously passengers used a check-in counter or desk to do all of the above, the check-in concourse is now generally comprised of a three-part check-in desk option:

- self-service check-in kiosk
- self-bag drop
- traditional (full service) check-in desk.

See Figure 41.10 for the range of check-in options and typical check-in desk types.

Factors to consider:

- *Security:* if pre-security terminal checks are not required (see Section 4.2) then designers must be aware that the materials selected for use in check-in concourse may be subject to bomb-blast criteria.
- *Baggage*: one or more delivery points may be required for out-of-gauge (oversized) baggage.



41.10 *Check-in desk options*

- *Government controls*: a customs check facility immediately after bags are checked-in (prior to the bags entering the baggage system) may be required in some countries (e.g. South Korea). This check may require accommodation for customs officials to remove and inspect bags and interview passengers.
- *Airline needs*: offices for airlines and handling agents will be needed with close relationship with the check-in desks.
- *Information systems*: CUTE (common user terminal equipment) will make it possible to allocate desks to any airline at any time,

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

thereby reducing the number of desks needed. Otherwise the number of desks required is the sum total of those required by each handling agent.
- *Predicted changes*: following automated ticketing and issuing of boarding passes, self-bag-tagging is likely to be the next advance with systems currently in operation in Australia and Ireland, and being trialed in the UK.

There are several quantities to be assessed:

- *Hourly passenger flows*: if CUTE (common user terminal equipment) is in use the total hourly flow to all desks can be used to compute the number. Landside transfer passengers to be included.
- *Processing rate*: commonly about 1.5 minutes/passenger, with faster rates for domestic passengers.
- *Estimated dwell time*: this is dependent upon the number of staffed check-in desks for each flight, but all check-in layouts have to make provision for queuing. Assume a wait of 20 minutes is acceptable to passengers.

A typical space calculation based on 2000 originating passengers/hour with a central check-in is:

- *Number of passengers per hour*: 2000 excluding transfers and including gate check-in numbers.
- *Equivalent number/hour* (peak factor, say 50 per cent in 20 minutes): 3000.
- *Number of desks*: 3000/40 = 76.
- *Queue depth might* be 20 passengers at 0.8 m per person with check-in desks at approximately 2.0m centres.
- *Space per person* (with a high % of trolley use): 2.3m^2 (LoS 'A'); 1.9m^2 (LoS 'B'); 1.7m^2 (LoS 'C').
- *Space per person* (with few trolleys/average 2 bags): 1.8m^2 (LoS 'A'); 1.5m^2 (LoS 'B'); 1.3m^2 (LoS 'C').
- *Total queuing area*: 76 × 2.0 × 16 = 2432 m^2.

4.4 Security control

Factors to be considered:

- *Baggage*: hand baggage only at this point. Allow for sufficient space prior to the security comb for passengers to prepare for the liquid, pastes and gels 100mL compliance. In this area allow provision of plastic bags and counters for re-packing.
- *Government controls*: security control will be the responsibility either of the government or of the airport authority.
- *Airline needs*: some airlines conduct their own additional security checks; often this will be at the gate (e.g. American Airlines for flights to the USA).
- *Predictable changes*: ever-changing regulations in response to the terrorism threat levels make this process susceptible to frequent change. Automation is another area of change. An auto-gate boarding-pass check (similar to a metro turnstile that scans passenger boarding pass and permits entry into the security comb) is being trialed in various airports currently (e.g. Heathrow T5).

Full body scanning is also being introduced. This non-invasive scan occurs immediately upon passing through the metal-detector arch.

Figure 41.11 shows a typical security lane layout.

Quantities to be assessed

- *Hourly passenger flows*: for central security allow for transfer passengers.
- *Processing rate*: X-ray units handle 360 items per hour, with two X-ray units per metal detector archway.
- *Estimated dwell time*: this is not calculable, since a problem item or passenger can rapidly cause a queue to build up. The security check should not unduly interrupt the flow of passengers. In reality staffing levels cannot totally eliminate queuing, and space for a long queue must be provided to avoid obstructing other functions.

Typical space calculation:

- Assume one item of baggage or hand baggage per passenger. One set of equipment consisting of a personnel metal detector and two X-ray units can handle 360 passengers per hour.
- 2000 passengers per hour, excluding transfers, require 6 sets.
- Allow sufficient space immediately after security for passengers to gather their bag, replace shoes, belts and items of clothing that may have been required to be removed as part of the security process.

5 DEPARTURES – AIRSIDE

5.1 Departures lounge

Here passengers wait, shop, eat, drink before moving sooner or later to their flight departure gate. This may mean walking to the gate, or to the people-mover leading to a satellite or the coach station serving remote stands. It may be possible to have an Integrated Departures Lounge (aka IDL) accommodating both international and domestic passengers. If local regulations do not permit this integration, then separate lounges must be provided for international and domestic passengers.

Factors to be considered:

- *Security*: no further security checks will be needed where there is comprehensive centralised security at entry to the airside. Otherwise checks may be made at each gate or entry to a lounge.
- *Commercial*: there will be shopping and catering facilities here, particularly duty-free.
- *Airline needs*: airlines will have specific requirements at the gates. They often have CIP (commercially important passengers) lounges for first-class and business-class passengers.
- *Information systems*: full information on flight numbers, departure times, delays and gate numbers must be provided throughout, but especially at the entries. Take care with the positioning of these to avoid the creation of congestion spots, as passengers will congregate at these screens.

Quantities to be assessed:

- *Hourly passenger flows*: include landside and airside transfers.
- *Estimated dwell time*: commonly about 30 minutes.

Typical space calculation based on 2000 originating passengers/hour:

- *Passengers per hour*: 2000 excluding transfers.
- *Passengers at one time*: 1000.
- *Space per person*: 2.7m^2 (IATA LoS 'A'); 1.9m^2 (IATA LoS 'B'); 2.3m^2 (IATA LoS 'C').
- *Area required*: 2300 m^2. Some may be in shops and catering spaces.

A very simple rule of thumb for approximating retail floor area is:

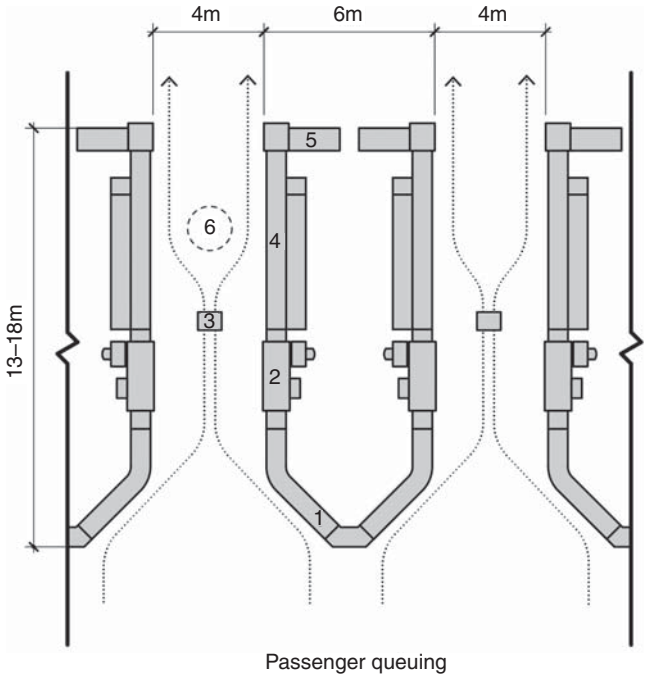
- For every one million passenger per annum (mppa) the terminal expects to process, multiply by this by a range of 300 to 1,000 m^2.

So, a terminal planned to process some 30 mppa will should have approximately between 9,000 to 30,00 m^2 of retail space.

5.2 Gate holding areas

These should be able to hold 80 per cent of the number of passengers boarding the largest aircraft which can dock here:

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



41.11 *Security lane Key: 1 Empty tray collection, 2 X-ray machine, 3 Metal detector, 4 Bag retrieval, 5 Bag Search, 6 Option for full body scan machine*

- *Space per person* (level of service A): 1.4 m^2.
- *Area for 400-seater aircraft*: 320 × 1.4 = 448 m^2.

6 ARRIVALS – AIRSIDE

6.1 Immigration check

Factors to be considered:

- *Security*: none.
- *Government controls*: national policy determines the allocation of separate channels for different passport holders. There may also be checks here for which offices (with viewing platforms), interview and detention rooms will be required.
- *Predictable changes*: changes to border controls within the European Union are an example of the effect of international policy making. The introduction of biometric 'chip' passports has enabled an automated immigration clearance system, not dissimilar to a turnstile system in some airports.
- *Other*: in certain countries (e.g. Gulf States), allow for provision of a visa counter prior to the immigration queue. This permits passengers to purchase their visa on landing.

Layout for a typical immigration desk is shown in Figure 41.12.

Quantities to be assessed:

- *Hourly passenger flows*: include landside transfers.
- *Processing rate*: commonly 0.5min/passenger for departing, 1–1.5min for arriving.

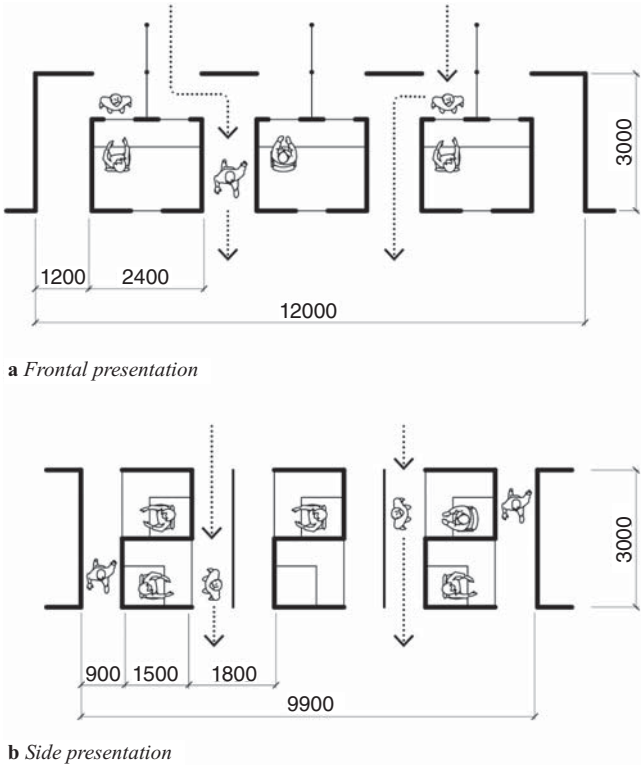
Typical space calculation based on 2000 originating passengers/hour:

- Number of passengers per hour: 2000 excluding transfers.
- Number of desks required: 17 (departing); 50 (arriving).
- Area required: 2.4 m^2 including gangway per desk.

6.2 Baggage reclaim

Here passengers await and reclaim their luggage which has been unloaded from the aircraft while they have been through the terminal and passing through the immigration control.

Factors to consider:



a *Frontal presentation*

b *Side presentation*

41.12 *Typical immigration desk layouts showing a Frontal presentation b Side presentation*

- *Baggage*: some means of delivering outsized luggage to the passengers is required.
- *Information systems*: display the numbers of reclaim units against the arriving flight numbers, particularly where passengers enter the reclaim area.
- *Trolleys*: considerable space will be required for trolley magazines, ensuring all passengers have access to a trolley. Trolley re-circulation should also be considered.

Quantities to be assessed:

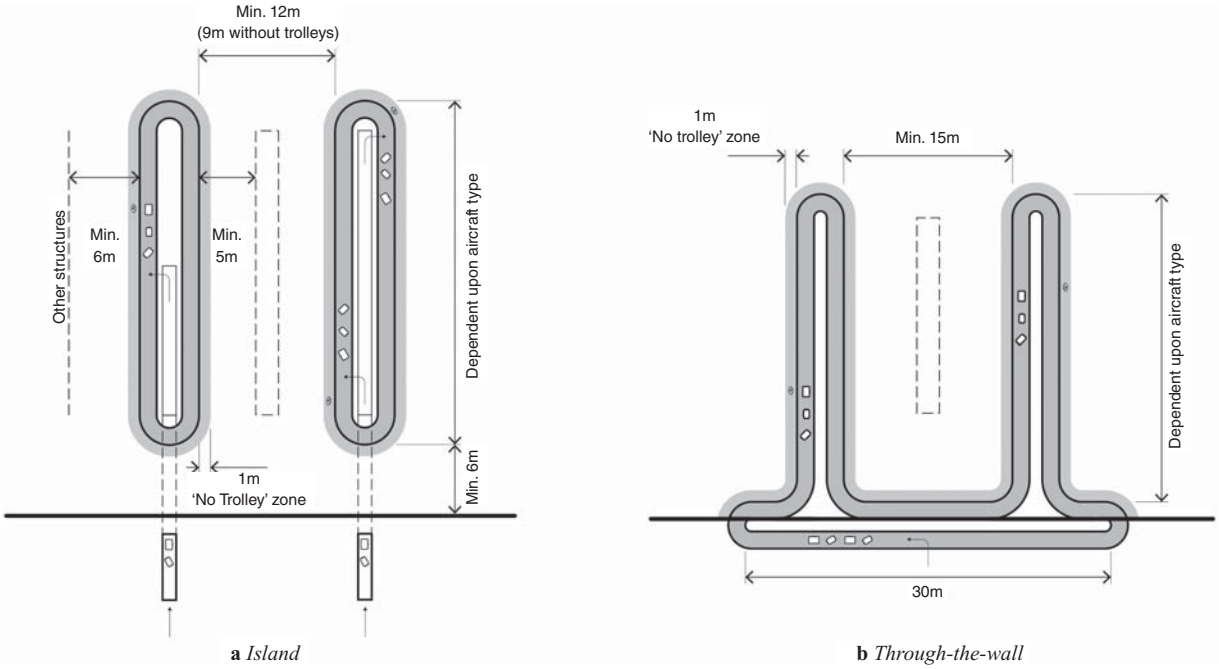
- *Hourly passenger flows*: passengers transferring on the landside need to reclaim their baggage.
- *Processing rate*: there are several ways of calculating throughput in baggage reclaim, but the one used here is from the *IATA Airport Terminals Reference Manual*. Reclaim devices should have a length of 30–40 m for narrow-bodied aircraft, 50–100 m for wide-bodied. Average occupancy times are 20 and 45 minutes respectively.
- *Estimated dwell time*: Commonly about 30 minutes.
- *Number of checked-in bags per passenger*: average 1.0, depending on whether the flight is long haul or short haul, although the flow calculation method used does not depend upon this factor.

Typical space calculation based on 2000 terminating passengers/hour.

The important calculation is for the required number of reclaim units and the space round each for a flight load of passengers waiting:

- *Number of passengers per hour*: 2000 excluding transfers.
- *Number of passengers* per narrow-bodied aircraft at 80 per cent load factor: 120.
- *Number of passengers* per wide-bodied aircraft at 80 per cent load factor: 280.
- *Number of narrow-bodied devices*: 1000 ÷ (3 × 120) = 2.7, say 3.
- *Number of wide-bodied devices*: 1000 ÷ (1.33 × 280) = 2.7, say 3.
- *Space per person*: 2.0m^2 (IATA LoS 'B'); 1.7m^2 (IATA LoS 'C').
- *Waiting area for narrow-bodied device*: 240m^2 (IATA LoS 'B'); 204m^2 (IATA LoS 'C').

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



a *Island* **b** *Through-the-wall*

41.13 *Examples of baggage reclaim belts*

- *Waiting area for wide-bodied device*: 560m² (IATA LoS 'B'); 476m² (IATA LoS 'C').
- *Total waiting area*: 2040–2400m² (excluding central waiting space at entry to baggage reclaim area).

The two main types of reclaim installations are the oval and race-track, Figure 41.13.

6.3 Customs

Factors for consideration:

- *Security*: none specifically. Self-sorting of passengers is now the norm in the EU with passengers selecting one of 3 channels (red, green and blue – red for passengers with something to declare, green and blue being for passengers with nothing to declare, and depends on their originating flight – blue is from the EU, green is from destinations other than EU).
- *Government controls*: offices with viewing windows (one-way), interview and search rooms will be required.
- *Predictable changes*: non-intrusive scanning equipment (e.g. for explosives and/or drug detection) is being introduced in some parts of the world.

Quantities to be assessed:

- *Hourly passenger flows*: include landside transfers.
- *Processing rate*: allow 2 minutes per passenger searched.

Space calculation based on 2000 terminating passengers/hour:

- *Area required* if rule of thumb is 0.5 m² per passenger per hour: 1000 m².

7 ARRIVALS – LANDSIDE

7.1 Arrivals concourse

These are the factors to consider:

- *Security:* none.
- *Commercial*: shopping and catering facilities will be appropriate here, together with onward travel services such as hotel bookings, train tickets, rental car desks etc. Includes food and beverage provision for persons not travelling but meeting passengers and for taxi/private car drivers.
- *Baggage*: allow for trolley drop-off and sufficient circulation for trolley recirculation routes.
- *Government controls*: none
- *Airline needs*: provision of a landside CIP arrivals lounge.
- *Information systems*: public display of information on flights and information desk for meeters and greeters.
- *Predictable situations*: provision may be needed for exceptional conditions occasioned by delayed flights, with additional seating and extra catering space.

Quantity factors to be assessed:

- Hourly passenger flows: two-way flow will be relevant where there is to be a combined departures and arrivals area (e.g. Stansted Airport).
- Visitor ratio: a common ratio in the West would be 0.5 to 0.2 visitors per passenger (with even lower ratios for certain domestic traffic) and in the East or Africa 2.5 to 6 or even higher.
- Estimated dwell time: around 10 minutes for passengers and 30 minutes for meeters and greeters.

Typical space calculation based on 2000 terminating passengers/hour:

- Number of people per hour: 2500 (0.25 visitors/passenger).
- Number at one time (2000/6 + 3000/2): 583.
- Space per person: 2.7m² (IATA LoS 'A'); 2.3m² (IATA LoS 'B').
- Area required: 1340m² excluding retail and food and beverage spaces. These add 20 per cent to the concourse area, making a total of 1608m².

7.2 Arrivals vehicle pick-up forecourt (also known as kerbside)

These are the factors to consider:

- *Security*: consider a suitable vehicular bomb-blast stand-off distance for uncontrolled private vehicle traffic. Typically this is 30m from the terminal façade to the first lane of traffic.
- *Commercial*: the whole forecourt or at least the private car section may be incorporated into the short-term or nearest car park. This will require motorists to pay for the privilege of parking close to the check-in area.
- *Baggage*: drop-off areas for baggage trolleys should be available for passengers.
- *Airline needs*: often a dedicated pick-up area for CIP passengers is required.
- *Predicted changes*: increased premium services such as limousine pick-up and associated waiting lounges are a growing trend.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Quantities to be assessed:

- *Hourly passenger flows*: in the case of a combined departures and arrivals forecourt a planned two-way rate will be relevant.
- *Estimated dwell time*: an average of 1.5 minutes may be allowed for cars and taxis.

8 LEVELS AND VOLUMES

Smaller terminals may be able to accommodate these processes on one level, with departures and arrivals journeys segregated horizontally. However, depending on the number of mppa the terminal building is processing, the processes described in the previous sections may be split horizontally over various levels.

Care must be taken as level changes, whilst improving large volume passenger flows and better accommodating the mix of transfer and destination passengers, do introduce complexity for passenger wayfinding.

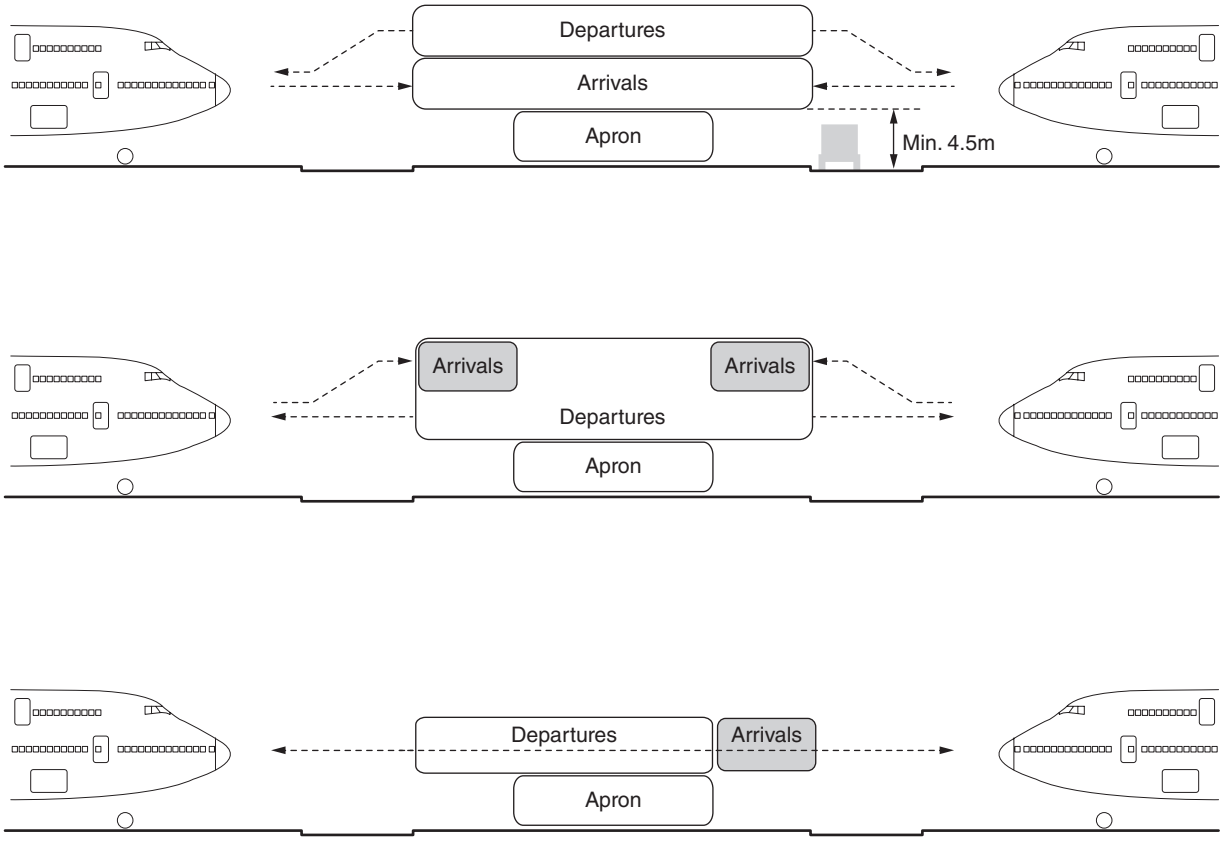
Multi-level terminals do reduce the distance that passengers need to travel and allow for better and more direct access to the aircraft door (typically 4m or more above ground level).

Another key consideration is how to 'stack' the different net passenger journeys; departures above arrivals or vice versa, Figure 41.14. Again, relationship to the aircraft door can be a key consideration.

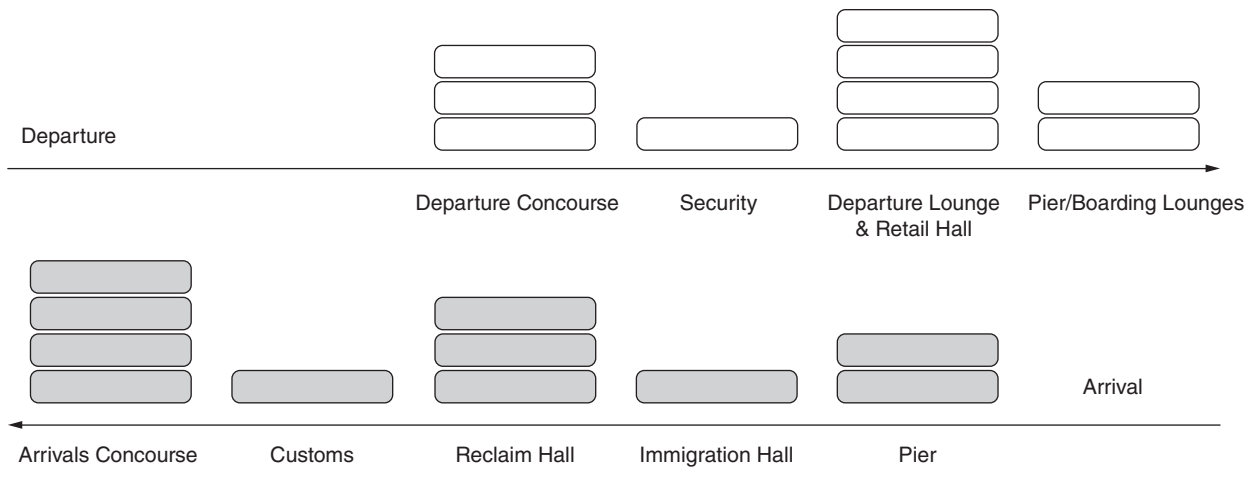
Multi-level terminals also provide the opportunity to exploit the volume afforded by these tall, soaring spaces. Large double-height spaces within the terminal building provide drama, introduce light deep into the lower levels of the building and provide opportunities for a collective enjoyment of these cathedral-like spaces.

Care however should be taken to differentiate the volumetric quality of these spaces based on the process they accommodate, Figure 41.15. Large, soaring halls welcoming passengers at check-in provide real delight and the ideal fond farewell. Again, these large volumes airside, in the retail halls of the departures lounge, afford a generous environment.

However evidence suggests that in areas where security processes are involved, such as immigration, security control and customs, passengers respond better to a more controlled volume, enhancing the feeling that the process is controlled, robust and serious.



41.14 *Options for vertical stacking of passenger flows*



41.15 *Sectional arrangement of volumetric response to the passenger process*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

9 AIRCRAFT AND APRON REQUIREMENTS

9.1 Baggage handling

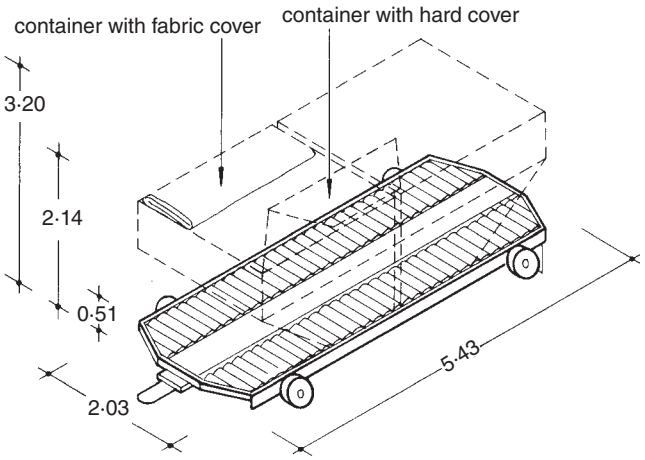
Figure 41.16 shows a container (aka ULD or Unit Load Device) and trailer used to assemble baggage. These trailers are transported hitched to a tug (electric or diesel) and are combined as a 'tug & dolly' combination of one tug and one, two, three or four trailers (i.e. tug plus one, two, three or four). The manoeuvering of trains of these trailers determines the layout of baggage loading and unloading areas.

9.2 Loading bridges

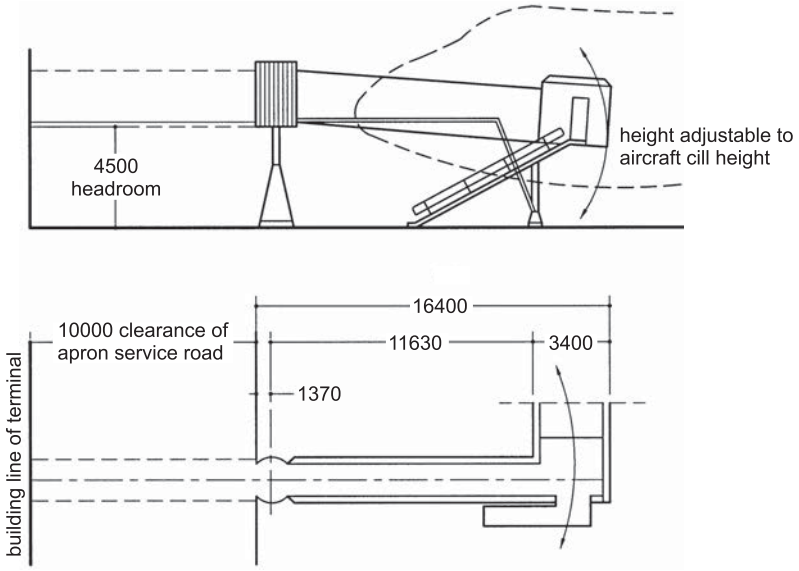
Figure 41.17 shows three types of loading bridges, otherwise known as air bridges, air-jetties or jetways, which connect terminal to aircraft.

9.3 Apron servicing

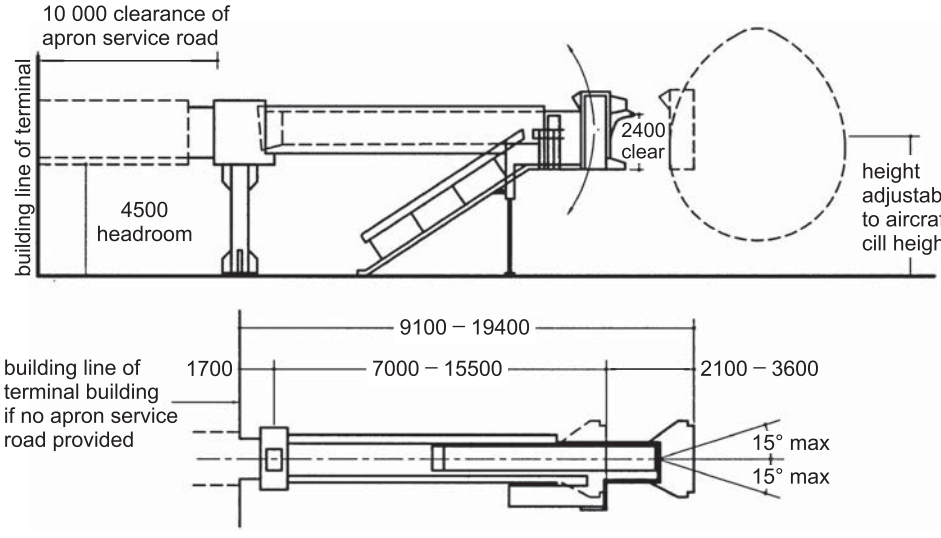
Figure 41.18 shows apron servicing arrangements with all necessary vehicles clustered around a parked aircraft. They determine the space requirement. Alternatively, sub-apron hydrants and power can supply fuel by connection through the loading bridge.



41.16 *Baggage handling transport: double container dolly*



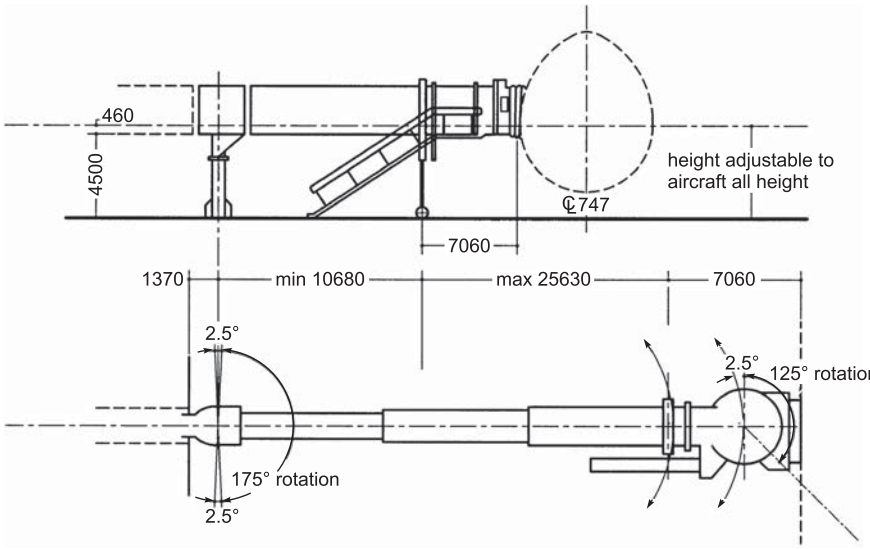
radial drive



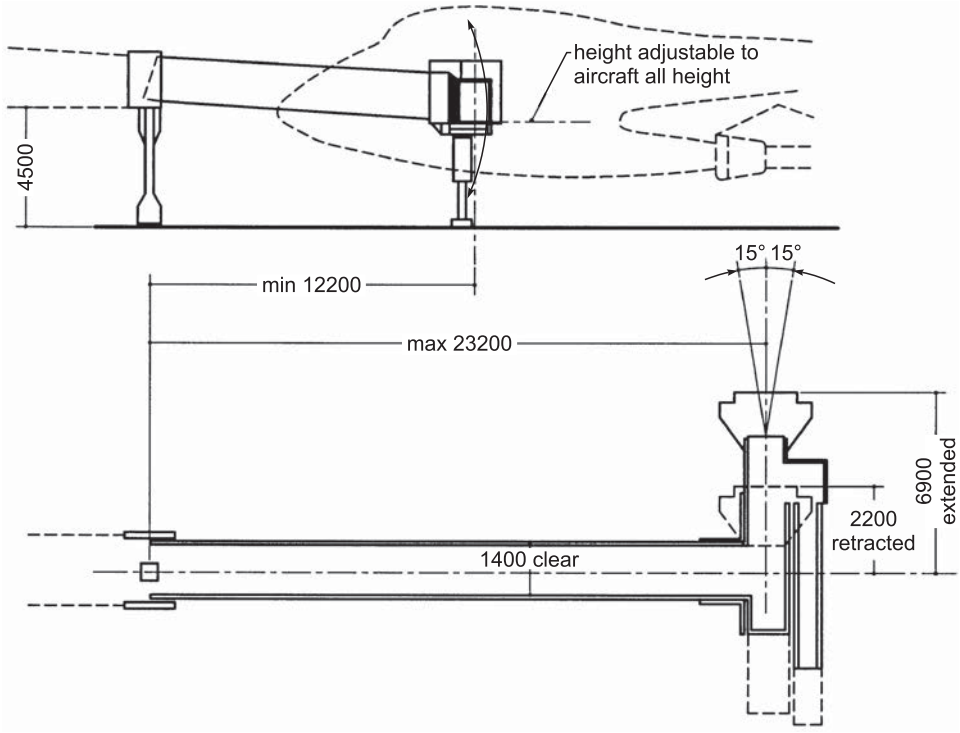
pedestal

41.17 *Loading bridge types: plans and elevations*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



apron drive



elevating

41.17a *Loading bridge types: plans and elevations (contd.)*

9.4 Apron accommodation

Office, workshop, store and staff facilities will be required adjacent to the apron. This accommodation is generally located at apron level as this level is usually not allocated to passenger processes, particularly in stacked terminals (see Figure 41.14).

10 THE CHANGING AIRPORT

10.1 Low cost terminals

Traditional multi-terminal airports are now planning low-cost terminals within their terminal mix, seeking to provide a complete range of passenger options from the one airport.

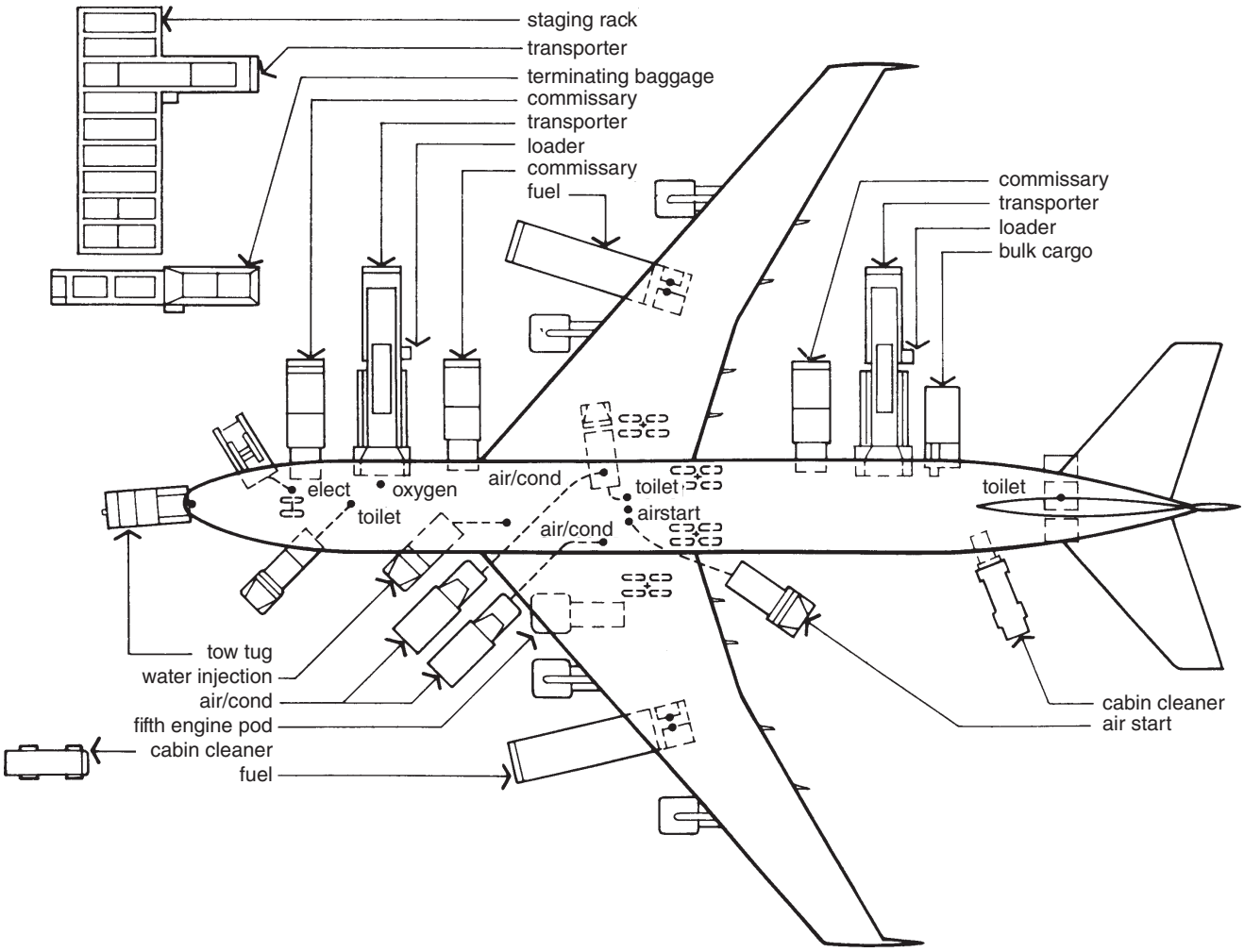
10.2 Airport as a total integrated transport hub

Airports are becoming a centre of gravity, attracting greater numbers of passengers from further afield, and in turn collecting and distributing these passengers both by air, rail, coach and car, internationally, nationally, regionally and locally. Airports are ideally placed to serve as major transport interchanges, serving heavy rail, metro, high speed rail and coach services, acting as an interconnected multi-modal transport hub.

10.3 Airport city

Airports have long been likened to small cities. Heathrow employs some 80,000 people on airport, and it is estimated some 250,000 others in related industries in close proximity to the airport. The very presence of the airport as an attractor makes land adjacent to it valuable. This has led to the advent of the ‘airport city’ with landside commercial and cultural developments supporting hotels, conference centres, and offices, all benefiting from their proximity to a busy hub airport. This proximity is convenient for business passengers who do not wish to have to travel into city centres for meetings, for passengers on longer transits and also for staff.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



41.18 *Servicing arrangements for passenger model Boeing 747-100/200B + C. Under normal conditions external electric power, airstart and air conditioning are not required when the auxiliary power unit is used*

11 CASE STUDY

Pulkovo Airport terminal, St Petersburg, Russia
Architect: Grimshaw

11.1 Introduction

Grimshaw won an international competition to masterplan the expansion of Pulkovo Airport in 2007 as part of a team with Naco, Arup, Buro Happold and Chapman Taylor. The airport is conceived as the gateway to both St Petersburg and Russia and is an expansion of the existing 1950s airport to the south of the city. The first phase completed in 2013 with an annual capacity of 12 million travellers. A second phase will allow the airport to handle 17 million.

11.2 Masterplan

The new, second terminal at Pulkovo is part of the Airport City masterplan which centres on a new sculpture-lined boulevard. This forms the Airport Gateway and is designed to be reminiscent of St Petersburg's wide avenues. The boulevard terminates in a large square that fronts the 1950s old terminal to create a 'heritage quarter'. The new terminal is positioned adjacent to the existing building and can be viewed unobscured on approach from most directions, Figure 41.19. A series of new buildings, known as 'The Wedge', provides a service and business park to the airport.

11.3 Terminal brief

The brief was for a new terminal that responds to the rich cultural heritage of St Petersburg, the geographical location of the airport by the river Neva and the extreme climate of St Petersburg. This is characterised by short, mild periods during the summer and long, harsh winters with heavy snowfalls.

11.4 Design solution

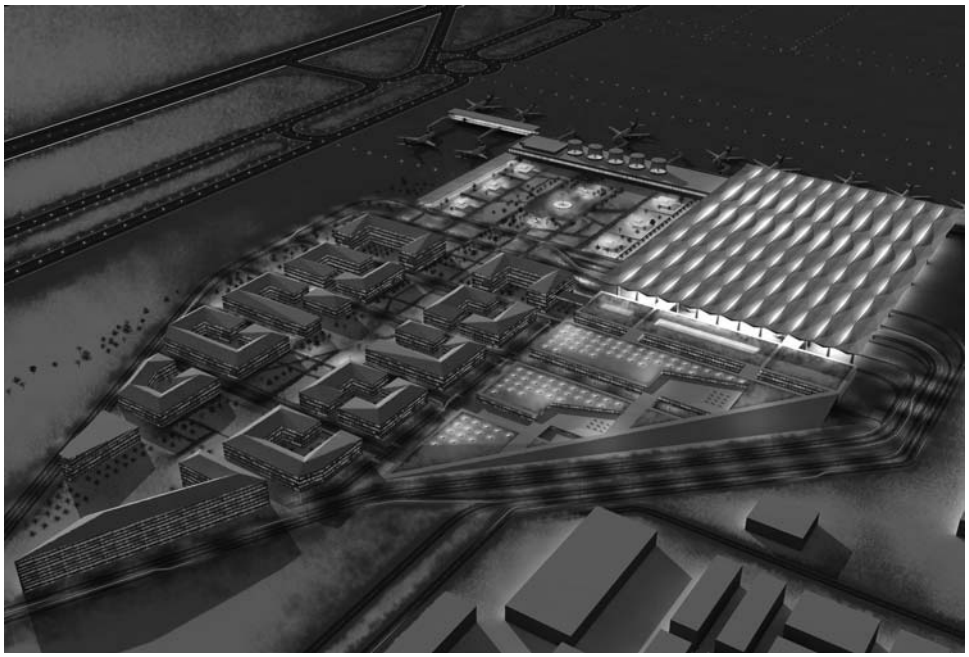
The airport is a single terminal of 110,000 sq m designed over 3 segregated levels, Figure 41.20a. Conceived as the first and last great public space of the city, the terminal's internal layout consists of separate zones connected by individual walkways to echo the external layout of islands and bridges that make up St Petersburg. The new terminal has 88 check-in counters, 110 passport control booths and 7 baggage belts. Restaurants, cafes, bars, duty free, and numerous shops take over 15,400 sq m of the internal space. Arrivals, Figure 41.20b is on the lower level, with departures, Figure 41.20c on the upper level.

The terminal is designed without the usual bias towards departing passengers. Grimshaw's design brings natural light down into the very lowest levels of the arrival spaces, via great skylights over the voids between departure islands above, Figure 41.21. This helps to provide an immediate orientation for the arriving passenger. The arrival areas are designed with exactly the same attention to detail as the departing areas, allowing for the same clarity of progression through the building.

11.5 Roof

The sweeping roof is created from a series of 18m bays, which effectively act as large hoppers, shallow enough not to encourage gathering snow, but deep enough to provide effective drainage. The drains are located directly above the roof's supportive columns to ensure that the greatest snow load is concentrated on the area of maximum structural support. The roof lights are positioned above the datum

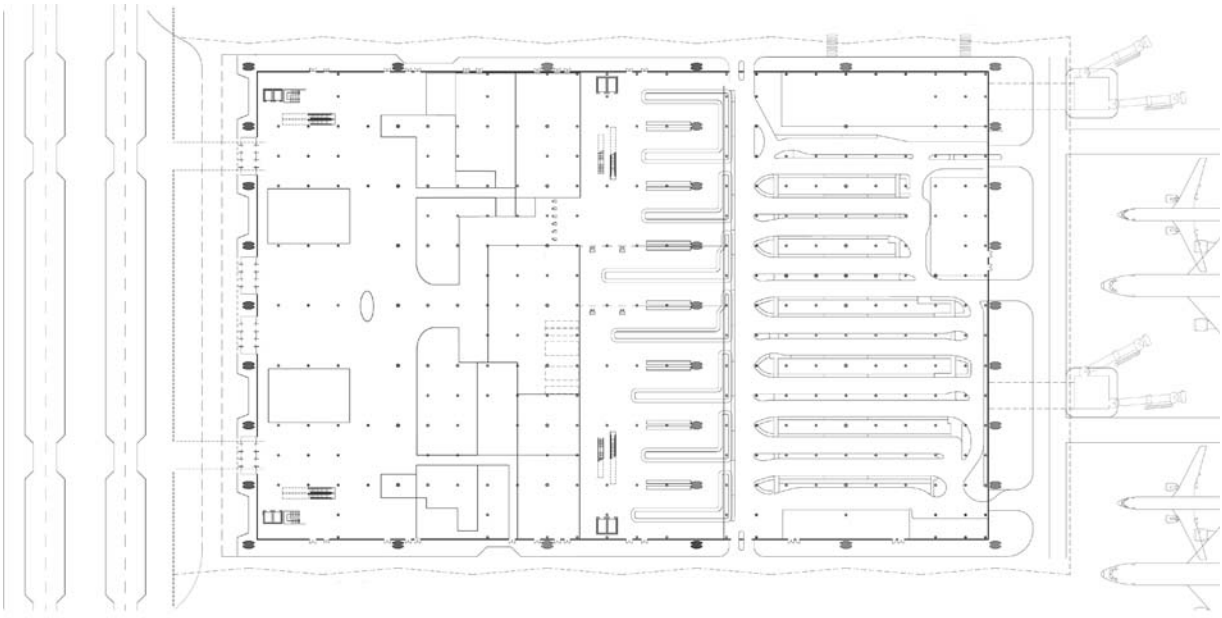
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



41.19 *Pulkovo Airport site with new terminal (right)*



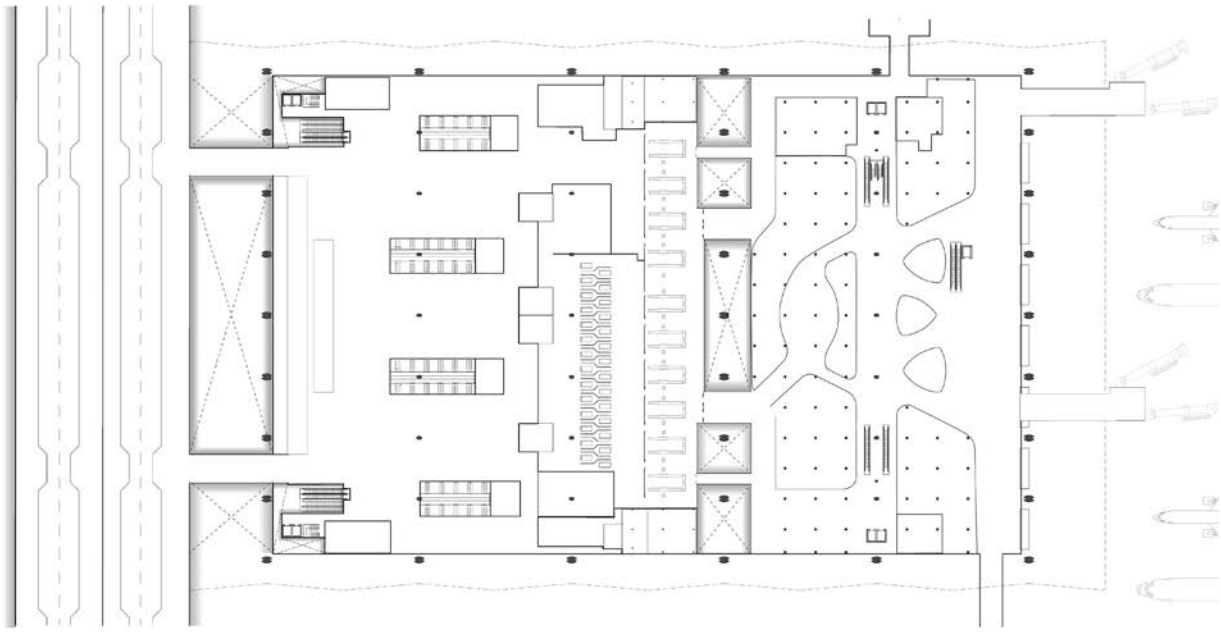
41.20a *Elevation*



41.20b *Arrivals level plan*

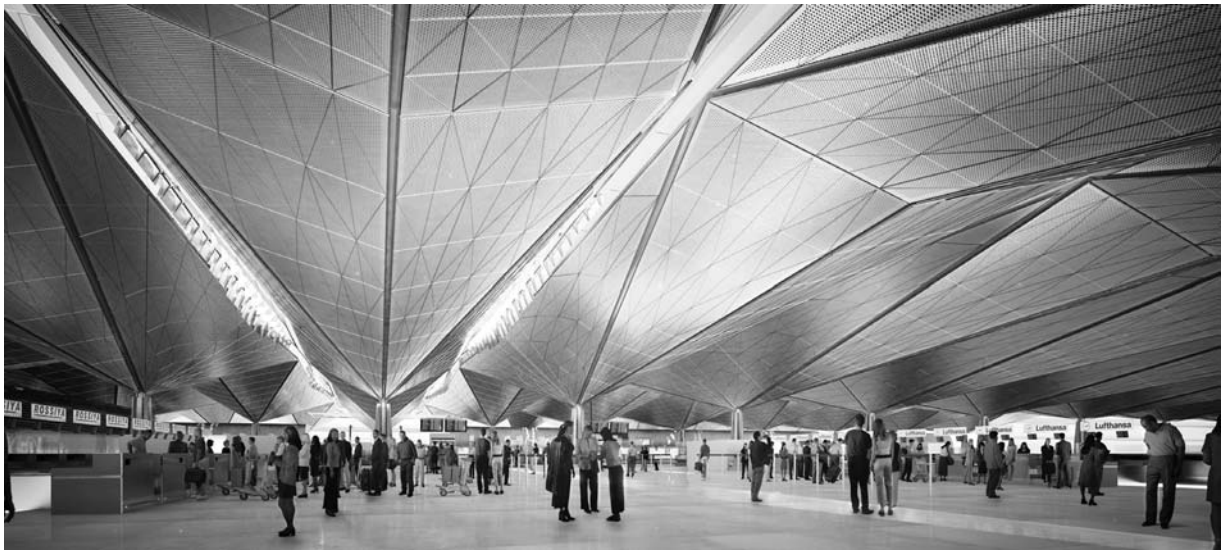
41.20 *Pulkovo Airport elevation and plans*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



41.20c *Departures level plan*

41.20 *Pulkovo Airport elevation and plans*



41.21 *Pulkovo Airport interior*

line to give them the greatest protection from blanketing snow and to enable them to make optimal use of the low angle natural light.

It has a clear span over the landside and airside zones, creating column free, flexible rooms. This flowing structure unifies the new terminal and aids the intuitive direction of passengers throughout.

12 RAILWAY STATIONS

12.1 Introduction

This chapter provides guidance for the design of mainline railway stations only.

There has been a growth in railway station projects in the UK since the 1990s, driven by the increase in demand for rail travel and the ageing of much of Britain's rail infrastructure. Railway stations have complex contextual, constructional, urban design and user requirements and these need to be considered from concept design onwards. Most railway projects also need to consider the civic, cultural, and community impact that a station redevelopment can have on its surroundings. For all railway proposals, designers will need to have a thorough understanding of passenger movement and station operation to ensure that an efficient and functional station layout is developed.

12.2 Operational types

Designers should consider what type of station they are designing as part of the preliminary design. One of the most important factors is how the station will operate, for example, is it a terminus station, a through station or a mixed terminating/through station? Each of these categories has different size and arrangement requirements.

Some operational characteristics are not defined entirely by whether or not services terminate at the station. Some stations, such as Birmingham New Street, have a majority of through platforms, but because of the capacity of the station and the size of the city

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

they serve, operate in a similar way to terminus stations. Designers should use their judgement to determine which of the categories below best describes the particular station under consideration.

Terminus stations
Terminus stations are stations where all tracks stop and there are no through services.

- Almost always located in major urban centres at the end of a particular line.
- Tend to be larger than through stations.
- Concourse tends to be located at the end of the platforms and normally at the same level.
- Passengers tend to wait longer at terminus stations, and are normally encouraged to wait in the concourse rather than on the platforms.
- Normally have more retail facilities than through stations with few, if any, facilities provided on the platforms.
- Onward travel is often onto another type of public transport (bus, metro, taxi etc.).
- Normally accommodate more operational facilities than through stations, including offices for train operating companies; facilities for train servicing, staff accommodation, food preparation, etc.
- Few passengers interchange between platforms at terminus stations.
- Often important and distinctive buildings with a civic and historical importance beyond their transport function.

Through stations
At through stations none of the tracks terminate. Most stations in the UK are through stations, including most smaller suburban and rural stations.

- Normally located in smaller urban centres, in suburbs, or rural areas.
- Tend to be smaller than terminus stations, with less regular train services.
- Normally don't have defined concourse areas, but often have enlarged entrances or wider areas of platforms where retail, ticketing and other facilities are located.
- Passengers normally wait on the platforms.
- Onward travel by private car is proportionally more common than at terminus stations.
- Normally accommodate few, if any, operational facilities aside from those directly associated with the running of the station itself.
- Station entrances are normally located on one side of the station only, with bridge or subway links required to access some platforms.

Mixed-operation (terminus/through) stations
Many stations have a mixture of both terminating and through platforms. They are normally operated in a similar way to through stations, although this depends on the balance of services, the capacity of the station and the size of the town or city served:

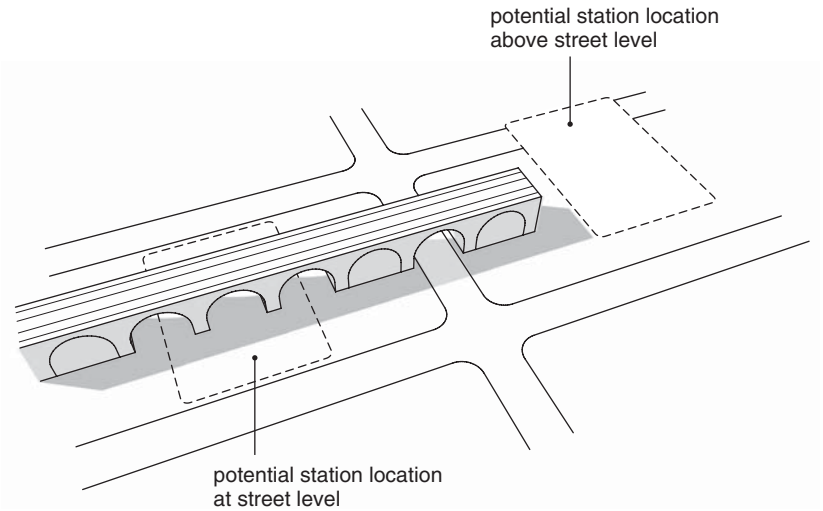
- Rarely located in rural areas, but can be located in towns and major urban centres.
- Vary significantly in size, but tend to be larger than through stations.
- Concourse is generally located at platform level but not always. It is not uncommon for a concourse to be provided at the end of the terminating platforms with a bridge or subway link provided to access any platforms separated from the concourse.
- Most passengers wait on the platforms, although in some mixed stations passengers for terminating services are encouraged to wait in the concourse while passengers for through services tend to wait on the platforms. This is normally dependent on the service frequency and predictability of platform allocation.
- Normally have more retail facilities than through stations with few, if any, facilities provided on the platforms.
- Onward travel is often onto another type of public transport (bus, metro, taxi, etc.), but passengers often complete their journey by private car, particularly in stations outside urban centres.
- May need to accommodate many of the same operational facilities as terminating stations, depending on their location on the network and service pattern.
- Some have significant interchange movements within the station, particularly between through and terminating platforms.

12.3 Rail approach typology

In addition to the station typology, designers should also consider how the station relates to its context. One of the most important factors in determining this is whether the tracks and platforms are located below, level with or above street level.

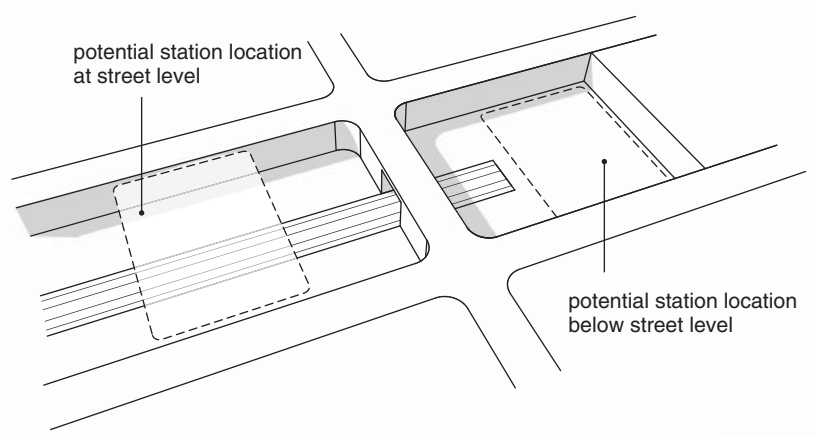
It is customary for the track and platform layout to be determined first in the design process, often by specialist railway engineers. It is important that the constraints the track layout imposes on the remainder of the station design are considered carefully as part of preliminary feasibility studies as they will have significant impacts on how the station operates, passenger movement and how the station relates to the surrounding townscape.

Raised track (viaduct) station (Figure 41.22)
A raised viaduct allows pedestrians and traffic to move freely beneath without having to cross the tracks at grade.

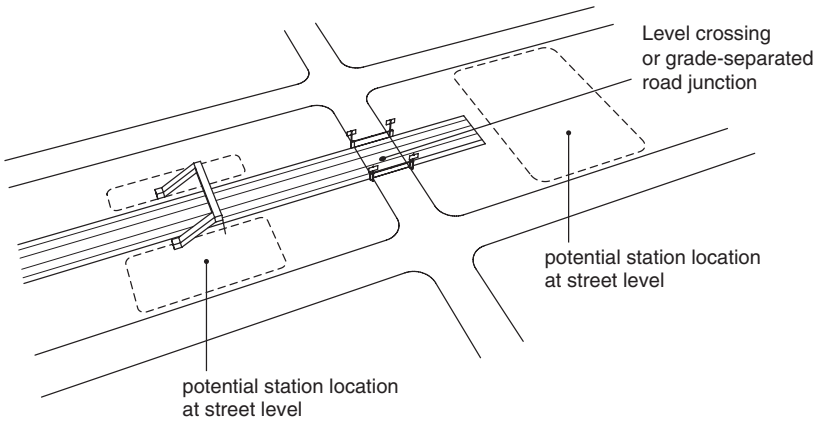


41.22 *Raised track (viaduct) illustrative diagram*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



41.23 *Sunken track (cutting) illustrative diagram*



41.24 *At grade track illustrative diagram*

- More expensive to construct than accommodating tracks at grade but causes less severe severance to streets and less restriction on railway capacity.
- Viaduct is highly visible and can have a negative impact on the quality of the urban or rural environment.
- Can result in an adverse train noise impact on neighbouring buildings.
- Allows a station entrance to be located at street level below the tracks, or above street level at platform height which is less than ideal because the station normally has a poor relationship with the street.

Sunken track (cutting) station (Figure 41.23)
This allows pedestrians and traffic to move freely on bridges above without having to cross the tracks at grade.

- More expensive than accommodating tracks at grade, but causes significantly less severance to streets and less restriction on railway capacity.
- Can still cause severance, particularly in urban areas, but has significantly less visual impact than either a viaduct or an at-grade railway line.
- Mitigates impact of railway noise.
- Allows a station entrance to be located at street level above the tracks, or below street level at platform level (less than ideal because the station normally has a poor relationship with the street)

At-grade track (level) station (Figure 41.24)
Lengthy at-grade railway track approaches to stations should be avoided. Other than in exceptional circumstances, no new level crossings should be built.

- Cheaper to construct than accommodating tracks in a cutting or on a viaduct.
- Likely to result in unacceptable severance to roads and restrictions to railway capacity.
- Significant safety issues associated with level rail crossings across roads, which are considered unacceptable for new railway lines.
- Has no impact on railway noise.
- Station entrances will normally be located at platform level as this allows easy access to both trains and the surrounding streets. For a through station, a platform access bridge will be required to access some platforms.

12.4 Station arrangement

There are a number of factors common to the arrangement of all stations. Most have pay barriers, or gate lines, dividing the areas for passengers with tickets (paid side) from the public areas (unpaid side). Many smaller through stations do not have pay barriers, but their arrangement still separates entrance and ticketing areas (analogous to unpaid side) from platform areas (analogous to paid side).

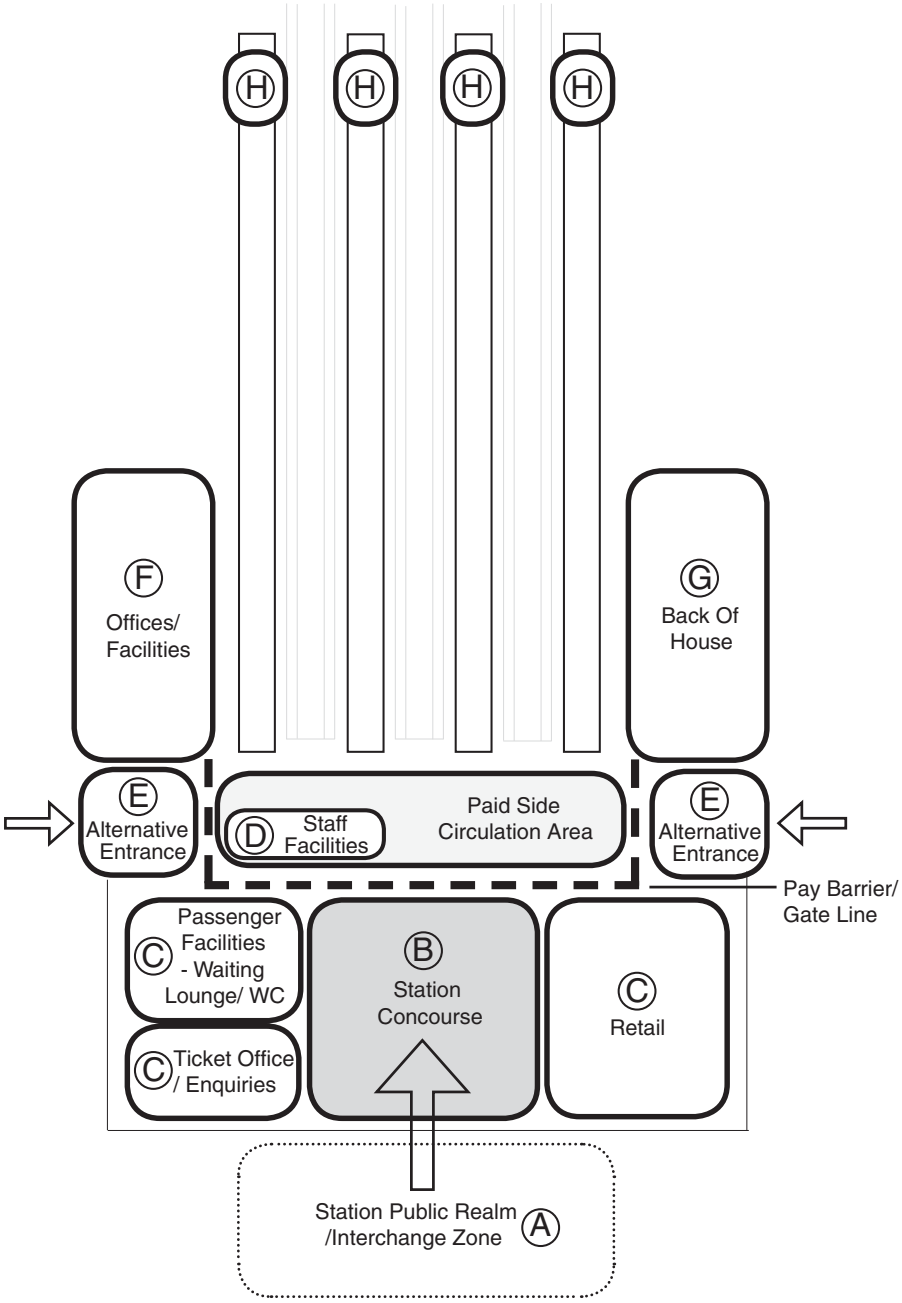
Terminus station arrangement
Figure 41.25 shows an arrangement for the different zones in a terminus station.

Key:

A – The public space in front of a terminus station accommodates a number of important functional requirements for the station. It is normally the place where interchange between the station and other modes of surface transport occur. It allows a space for people to wait and meet, and to orientate themselves before

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



41.25 *Terminus station adjacency diagram*

making any onward journey. It also allows space for passengers to gather safely during an emergency situation or service disruption. It tends to be an important civic space for the town or city itself and designers should consider its urban-scale relationship to its surrounding context.

B – The station concourse normally accommodates information, ticketing and retail. For termini it tends to be a grand space, positioned at the end of platforms. It can also be located above or below the tracks depending on context and railway approach typology.

C – Typically, retail, ticket and enquiries offices, and other passenger facilities such as waiting lounge, toilets, left luggage, etc., are arranged around the concourse.

D – Facilities for staff may be required close to the gate line. This may just be a small secure room in which to rest between work periods, or a larger mess room with kitchen and toilets.

E – Most termini incorporate more than one entrance to the station, allowing easier movement and access to and from the surrounding streets.

F – Termini will normally require facilities for train, rail and freight operating companies. They may also require accommodation for organisations such as British Transport Police, maintenance personnel, and food and beverage suppliers. Needs vary from station to station depending on the operational requirements, but will normally include office space, changing rooms, showers, toilets, mess rooms, etc.

G – Larger stations will also require large back-of-house areas for functions such as train servicing, retail servicing, waste management, food preparation, staff parking, plant, etc.

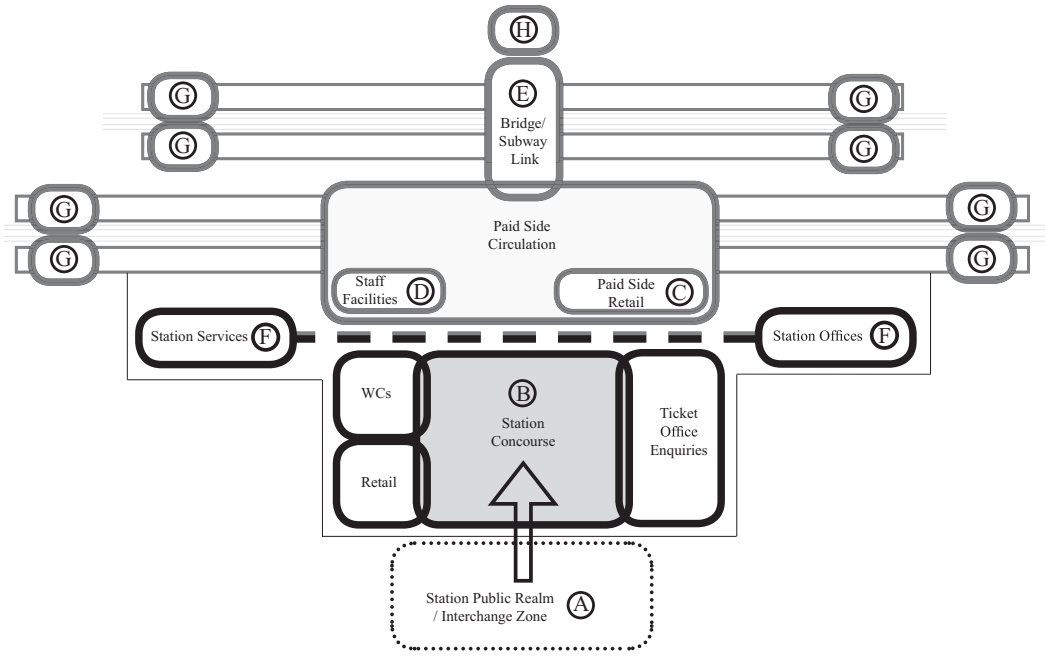
H – Platforms for terminus stations normally house few, if any, passenger facilities. Depending on how the station is operated, it may be necessary to locate accommodation for train dispatch staff or train drivers on the platforms.

12.4.2 Mixed-operation station arrangement

Figure 41.26 shows for the different zones in a mixed operation station.

Key

A – The public space in front of a mixed-operation station is similar in function to that of a terminus station. It doesn't always have the same civic importance as a terminus station's public realm, but designers should still consider its functional, urban and contextual requirements.



41.26 *Mixed-operation station adjacency diagram*

B – Although typically smaller in scale, the station concourse has the same function as that of a terminus station typically positioned alongside the platforms at the same level. It can also be located above or below the tracks depending on context and railway approach typology.

C – Mixed-operation stations may incorporate some paid-side or platform retail.

D – Facilities for staff may be required close to the gate line. This is likely to be a small, secure rest room.

E – To access the through platforms, mixed-operation stations are likely to require bridge or subway access, ideally located close to the gate line, away from congested areas. For new stations, lifts and stairs – as a minimum – will be required to accommodate the level change. If the change is greater than 4 or 5 m, escalators may also be required.

F – Mixed-operation stations will require some space for staff offices and station servicing, but these areas are likely to be much smaller than those provided at terminus stations.

G – Depending on how the station is operated, it may be necessary to locate accommodation for train dispatch staff or train drivers, as well as waiting areas for passengers, on the platforms.

H – Some stations will require an alternative entrance depending on the surrounding areas.

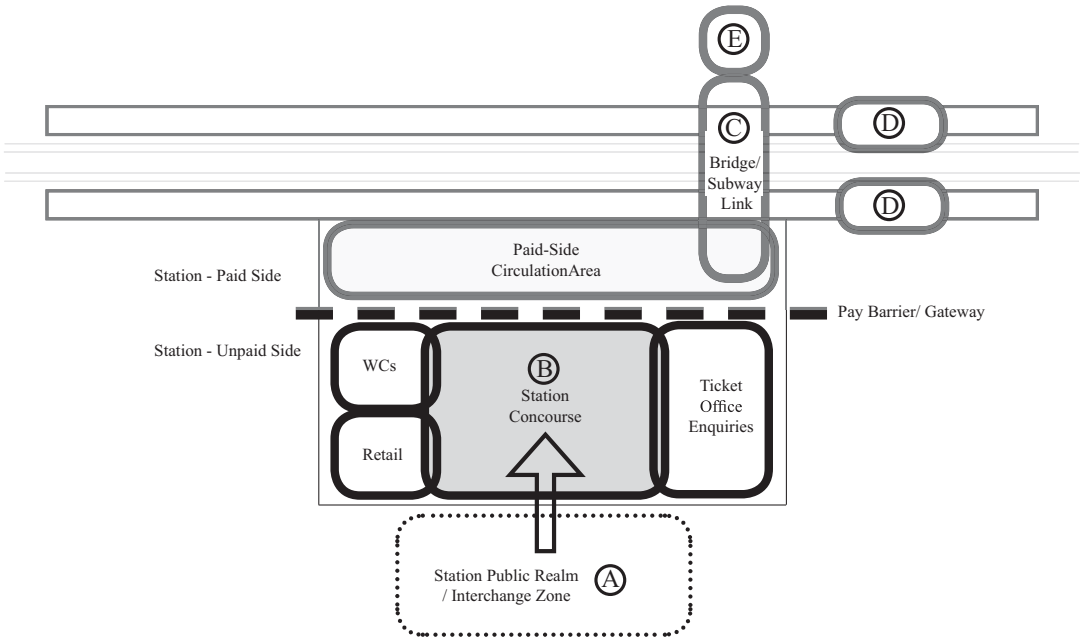
12.4.2 Through station arrangement

Figure 41.27 shows the different zones in a through station.

Key:

A – The public space in front of a through station is similar in function to that of a mixed-operation station.

B – Through stations may just have an enlarged entrance rather than a full concourse, typically positioned alongside the platforms at the same level. It can also be located above or below the tracks depending on context and railway approach typology.



41.27 *Through station adjacency*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

C – To access the platforms furthest from the station entrance, through stations will require bridge or subway access, ideally located close to the gate line, away from congested areas. For new stations, lifts and stairs – as a minimum – will be required to accommodate the level change.
D – At through stations the majority of passengers wait on the platforms, so sheltered waiting areas will be required.
E – Some stations will require an alternative entrance depending on the surrounding area.

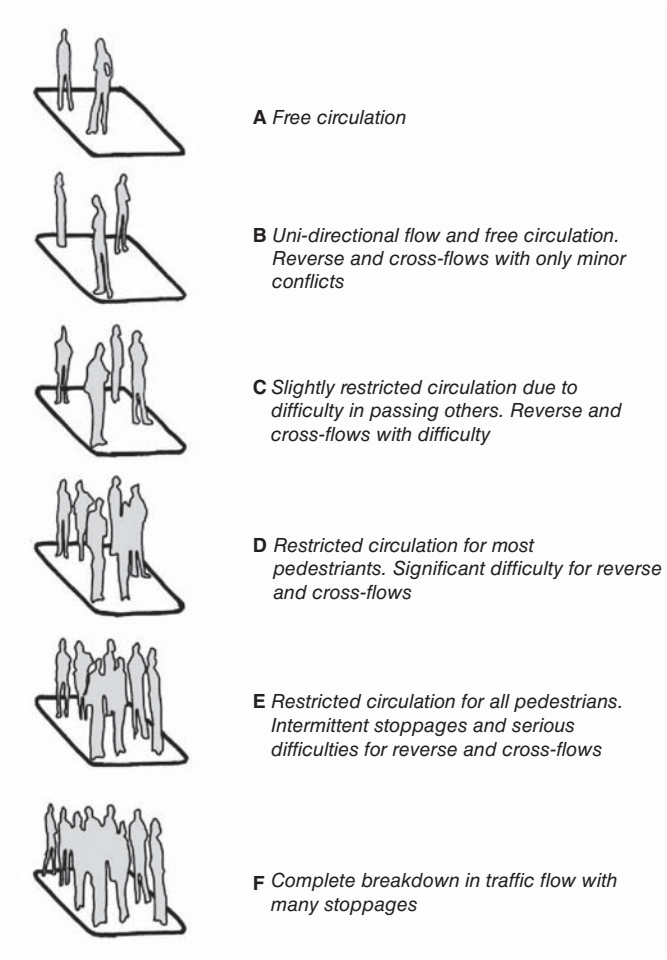
12.5 Passenger movement

Station designs should be based on a thorough understanding of pedestrian movement requirements. The station brief should define the anticipated passenger numbers that the station will need to accommodate, as well as the level of service required. Figure 41.28 illustrates the basic Fruin Levels of Service. The Levels of Service will vary within a station, with more congested areas concentrated close to gate lines, entrances, and vertical circulation areas. Stations should normally aim to achieve a Fruin Level of Service C, but this is not a universal requirement. To prove the design will meet requirements, test using pedestrian flow software.

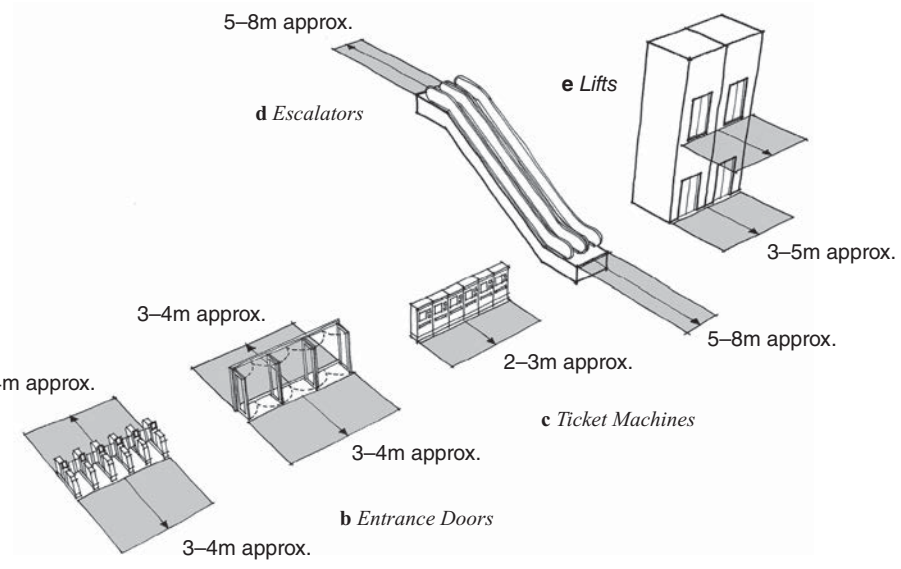
Figure 41.29 shows typical run-off zones associated with station components. When block-planning station accommodation, these zones should be kept clear of main pedestrian routes. The diagrams should be used as approximate guidelines only. They will need to be tested against a full pedestrian flow model to determine whether the dimensions indicated are appropriate for a particular station, The run-off zones are cumulative refer to Network Rail Station Capacity Assessment Guidance.

There are some general passenger-movement principles that can be applied when planning the majority of stations:

- Aim to minimise the number and height of level changes required to move between different parts of the station.
- Where up and down level changes are required along a single route, design the station to have breaks or level areas in between.
- Wherever possible, avoid cross-flows between different passenger movements as this is confusing and causes congestion.



41.28 *Illustrative Fruin Levels of Service*



41.29 *Typical minimum run-off zones associated with station components*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

- Aim to maintain visibility along primary routes from start to finish to promote intuitive wayfinding.
- Minimise changes of direction along primary routes, particularly 180° turns.
- Position bridges and vertical circulation to distribute passengers evenly along platforms, to minimise journey times and congestion.

12.6 Platform dimensions

Figure 41.30 shows some typical platform dimensions for a two-sided island platform. To determine accurate platform dimensions, designers will need to take account of the rail layout, the passenger movement requirements and the size of elements that need to be located on the platform. Designers will also need to consider the space required by the train when in motion, known as the kinematic envelope. Reference should also be made to *Accessible Train Station Design for Disabled People: a Code of Practice*.

Key

A – Zone to be kept clear of structure, furniture and other obstruction. Dimension depends on speed of trains. Refer to the Network Rail *Track Design Handbook NR/L2/TRK/2049.* As a rule, nothing requiring maintenance or access such as lights, speakers, cameras etc. should be positioned within the vertical zone 1.25m from the platform edge.

B – The central platform zone should be designed to accommodate passenger numbers as well as any platform structures and vertical circulation. Platforms often vary along their length and taper towards their ends to respond to track alignment. As a guide, island platforms tend to have a typical width of between 8 and 12 m.

C – This dimension should be calculated from the dimensions associated with the kinematic envelope of the relevant trains, with allowance made for passing clearances. Refer to the Network Rail *Track Design Handbook NR/L2/TRK/2049.*

D – Dimension between running edge of rails.

E – Dimension varies depending on the kinematic envelope of the relevant trains and the stepping distance required by different train designs. Refer to the Network Rail *Track Design Handbook NR/L2/TRK/2049.*

F – Height above rail for 25kV 50Hz electrification systems. Additional height may sometimes be required. Refer to the Network Rail *Track Design Handbook NR/L2/TRK/2049.*

G – Dimension from top of running rail to surface of platform. Refer to the DfT Accessible Train Station Design for Disabled People: A Code of Practice

H – Minimum clear height above platform. Any signage or lighting should be clear of this zone.

I – Additional height is required above the platform edges with overhead electrified lines. This dimension is for primary Inter-City routes. It may be possible to have tighter clearances on other routes, or where there is no overhead electrification. Refer to the Network Rail *Track Design Handbook NR/L2/TRK/2049.*

13 BUS AND COACH STATIONS

13.1 Location

A bus station is an area away from the general flow of road vehicles, which enables buses and coaches, to set down and pick up passengers in safety and comfort. The best locations are near shopping centres or other transport terminals.

Two particular trends have affected urban bus and coach operations:

- one-driver buses for economy;
- deregulation with new companies with new operating methods and equipment such as minibuses.

13.2 Vehicles

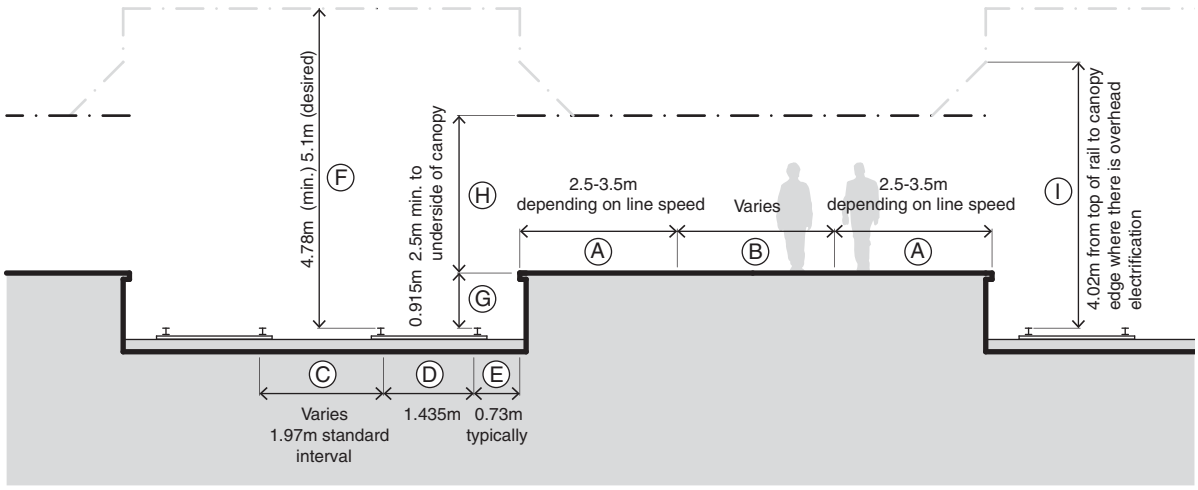
A variety of bus and coach types are now used, Figures 41.31 to 41.33. Turning dimensions are shown in Figures 41.34 to 41.36. A kerbside bus stop in a lay-by is shown in Figure 41.37. Overall length is $A + n\,B + C$, where n is the number of buses to be accommodated. So for one stop 44.6 m, two stops 56.8 m and three stops 69 m.

13.3 Factors affecting size of station

Apart from the physical site constraints, station size is governed by the following:

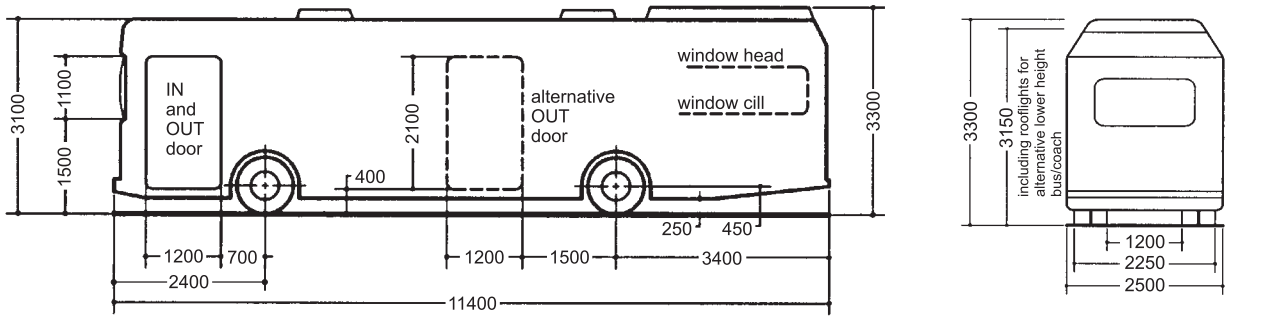
- *Number of bays to be incorporated* (the term bay is used in bus stations instead of bus stop), determined by the number of services operated from the station; and by how practical it is, related to the timetable, to use each bay for a number of service routes.
- *Vehicle approaches to the bays*. Three types of manoeuvre are used, Figure 41.38. The 'saw-tooth' is further explored in Figures 41.39 and 41.40.

The choice of manoeuvre will be influenced by the size and shape of the available site, the bus operators' present and anticipated

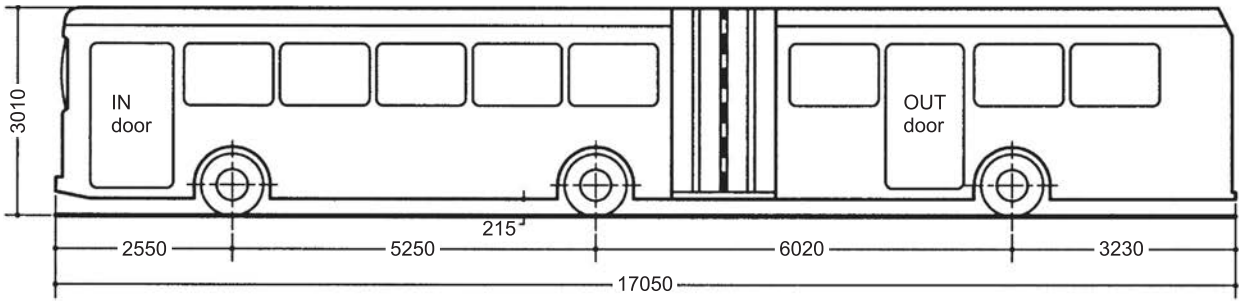


41.30 *Two-sided island platform section*

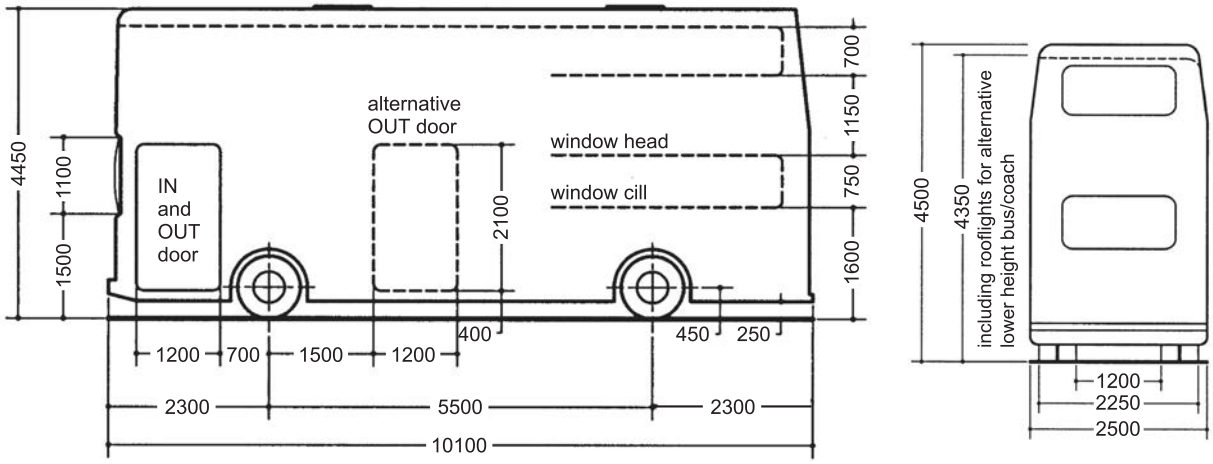
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



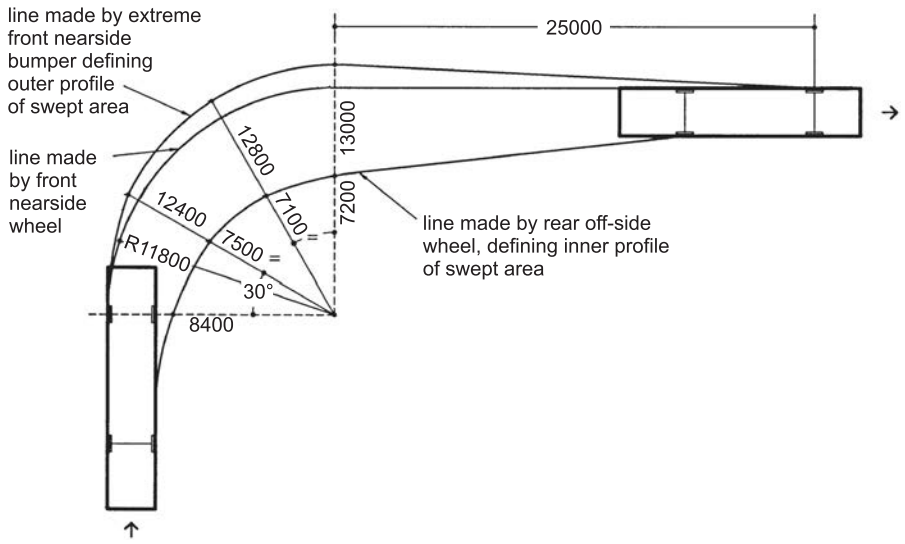
41.31 *Single-decker bus*



41.32 *Articulated bus*

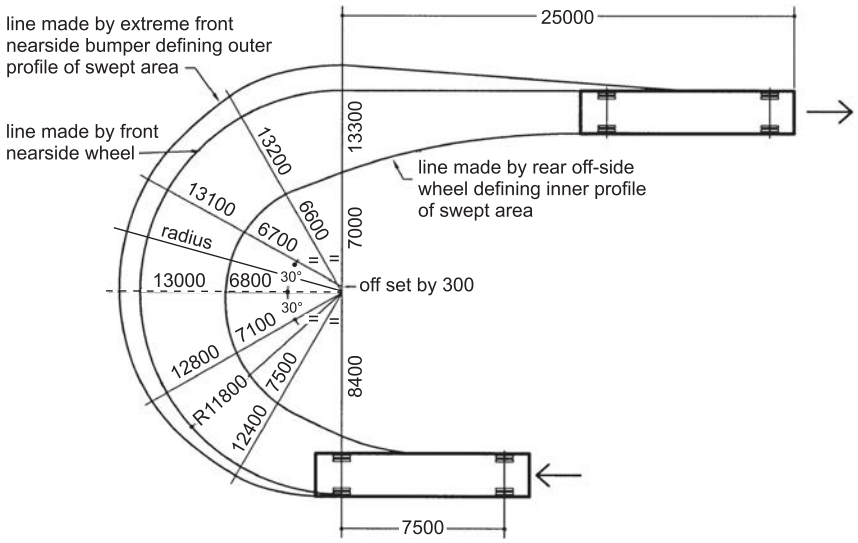


41.33 *Double-decker bus*

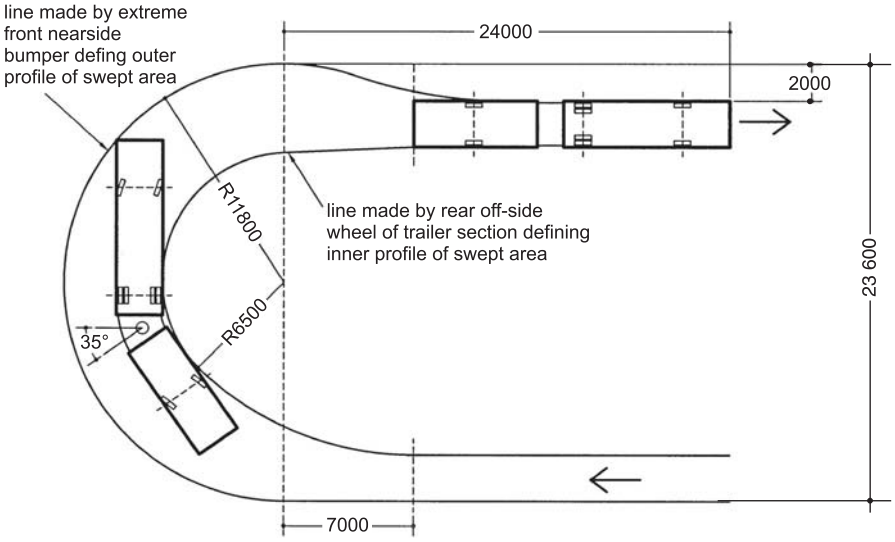


41.34 *Rigid 12 m vehicle turning through 90°*

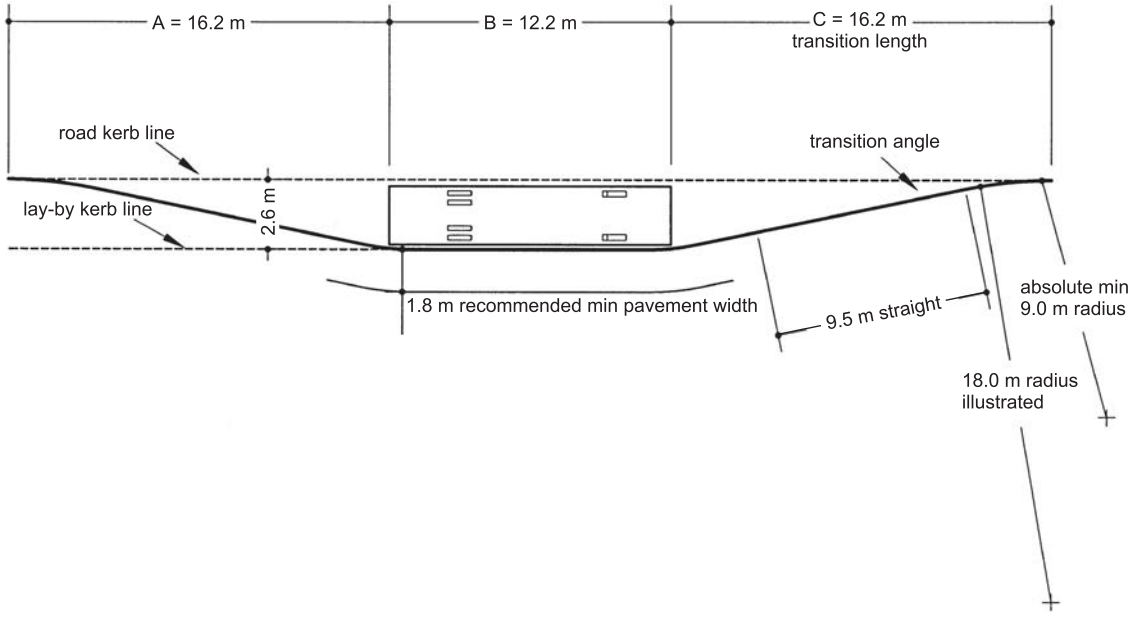
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



41.35 *Rigid 12 m vehicle turning through 180°*

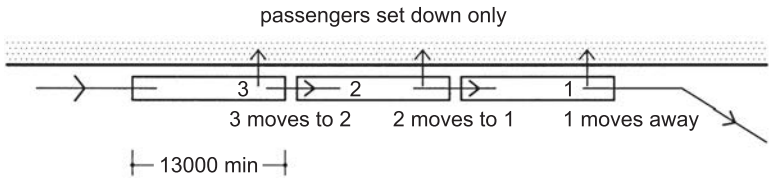


41.36 *17m articulated vehicle turning through 180°*

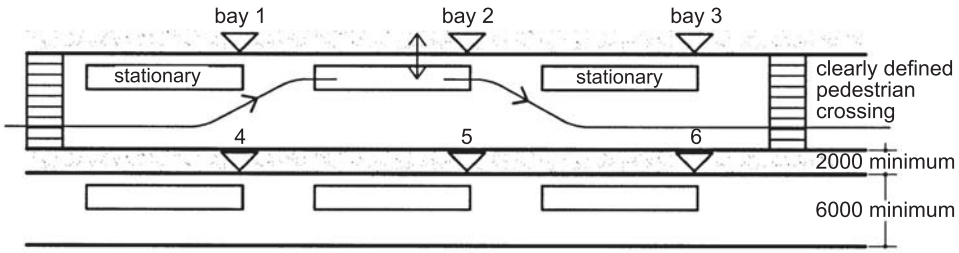


41.37 *A lay-by with one bus stop, assuming normal urban speed of approach. The transition length of 16.2 m is the minimum for a 12 m rigid vehicle. Three bus stops is the desirable maximum in a lay-by, the maximum comfortable distance for a passenger to walk*

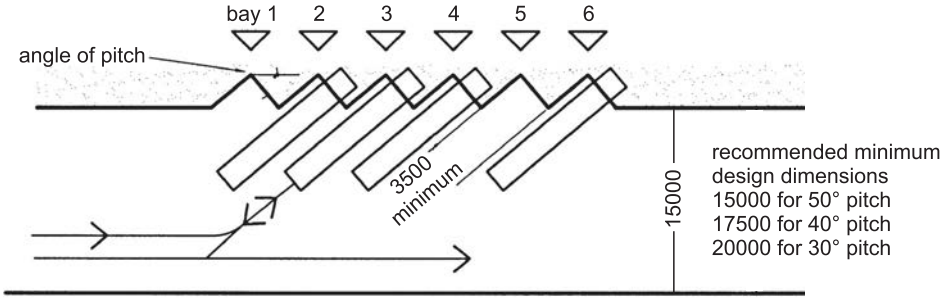
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



41.38a *Shunting, where a vehicle only sets down passengers on the concourse before moving off to park pick up more passengers. This avoids waiting to occupy a pre-determined bay, and reduces effective journey time*

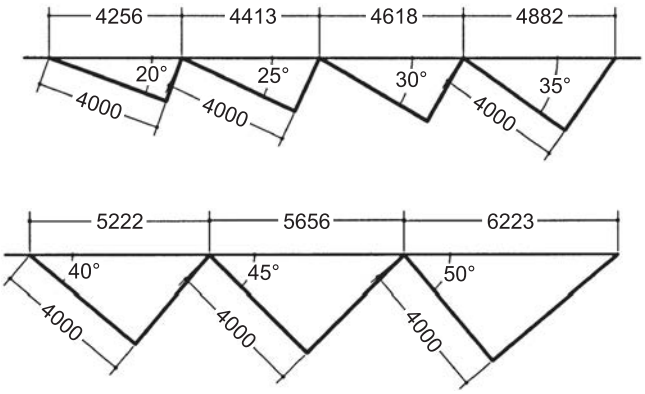


41.38b *Drive-through bays are fixed positions for setting down and/or collecting passengers. They are in a line, so a vehicle often has to approach its bay between two stationary vehicles. In practice it is often necessary to have isolated islands for additional bays, with the inevitable conflict between passenger and vehicle circulation*

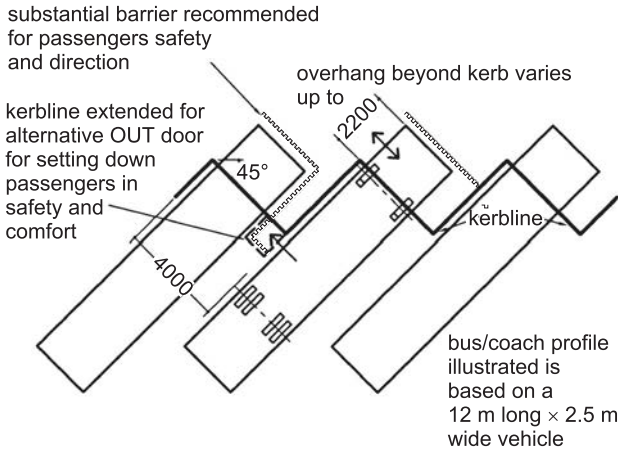


41.38c *'Saw-tooth' layouts have fixed bay positions for setting down and/or collecting passengers with the profile of the concourse made into an echelon or saw-tooth pattern. In theory the angle of pitch between the vehicle front and the axis of the concourse can be anything from 1° to 90°; in practice it lies between 20° and 50°. The vehicle arrives coming forward, and leaves in reverse, thus reducing the conflicts between vehicle and passenger circulation, but demands extra care in reversing*

41.38 *Vehicle manoeuvres used in approaching parking bays*



41.39 *As the angle of pitch in saw-tooth bays increases so does the distance between each bay*



41.40 *Passenger safety and control are particularly important when detailing saw-tooth bays*

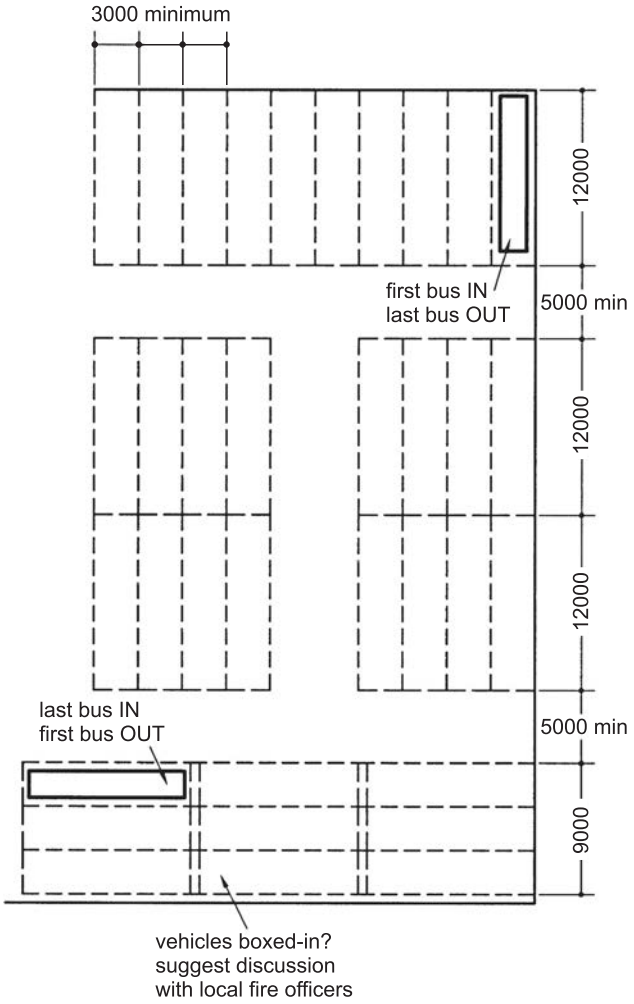
needs, and in particular the preference of their staff. Some will accept the saw-tooth arrangement while others prefer the drive-through.

The required area of the site is further increased by the need for lay-over. This is when vehicles are parked after setting down passengers, but which are not immediately required to collect more passengers. The layout for this should be as for parking, Figures 41.41 and 41.42, preferably so that no vehicle is boxed in or interferes with other bus movements.

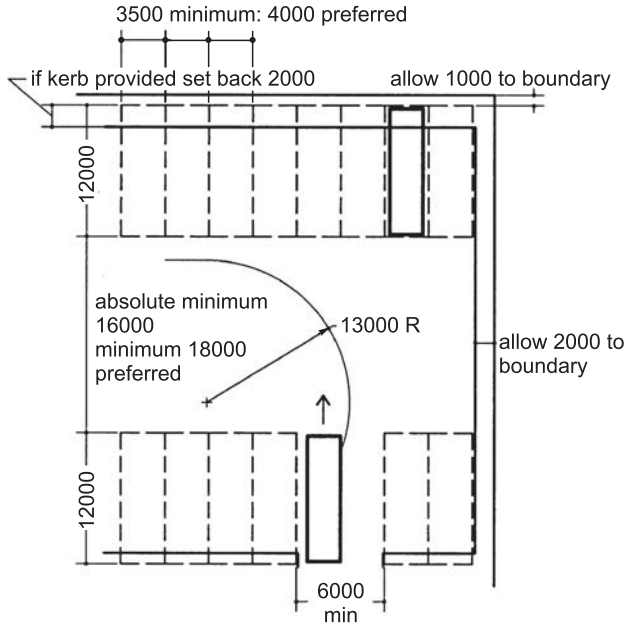
Economy of space may be achieved, again dependent upon timetables, by using spare bays for lay-over purposes.

Facilities for passengers: these will depend entirely upon anticipated intensity of use and existing amenities. If, for example, there are already public toilets, a bus and coach information centre and

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



41.41 *Bus garaging layout for where the buses are parked in a pre-determined order to get the maximum number of buses in the available space, subject to the fire officer's limitations*



41.42 *Coach park for random arrival and departure of vehicles. The larger bay size (4 m) is necessary if coach parties enter and leave the coaches in the park*

cafes nearby, then these will not be required on the station concourse. However, waiting room facilities may be required with someone on hand to give information and supervision. In more comprehensive schemes consider:

- waiting room
- buffet
- public toilets
- kiosks
- enquiry and booking
- left luggage
- lost property.

Facilities for staff: there are invariably inspectors who, as well as assisting passengers, are primarily concerned with organising the movements of vehicles, and supervising their drivers and conductors. If there is a depot near the station then staff facilities will be provided there. If not, canteen and toilets facilities will be needed for staff on the station site, so that during breaks and between shifts they do not need to get back to the depot until they return their vehicle for long-term parking. Should the depot be even more remote, all facilities should be provided at the station and only basic amenities at the depot. In addition to those listed above these include a recreation area, locker rooms and a facility for paying in takings. This would be an office where drivers or conductors check, then hand over monies taken as fares, which in turn are checked and accounted for by clerical staff. Secure accommodation for any cash that cannot be immediately banked will be needed.

Facilities for vehicle maintenance: the inspection, repair and servicing of buses and coaches is an integral part of an operator's responsibility. Normally such work would be carried out at a local depot, with a repair workshop together with fuelling, washing and garaging facilities. The provision of any such facility within a station complex is unusual, but not unique. For a new town bus station or one where it will be difficult and time consuming to drive to and from the station and depot because of traffic congestion, it would be advantageous to provide at least a workshop.

13.3 Planning

Whatever facilities are to be provided on the station site, the final arrangement must be carefully planned, Figure 41.43.

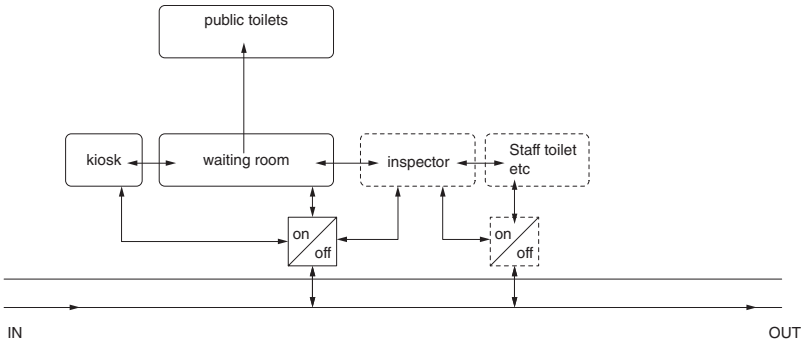
13.4 Joint company use

If two or more bus and coach companies operate from the same station, this can mean that different types of vehicle manoeuvre are used on one site. Figure 41.44 is based on a proposal for a new station within a centre-town commercial development in the south-east of England, and illustrates this. The predominant company (which is a local one) favoured the saw-tooth layout, while the other preferred the drive-through arrangement. Full use has been made of a restricted site, and conflict between passenger and vehicular circulation has been minimised.

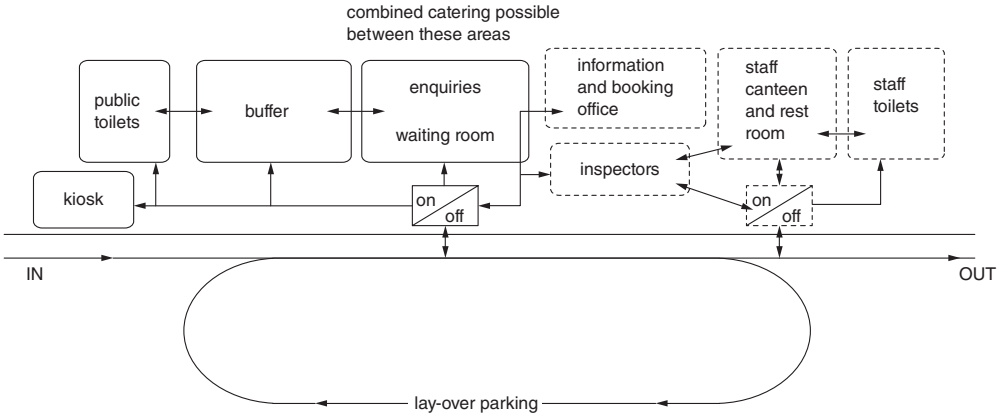
14 TRAMS AND LIGHT RAIL

There are a wide variety of these installations. Figure 41.45 shows a typical light railcar designed to facilitate use by wheelchair users.

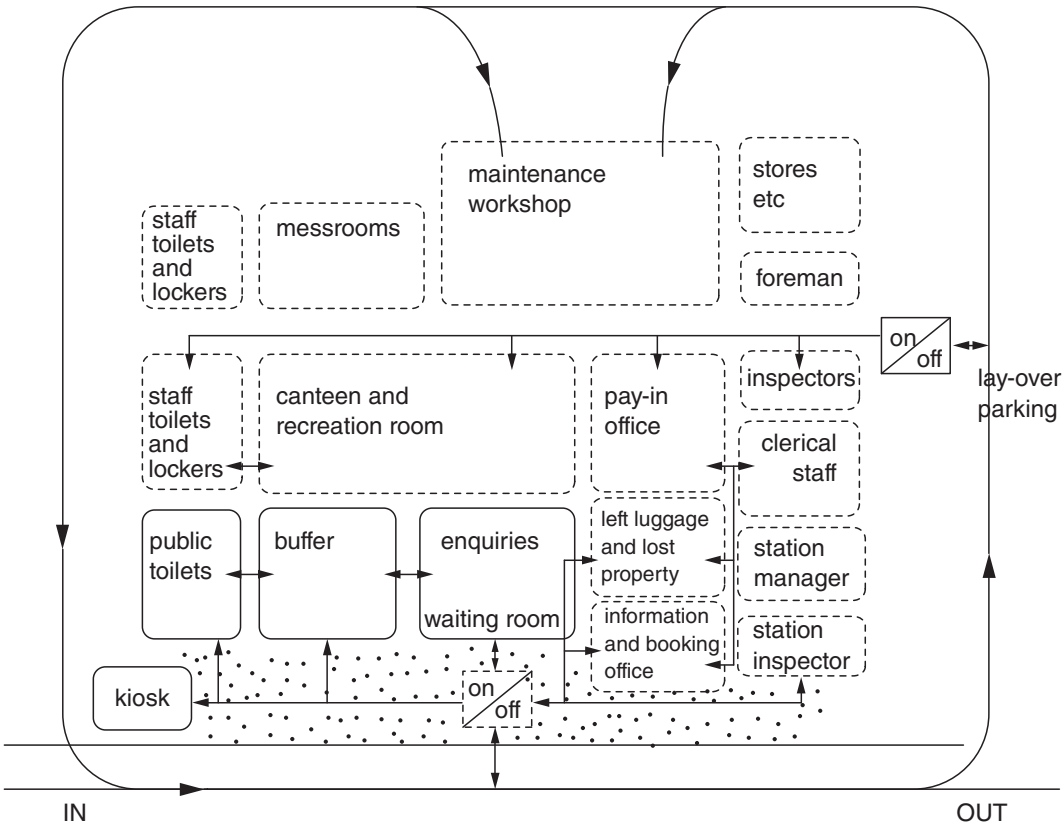
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



a *In a small town where all services run through*



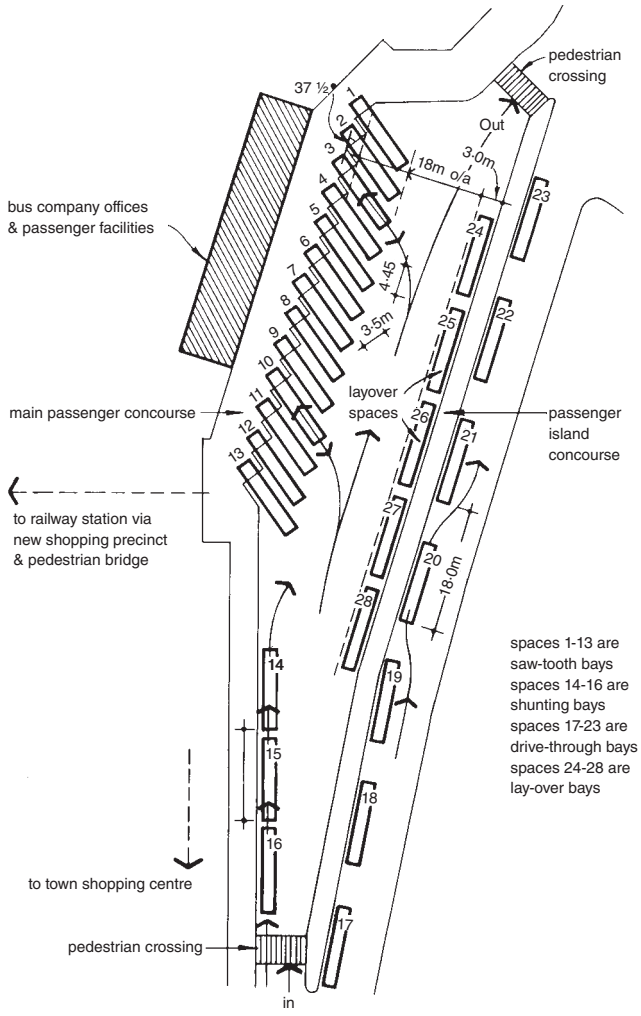
b *For a medium-sized town with both terminal and in transit services*



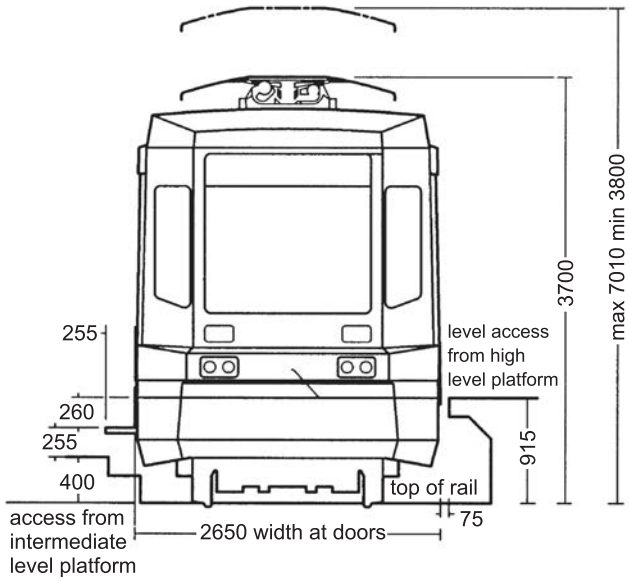
41.43 *Relationship diagram for different types of bus station*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



41.44 *Bus station accommodating two bus companies, each with different bay requirements*



41.45 *Manchester Metrolink: a typical modern tramway system. Frontal view of a car, showing level access for wheelchairs from a high-level platform*

15 BIBLIOGRAPHY

Air

Norman Ashford, *Airport Operations,* McGraw-Hill Professional, 1984

Christopher Blow, *Airport Terminals,* Architecture Press, *1996*

Guilio de Carli, *New Airports,* 24 Ore Cultura, 2010

Brian Edwards*, The Modern Airport Terminal: New Approaches to Airport Architecture,* Taylor & Francis, 2005

Anne Graham, *Managing Airports*, 3rd Edition, Routledge, 2008

IATA Airport Development Reference Manual, 10th Edition, 2014

ICAO Publications (refer to catalogue) in particular *Design Manual ICAO 9157 for Aerodrome Design*, *Design Manual ICAO 9184 for Masterplanning*

Richard de Neufville, Amedeo Odoni, *Airport Systems: Planning, Design and Management*, McGraw-Hill Education, 2013

Hugh Pearman, *Airports – A Century of Architecture*, Laurence King Publishing, 2004

www.airports-worldwide.com

www.iata.org

www.icao.int

Rail

Department for Transport and Transport Scotland *Accessible train station design for disabled people: A code of practice,* 2011

Network Rail *Making Rail Accessible: a guide to our policies and pratices,* 2012

Network Rail *Station Capacity Assessment Guidance,* 2011

Network Rail *Track Design Handbook NR/L2/TRK/2049*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

42 Tropical design

Patricia Tutt

CI/SfB: (H11)

Patricia Tutt is an architect, architectural photographer and editor who has spent half her life in central Africa. She co-edited an earlier edition of the Metric Handbook *and is now a lecturer at the Isle of Man College*

KEY POINTS:

- *Study existing buildings that work, and learn from them*
- *Apply normal good design and environmental practice, being sensitive to site, climate, culture and construction industry practices*
- *Review and revalidate all design assumptions*
- *Use local information and expertise*
- *Carry out a thorough desk study*
- *Anticipate extremes of climate change*

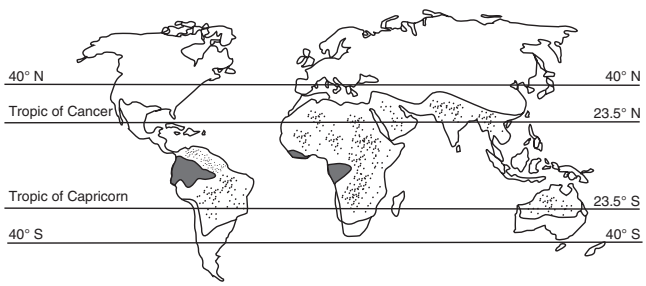
Contents

1 Introduction
2 Desk study – factors affecting design
3 Climate-responsive design: climate types
4 Environmental design strategies: passive design
5 Environmental control strategies: active measures
6 Structure, services and environmental design
7 Building science data
8 Bibliography, information sources and further reading

1 INTRODUCTION

1.1 'The Tropics'

'The tropics' are, technically, the low latitudes contained in the 'Torrid Zone' between the Tropics of Cancer and Capricorn, Figure 42.1, but the term is most typically applied to the world's hot, humid, equatorial coastal regions which have high rainfall, lush vegetation and, almost invariably, a colonial past. For our purposes here, however, the term can be applied to all climates in which the cooling load in buildings significantly exceeds the heating load, Figure 42.2. This extends into the hot dry areas, the composite climates in the centre of large continental land masses, and some areas tempered by warm seas or prevailing winds that are as far away from the equator as latitudes 45° north and south. This section provides an introductory design guide for architects undertaking work in unfamiliar environments and climates. All guidance must be substantiated by site-specific data.



42.1 *The 'Torrid Zone' lies between the Tropics of Cancer and Capricorn. Toned areas have a mean annual temperature of 20°C or above; black areas have persistent overcast skies with less than 1600 h sunshine per annum*

1.2 Current agendas

Within the last 20 years, there has been a major shift in design agendas worldwide, with increasing awareness of global warming, climate change and the need for responsible, sustainable design. Environmental design has become an essential component of building design. There has been widespread high-tech adaptation of traditional third world technologies by architects working in temperate climates, Figure 42.3. There is increasing awareness of the limitations of globalisation when compared to the merits of regionalism. Increasing sophistication in building design has become apparent in many tropical countries, especially those around the Pacific Rim; and web-based documentation, communication and transfer of knowledge have revolutionised design methodologies in all climates, whilst research has revalidated many traditional tropical design technologies.

Many governments are dependent on external funding to enable them to execute major development programmes and government agendas may, therefore, be diverted or constrained by the policies of the donor agencies which may be single governments (USAID, CIDA), regional organisations (EC, ADB, AfDB), international agencies (UN, World Bank, WHO) or charities (Oxfam, Red Cross, Red Crescent). *(The acronyms stand for the United States Agency for International Development, Canadian International Development Agency, the European Community, Asian Development Bank, African Development Bank, the United Nations and the World Health Organisation.)*

1.3 Tropical design

Tropical design is no longer seen as a separate entity, but as good design that is attuned to specific variations in climate, construction industry structure, culture and socio-economic conditions, Figures 42.4 and 42.5. A high-tech, expensive building can disregard context and be built anywhere if funding is available; the harder task is to design a sensitive, sustainable, lower-tech, climate-responsive building that will serve its intended community well and need little maintenance. Ideally, this building should embody cultural memory without being a pastiche of the vernacular or colonial model, using valid older principles in ways that suit a modern, urban and, in many cases, industrial society. Whilst many third world clients understandably aspire to the twentieth century, high-tech Western model for their new buildings, it is the responsibility of their architect to ensure that they are aware of this twenty-first century shift in thinking towards sustainable models, and to understand the options available to them and the potential long-term consequences of their choice.

The purpose of this chapter is to provide prompts and checklists to enable the building designer working in an unfamiliar region to carry out a detailed desk study, having first identified those issues that require detailed research. Many of these prompts would be relevant in any climate, but the details given here highlight tropical contexts.

2 DESK STUDY – FACTORS AFFECTING DESIGN

2.1 General

Whenever a building is being designed for an unfamiliar environment, the architect must check and revalidate even the most basic

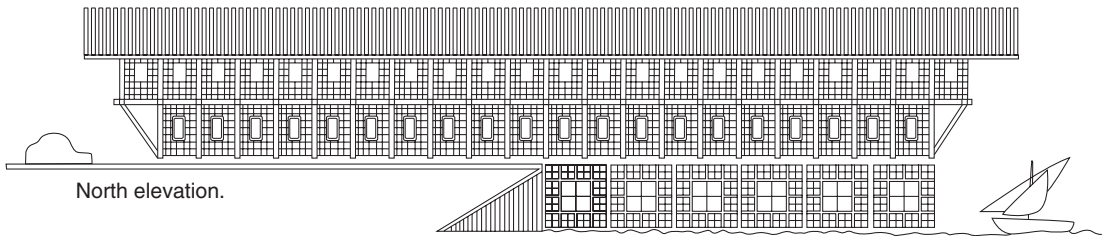


42.2 *Colonial bungalow, Zomba, Malawi, with clerestory windows, high ceilings and deep shaded verandas, including one for the car. Drawing by the Rev'd D Brian Roy, RIBA*



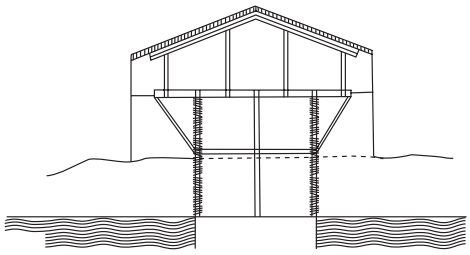
a **b**

42.3 *Many of the traditional environmental strategies used throughout the Middle East have been co-opted into current mainstream architectural design. Portcullis House, the new offices for MPs alongside the Houses of Parliament, in London, updates the wind-catcher and wind-venting tower by incorporating heat recovery and mechanical back-up systems (Smith, 2001)*



42.4 *The work of the Singhalese architect, Geoffrey Bawa, ranges between a restrained aesthetic using modern materials, and a sophisticated and heightened reinterpretation of the vernacular in private houses and tourist hotels, and, as can be seen in his exquisite drawings. Steel Corporation Offices, Oruwela, Sri Lanka, 1968 – set half in the large pool (steel production holding tank) and in reinforced concrete throughout, with precast perforated and windowed walls*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



42.5 *Bawa's Ena De Silva house, Colombo, 1962 – the courtyards for secure outdoor living are kept cool by through ventilation, deep overhangs and shade trees. All materials except a small amount of glass and some steel reinforcement are local. One of the large trees was brought onto the site by elephant; the other was already on site and influenced the design*

design assumption, as it might be invalid in the new context. This section highlights some areas where research may be necessary. Relevant building science data is given in Section 7.

2.2 Climate and microclimate

Confirm the climate type, Table I, and obtain as much site-specific data as possible, Tables II and III. Make sure you understand the terms used and are comparing like with like when evaluating data from differing sources. (Annual average temperature is the average of the mean monthly maximum and minimum temperatures. The average of the highest mean monthly maximum and lowest mean monthly minimum gives a close approximation.)

It is particularly important to ensure that data has not been distorted by periodic aberrations, especially if based on short-term records. A comparison of annual rainfall records will show if any cyclical pattern occurs. The great lakes of east Africa had a pattern of rising and falling over a 7-year cycle in the first half of the twentieth century – believed to be related not only to rainfall but also to activity in the Great Rift through which the lakes seem to be interlinked. The continuation of this pattern will have been distorted by deforestation, the change from subsistence to cash crop agricultural practices that have allowed extensive run-off of topsoil and fertiliser into the lakes, and the construction of dams, barrages and other features that alter natural hydrological cycles.

A lot of the current and historical weather data will be available on the internet, as will definitions of the terms used, but as weather bureaux are often located at airports, which tend to have distinctive microclimates, this data needs confirmation on site. Where rainfall is dependent on prevailing winds from one direction, a hillside site may be in the rain shadow and very much drier that the records suggest. On large projects, it may be advisable to establish a weather station on site to verify data and study microclimate. If climate change (see Section 2.3) accelerates as expected, more extreme weather will occur, causing catastrophes of increasing magnitude. In particular, extreme storms, wind, rainfall or drought may get worse as well as occurring more frequently. Building design and site selection need to take account of this.

Thermal comfort

Thermal comfort is dependent on temperature, humidity, radiation and air movement as well as type of activity, clothing and degree of acclimatisation. No two people will perceive and describe comfort equally. In a hot dry climate, perspiration evaporates quickly,

Table I Occurrence and characteristics of main climatic zones

Zone	Approximate latitude range	Natural vegetation	Typical cultivation	Climate	Problems	Requirements
Warm humid equatorial	7½°N–7½°S	Tropical rain forest	Banana, palm oil	Warm with high humidity and rainfall	Humidity prevents sweat evaporation; hot nights make sleep difficult; high rainfall and glare from overcast sky, sun on east and west facades	Air movement from fans or cross ventilation, low thermal capacity construction, sloping roofs and large overhangs, windows facing north and south
Tropical island	5–30°N 5–30°S	Rain forest	Sugar cane	Warm, humid but less cloud than warm humid zone	Similar to warm humid equatorial, but clear skies and bright sun more frequent	Similar to warm humid but with additional care in the design of shading the south facing windows in the northern hemisphere (vice versa in the southern)
Hot dry tropical	15–32°N 15–32°S	Desert, steppe	Palms, grazing (nomadic)	Hot and dry with high annual and daily variation of temperature	High diurnal range, very hot days in summer, cool winter days, low rainfall, very strong solar radiation and ground glare, sandy and dusty environment	High heat capacity construction, shading devices which allow solar heating in winter, small windows, flat roofs (often used for sleeping), small courtyards to give shade and protection
Maritime desert	15–30°N 15–30°S	Desert	Palms, grazing	Hot, humid with low rainfall	Similar to hot dry climates but with high humidity causing discomfort by preventing sweat evaporation	Similar to hot dry but air movement is desirable at times
Intermediate composite or monsoon	5–20°N 5–20°S	Monsoon forest, dry tropical forest or scrub, savannah	Paddy rice, sugar cane, millet	Warm humid and hot dry seasons often with cool season	Combines the problems of warm humid and hot dry climate	Compromise between the requirements of warm humid and hot dry climate or ideally (but more expensively) two buildings or parts of buildings for use at different times of the year
Equatorial upland	10°N–10°S	Broadleaf forest, mountain vegetation	Millet	Temperate to cool depending on altitude	Combine the problems of warm humid and hot dry climates with those of a temperate or cold climate for all or part of the year	Design to take advantage of solar radiation when cool or cold. Heating and additional insulation may be required
Tropical upland	10–30°N 10–30°S	Steppe, cedars	Wheat	Hot summers, cold winters	Ditto	Ditto
Mediterranean	32–45°N 32–45°S	Mediterranean scrub	Vines, olives, citrus fruits	Hot dry summers, cold wet winters	Summers have some of the problems of a hot dry climate while winters are cold and humid with moderate rainfall	Design with high thermal capacity, medium to small opening, and courtyards to give shade and protection

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table II Climatic data

Data required	Units	Relevance
Monthly mean maximum temperature	°C	thermal comfort analysis
Monthly mean minimum temperature	°C	
Monthly mean maximum humidity	%	
Monthly mean minimum humidity	%	
Monthly mean rainfall	mm	vegetation
Peak rainfall intensity and duration	mm/unit of time	storm damage
(Daily or hourly rainfall may be the only data available)	mm	rainwater drainage
Sunlight	hours	natural lighting
Cloud cover	oktas* or %	
Absolute maximum temperature	°C	thermal expansion
Absolute minimum temperature	°C	and effect on building materials
Frequency distribution of wind for different speeds and directions	% m/s	siting and orientation
Frequency of special phenomena, i.e. sandstorms, fog, hail, thunder	days per year	provision of special precautions

* 1 okta = 1 eighth of the sky.

Table III Action points for weather data collection

Historical data	• Check local weather bureaux, starting with the airport, making sure the data is relevant for the specific site. Even small countries can manifest several different climate types. Note changing patterns and periodic cycles that have recurred since record keeping began.
Now	• As a priority, collect weather data on site, as soon as the site is identified
Rainfall	• Establish the rainfall pattern – peaks, daily patterns (monsoon or 'main' rains often recur at the same time every day; some areas have a week or two of 'planting rains' a month or so before the main rains appear) • In areas with distinct seasonal variations, are there two (or more) 'rainy' seasons (as in Kenya) • Are the rains reliable or is there evidence of climate change? • Is there a known periodic cycle, such as El Niño? • Does the rain come from one direction and, if so, does this affect micro-climate on the site? • How heavy is the rainfall – does it drizzle for months or all come at once in a torrential cloudburst?
Other precipitation	• Is there a risk of hail or snow – not unknown in the tropics?
Storms, sandstorms, gales, hurricanes, tsunami, tornadoes, earthquakes, flash floods, landslides and other extreme weather events	• There are two aspects to these risks – how extreme are these events, and how often do they occur? • How often are two or more of these events inter-related or dependent on other, predictable or observable climatic events (tornadoes and changes in atmospheric pressure, earthquakes and tsunami, hurricanes and landslides)?
Sunlight and cloud cover	• Are there clear skies all year, or does the sky stay overcast during the rains for weeks on end? • How predictable is the cloud cover?
Relative humidity	• Records, seasonal variation • Is there a risk of mould growth in cupboards? • Does high humidity affect normal tasks or construction materials?
Temperature	• Yearly graph • Seasonal variations • Diurnal maximum and minimum

enabling rapid cooling of the body; humid conditions prevent this, leading to heat gain and discomfort. Table IV indicates the range of bulb temperatures that are likely to be perceived as comfortable at particular levels of relative humidity.

These thermal comfort limits assume that there has been no heat loss or gain due to ventilation or insolation. Comparing monthly mean maximum and minimum temperatures for known levels of relative humidity will indicate whether that particular month will have days and nights that are comfortable or uncomfortable due to either heat, cold or humidity, Table V.

Table IV Thermal comfort limits (°C)

Monthly average relative humidity (RH)%	Annual average temperature					
	Over 20°C		15–20°C		Under 15°C	
	Day	Night	Day	Night	Day	Night
0–30	26–34	17–25	23–32	15–23	21–30	14–21
30–50	25–31	17–24	22–30	15–22	21–27	14–20
50–70	23–29	17–23	21–28	15–21	19–26	14–19
70–100	22–27	17–21	20–25	15–20	18–24	14–18

Table V Indicators of requirements for comfort for each month

Humid indicators		
H1	Air movement essential	mean monthly maximum temperature above the day comfort limits combined with humidity over 70% or humidity between 30 and 70% and a diurnal range of less than 10°C
H2	Air movement desirable	mean monthly maximum temperatures within the comfort limits combined with humidities over 70%
Arid indicators		
A1	Thermal storage required	diurnal range of temperatures over 10°C and humidity less than 70%
A2	Space required for outdoor sleeping	mean monthly minimum temperatures above the night comfort limits and humidity below 50%. Outdoor sleeping may also be indicated where maximum temperatures are above the day comfort limits and diurnal range is above 10°C with humidities less than 50%.
Cold indicators		
C1	Solar radiation desirable	mean monthly maximum temperatures below day comfort limits
C2	Additional heating required	mean monthly maximum temperature below 15°C

Various formulae for relating these indicators to design solutions have been developed. The most successful of these are the 'Mahoney tables' developed for the UN by Carl Mahoney and reproduced in *Manual of Tropical Building and Housing: Part 1 – Climatic Design* Koenigsberger et al. (1974). This remains an important text.

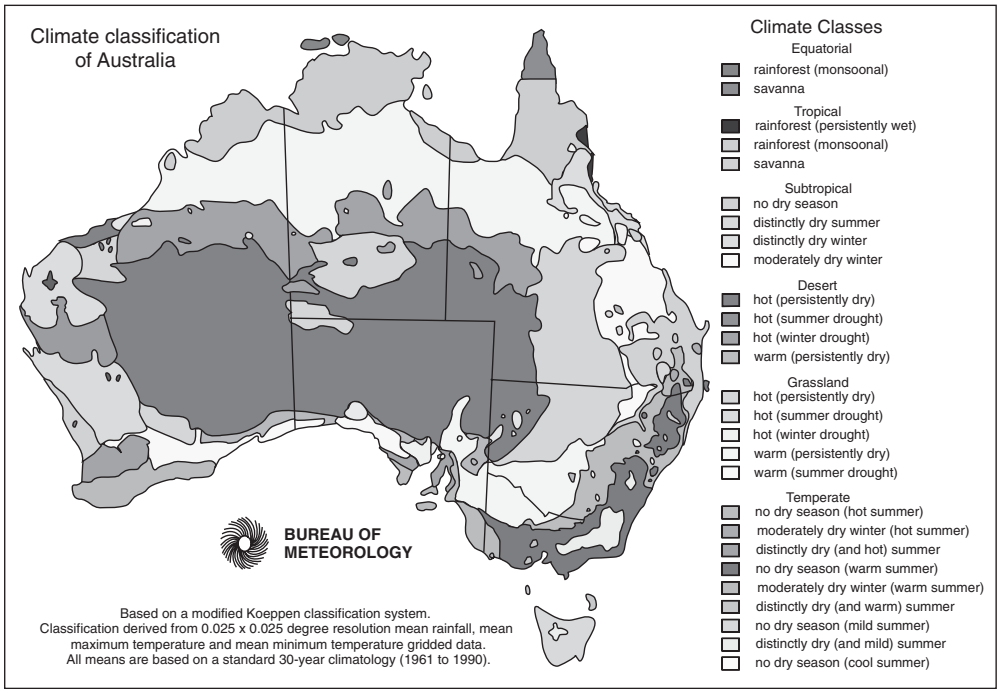
Meteorological data

Geographers and meteorologists distinguish a wide range of climate types in hot and warm climates and disagree over what to call them, but:

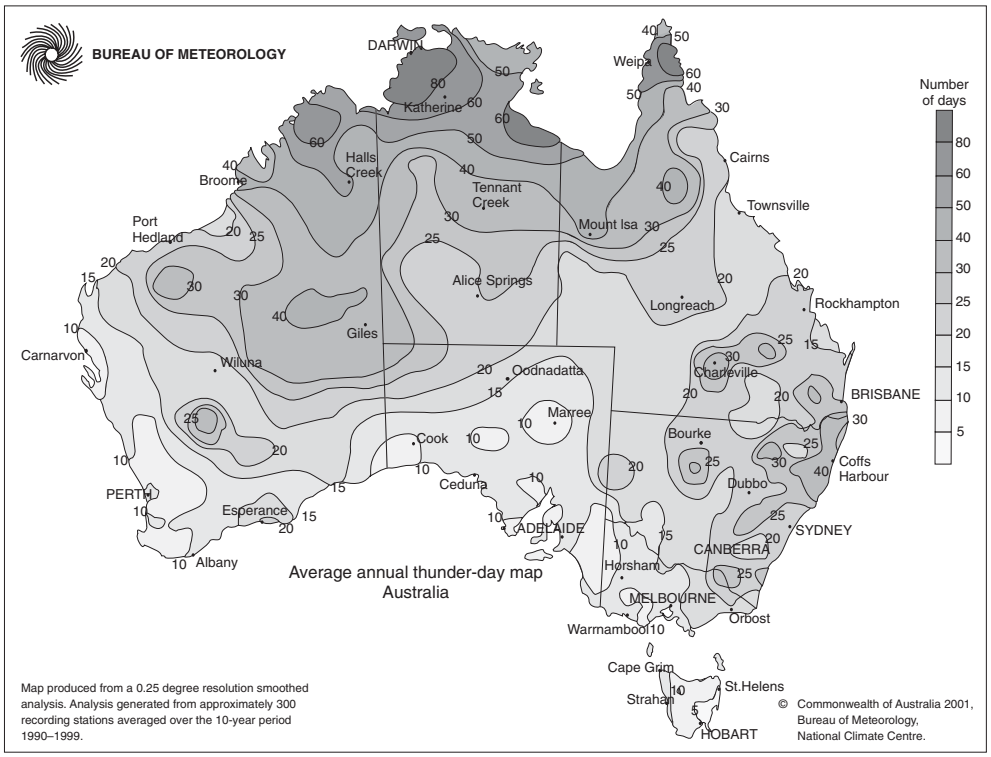
- The wet climates can be broadly distinguished by intensity and pattern of rainfall, humidity and cloud cover,
- The dry climates by how dry they are, how cold they get in the cold season (for simplicity, referred to hereafter as 'winter') and whether what little rain they do get falls in summer or winter.
- The composite climates by the degree of seasonal fluctuation in all climatic indicators; and whether it gets really cold in winter.

All these variables are moderated by latitude, altitude, prevailing winds, and whether they are at the centre of large landmasses. They can be covered by short lists of three or four types, based on data critical to particular groups (farmers concerned about rain,

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



42.6 *Range of tropical and subtropical climates found in Australia*



42.7 *Average annual thunder days in Australia*

tourists concerned about humidity and clear skies, skiers wanting snow) or broken down into a longer definitive list. The Bureau of Meteorology, Australia, produces a range of maps showing different criteria, Figures 42.6–42.9.

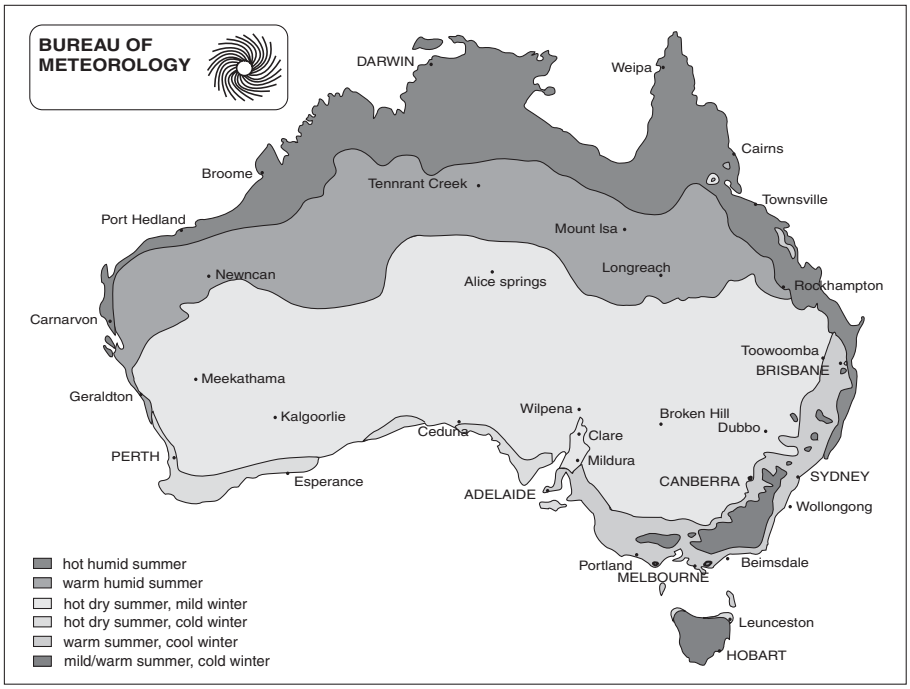
2.3 Climate change

Climate Change 2007, the Fourth Assessment Report (AR4) of the United Nations Intergovernmental Panel on Climate Change (IPCC), offers authoritative assessment of climate change implications for the tropics:

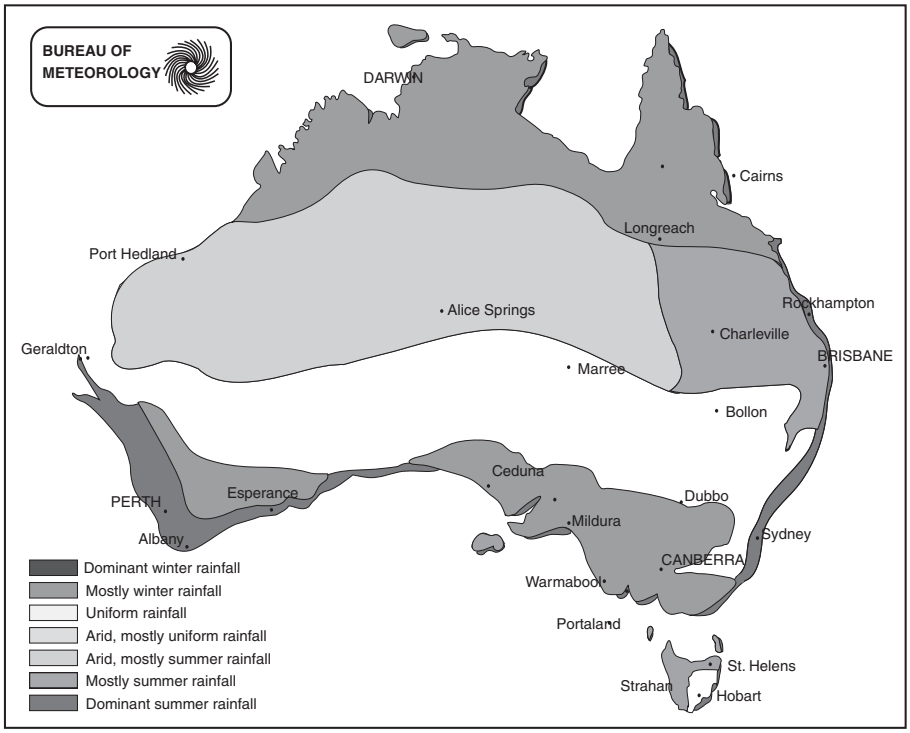
- low-lying island nations may be overcome by rising sea levels;
- future tropical cyclones (typhoons and hurricanes) are expected to become more intense, with larger peak wind speeds and more heavy precipitation, but the number of cyclone events may decrease overall;
- increase in drought in the centre of large continental land masses;
- increases in temperature;
- increasing unpredictabilty of weather patterns.

The report also anticipates ‘substantial reduction in regional differences in per capita income’ which will drive an expanding

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



42.8 *Map based on temperature and humidity only*



42.9 *Map based on rainfall only*

construction programme needing more resources and technological input.

2.4 Site selection

Sites and the detailed siting of individual buildings should primarily be chosen to maximise human comfort. Efficient performance of the building should follow from this.

Buildings should be sited:

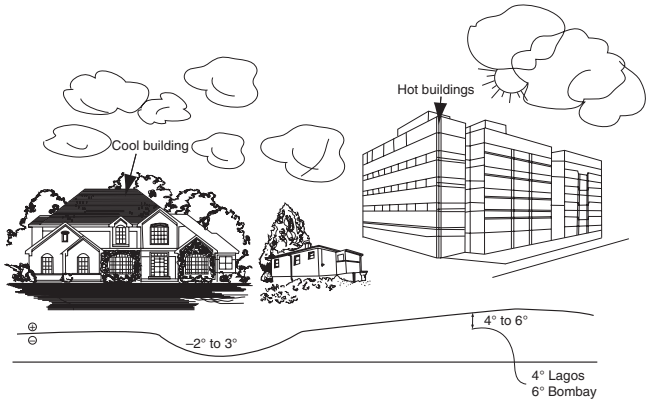
- close to, and downwind of, large heat sinks such as forests, rivers or lakes, which lower temperature and screen the site from airborne dust and noise, Figure 42.10;
- remote from major traffic routes and those industries which generate heat, noise, pollution and smells, Figure 42.11;
- where they will be shaded by trees or other buildings during the hottest part of the day and/or the hottest times of the year;

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

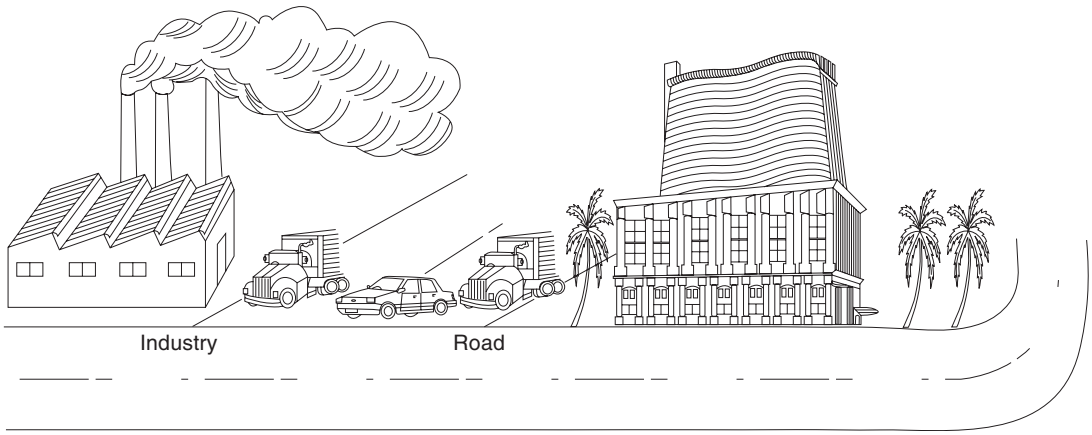
- where they will take advantage of the prevailing breezes (wet and humid climates);
- where they will be screened from dust-laden winds and glare (hot arid climates);
- where they will not be subjected to solar dazzle from other buildings, Figure 42.12;
- where they will not maximise heat gain and glare reflected from bright external paving or adjacent buildings with pale reflective surfaces (high albedo – see Section 7.2).

2.5 Site characteristics

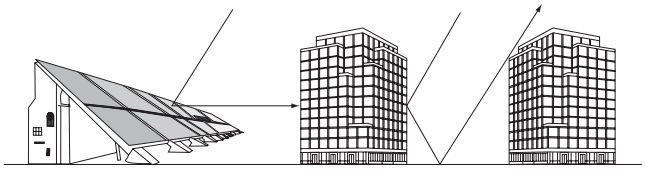
Altitude, aspect, insolation, gradient, prevailing wind, shelter, soil, geology, water table, vegetation, existing structures, archaeology and ecology may all be important. Traditional uses of the site, for grazing, footpaths or cultivation, may all need negotiation. Crops on a site may need to be reimbursed to their full value if destroyed, or allowed time to be harvested.



42.10 *Site buildings downwind of heat sinks*



42.11 *Site buildings well away from busy roads and industry*



42.12 *Solar dazzle off sloping glazed facades is more likely to be reflected horizontally into adjacent buildings or into the eyes of approaching drivers. Similarly, it is an offence in some countries to use uncoated metal sheeting on roofs, as it can temporarily blind airline pilots*

Pollution

Pollution and smells from tanneries and other industries, saltpans, open storm drains and sewers, contaminated water supplies and aerobic sewage treatment works may present serious problems in countries without environmental legislation.

Environmental impact

Even small projects may affect water supply, soil stabilisation, fragile flora and fauna, and local inhabitants and their patterns of agriculture. An environmental impact assessment may be required and should always be considered.

2.6 Site investigations and geotechnics

Soils and geotechnics

The site may present unfamiliar soil and ground conditions and behaviours. In southern Africa, for example, there are no glacial soils, there is much more igneous rock than elsewhere and the weathering of the ancient landmass has produced a much higher percentage of residual soils. Most of these soils are non-saturated and many are either of expansive or collapsing types where smaller structures need to be lightweight and flexible rather than heavy and rigid. Larger structures may need piled foundations. The absence of ground frost frees foundation design from some of the constraints that operate in cold climates, but other factors, such as soil type and seasonal cycles of saturation and desiccation, may present other problems. In many areas, tropical soils are thin and vulnerable to rapid erosion once tree-cover is removed or the surface exposed or cultivated. Soil stabilisation may be necessary, using planting, geo-membranes or gabions. It is rare to be working in a country that has not been extensively mapped geologically, however, and knowledge and expertise should be available.

Water supply

It may be impossible to ensure an adequate water supply throughout the year in dry or seasonally dry climates. There may be aquifers that can be tapped using wind pumps, but if water has to be piped over long distances or brought in by tanker, a scheme may become uneconomic. Ground water must be thoroughly tested by government or independent analysts to ensure that it is potable and free from contamination. (The widespread arsenic poisoning in Bangladesh is the worst of many examples of unforeseen contamination. This disaster arose from well-intentioned international aid intended to improve health by stopping people drinking contaminated surface water. Four million tubewells were sunk – into contaminated ground.)

Water table and flooding

The water table may fluctuate seasonally or be altered by other constructional or civil engineering work in the vicinity. Flash flooding

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

may be a risk in any dried out riverbed or low-lying area and roads may become impassable very quickly. Take advice, have up-to-date weather information and be alert to distant thunder.

Earthquakes and hot springs
World seismic data and geothermal activity are well recorded by the British Geological Survey and the US Geological Survey. Their web-based information is excellent.

Burial sites
Traditional burial sites may be unearthed in unexpected places, especially where the population is nomadic and the written record recent. All graves and religious sites must be treated with respect and local advice heeded. Burial sites may be indicated by the presence of particular tree species, or some other environmental marker.

Archaeological finds
Archaeological finds should be reported to local museum authorities. It may be wise when excavating a virgin site to take advice as to what to be looking out for, as remains or other finds may take unfamiliar forms, ranging from dinosaur eggs, through gemstones to rock paintings.

2.7 Culture and religion

Cultural and religious criteria
Many questions must be asked if they are germane to building design:

- Is the society homogeneous or divided on ethnic, political, religious or economic lines?
- Are there minority demands which have to be met?
- Are there strict gender-based criteria?
- Are there strict taboos with regard to personal hygiene and the butchering and eating of meat?
- Are some castes isolated?
- Do holy days vary?
- Does the workplace have to make provision for specific religious or social practices?
- Will shrines be required?
- Is Feng Shui practised?

Historical factors
Colonial procedures can be very persistent in former colonies including the former and present members of the (British) Commonwealth and in Francophone Africa, and the former American, Portuguese, Dutch and German colonies. Government and legal processes, the police, the army and a wide variety of social practices will all reflect the past administrators to a greater or lesser degree – as will the past and, sometimes, the present architecture.

Social and ethical criteria
Limited literacy or the absence of a common language may necessitate a different approach to building signage. If labour is cheap, buildings may need to accommodate the proliferation of servants, messengers and other service personnel that this permits. In some countries, they will be provided with residential accommodation on-site and will be able to keep their extended families there – with implications for power, water and sanitation provision.

2.8 Politics and economics

Business practices
Are people taking a siesta at midday, when the sun is overhead, but working later in the afternoons, when glare from low sun and solar gain are most difficult to keep out of buildings? Do meetings and other interactions require special facilities? Are there regular group activities (Tai Chi, mid-morning coffee, emergency drills) that need special spaces?

Political factors
Political instability and conflicting political, ethnic, religious or tribal agendas may influence design and affect the buoyancy of the construction industry.

External aid and funding
International debt repayment agreements may skew local economies and suppress regeneration; purchases of military hardware from the more aggressive vendors in this field have been particularly bruising. In the recent past, newly independent countries received large amounts of unconditional project funding as donor governments sought to keep undesirable influences from the Communist bloc, Cuba or China out of vulnerable and potentially unstable areas. Much of this aid was designed to provide employment in the donor country (… you will use our architects, our materials, our equipment …) with little regard for local expertise, culture or long-term viability: funding provided vehicles, but not the means of servicing them; hospitals, but not the staff to run them.

More recently, the more enlightened donors have started to move out of providing buildings and into support for sustainable, self-help projects that are intended to support local industries and generate wealth. Things still go wrong however – the never-ending stream of cheap second-hand clothing that charities are sending into Africa has destroyed the textile industry in several countries and stripped thousands of self-employed tailors of custom.

2.9 Construction industry, job management and professional expertise

Labour skills and costs
International price guides are now available for most countries and provide a good guide as to good local materials, cost peculiarities, materials that are difficult to source, labour rates and other cost indicators. It is important for architects to be familiar with local skills and use them, rather than to impose imported techniques that they are familiar with but local craftsmen are not.

Transport, accessibility and infrastructure
Transport can present many unforeseen problems on construction projects: vehicle availability, spares, maintenance, drivers, insurance, risks, road safety, road conditions, bad weather, roadblocks (official and unofficial) and drivers using official vehicles as unofficial, uninsured taxis.

Access and travelling
Is the country easy to get into and out of? Are permits, interpreters, guides, cost of flights, taxis, trains, buses or car hire required? It is important to develop local contacts and networks, using embassies, professional bodies and other agencies.

Project management strategies
Will these be local, international, co-partnership; via phone, fax or online?

Planning applications
Planning and other statutory procedures may be Anglophone, Francophone … or Byzantine. Local guidance is essential. Professional accreditation may be instantly available or complex and lengthy to obtain.

Cost
Costs will be unfamiliar and cost advice from resident consultants will be essential.

2.10 Resources and technologies

Utilities and services
Incoming services may include water (potable and recycled ‘grey water’), electricity, telecommunications (including satellite and

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

data services) oil and gas. Availability, reliability, method of reticulation and system type all need to be determined. In many countries, the very low density of new urban development imposes great strain on current and future services reticulation. Outgoing services – sewerage (mains and septic tank), storm drains and refuse – may also require non-standard design solutions. In areas without supply, alternatives must be considered.

Construction industry resources
Availability and reliability of materials, tools, plant, water supplies, resources, labour, skills, crafts, expertise, organisational structures, technologies and reliability of utility supplies will all affect the construction process, as will seasonal or climate events that affect employment, restrict transport movement or materials production, or stop construction (groundwork may not be possible during the rainy season). Local craftsmen may be adept in special applications of trades such as plastering and rendering, which have been lost in much of Europe or the USA. Scaffolding might use bamboo – a material worth exploring for a wide range of applications.

Alternative power sources
Water (hydro and wave), wind or solar power may be feasible. Grid-connected building-integrated photovoltaics (BIPV) are becoming more efficient and better documented.

Sustainability
The terms may differ – sustainable, ecological, 'green' – but the principles remain.

Good building design:

- should 'touch the earth lightly' by minimising use of nonrenewable fossil fuels in collecting, manufacturing, transporting or using building materials;
- should reduce the need for the power derived from these fossil fuels in heating, lighting, ventilation and cooking by using passive design strategies in buildings and
- lifestyle and working practices should reduce the need to consume excessive energy in transport, workplace, leisure or entertainment.
- In the longer view, this should affect urban planning, the nature of residential development, the reticulation of services and the policies of central governments.

Sustainable strategies to consider include:

- use local materials – but don't consume beyond the capacity to regenerate;
- make use of local waste products;
- use passive design;
- recycle energy;
- restrict water consumption.

Appropriate technology
It is dangerous to make assumptions about suitable solutions: two neighbouring countries may appear similar in terms of climate, environment and socio-political culture, but may have very different construction industries. One may have good labour, traditional brick-making skills, popular decorative traditions, and use steel extensively, whilst its neighbour has no masonry construction, but builds in cement block and reinforced concrete. One may welcome low-tech solutions; another might be insulted by them. Clay ovens, sisal-reinforced roofing sheets and modern pit-latrines may work wonderfully but are unlikely to satisfy people wanting to come up to speed in the modern world. Indeed, these solutions are most effective when offered to refugees from that modern world, who wish to experience the 'bush' for a week or two. A technology is only appropriate if people want it.

Transferable technologies
High-tech buildings in temperate climates now use design strategies that originated in the tropics (cooling towers, vented ridges, brises soleil). These sometimes perform less well than expected, as temperature variation is not sufficiently extreme to generate air movement, but when updated and reinterpreted in the tropics, they should work more efficiently. Conversely, temperate climate details (such as thermal insulation) can benefit tropical design, especially in composite climates at higher altitudes.

2.11 Environmental design

Environmental comfort within the building
Comfort depends on responding to climate specifics – humidity, seasonal variations that relate to altitude, prevailing winds and rainfall patterns, and the site and its environs. Do not forget that higher altitudes inland can get very cold overnight in the cold season – some areas have snow and frost; houses in the centres of large land masses and at altitudes over 1000 m often need room-heating fires in the sitting rooms and to take advantage of solar gain in winter. Effective passive solar design is an essential component of good design.

Environmental design around the building
Shading, restriction or enhancement of air movement, placement and type of landscaping, the use of water, reflectivity of surfaces, glare, screening against noise or dust and seasonal storm protection may all be important. Adjacent buildings may produce solar dazzle, block air movement or cast shade when it is most wanted. Public and private spaces, including car parking, may influence light levels, glare and general amenity.

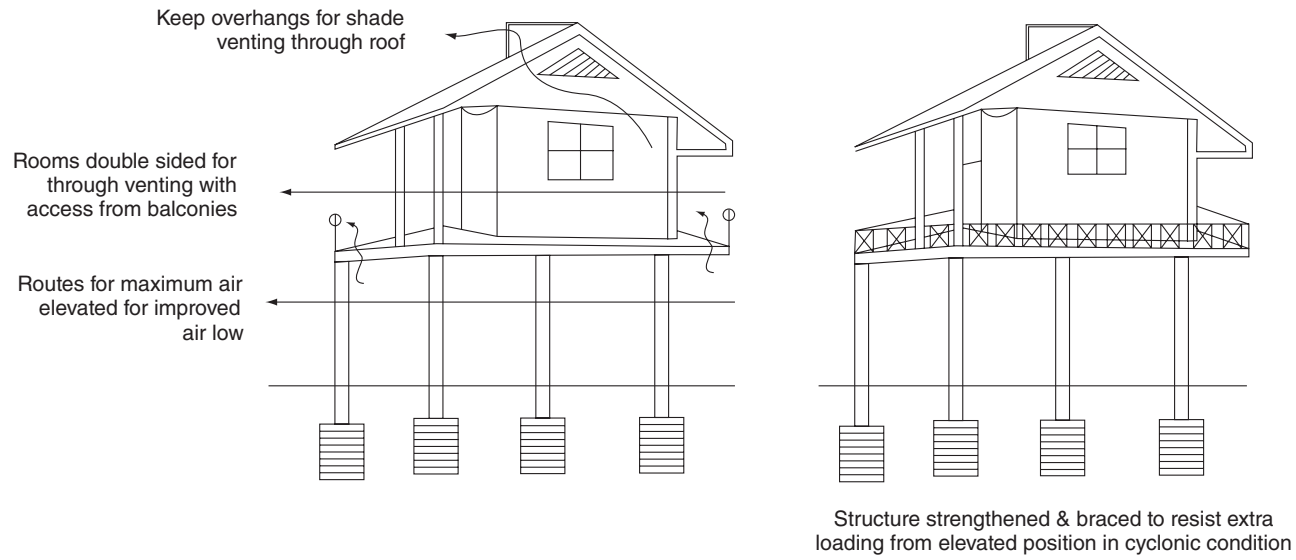
Performance of the building envelope in the context of the local climate
Buildings may have to withstand torrential driving rain, lightning, cyclones, hurricanes, sandstorms, very high temperatures, extreme diurnal temperature variations with associated extremes of thermal movement, persistent high humidity, extended dry periods or salt-laden atmospheres, Figure 42.13. Structures that are elevated to catch the breeze will need additional structural measures to withstand high winds.

2.12 Flora, fauna and biohazards

Tropical diseases and infections
With climate change, global public health is declining as tropical diseases and their carriers spread into new areas where populations do not have natural immunities. The World Health Organisation offers current information on the following diseases on its website: Leishmaniasis, Onchocerciasis, Chaga's disease, Leprosy, Tuberculosis, Schistosomiasis (Bilharzia), Lymphatic filiariasis, Malaria, African trypanosomiasis (Sleeping sickness) and Dengue.

Snakes, spiders and flying insects
Find out whether the habitat offered by the site suits any venomous snakes and spiders. If it does, make personnel aware of the appropriate remedial treatment for bites. Be aware of any risks of diseases, including water-borne diseases and of diseases transmitted by insects. Any stagnant or still standing water may carry diseases or their mechanisms of transmission (such as bilharzia in Africa). Bees and wasps may be very aggressive and inclined to swarm in roof voids. Cockroaches can be difficult to eradicate.

Mosquitoes
Mosquitoes are endemic in the tropics, and several species are capable of transmitting a range of diseases (malaria is the most widespread) by transferring infected blood from one person they have bitten to the next. Recently, the increased incidence of



42.13 *Structures that are raised on platforms or pilotis may need strengthening to withstand strong winds*

the more extreme forms of malaria (Blackwater fever, cerebral malaria) has been accompanied by hardening resistance to the known treatments; so prophylactic medication regimes and technical solutions need greater vigilance. Government health departments, tropical disease hospitals (most countries with a colonial past or significant immigration from the tropics will have tropical expertise) and national airlines can advise on precautions. See Section 6.8 for guidance on design strategies to keep mosquitoes at bay.

Many tropical climates have cyclical patterns of temperature and rainfall variation, such as El Niño, that recur over a number of years. These cycles will affect the water table and extent of open water created and, when wet phases are linked to high temperatures, there will be epidemics of diseases linked to mosquitoes and other water-breeding insects. In Australia, outbreaks of Murray Valley encephalitis occur at the peaks in the Southern Oscillation Index, which coincides with El Niño years.

Larger mammals

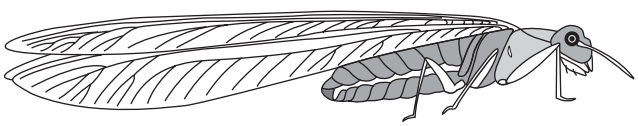
In rural areas, wild animals can cause problems, as can free-ranging livestock. Hippos leave the water to go night-grazing, elephants strip bark from trees and feeding monkeys cause a lot of willful damage.

Wood-boring insects

Structural timber and timber furniture may be at risk of disfiguring borer attack.

Termites

The presence of termites, Figure 42.14, may only be apparent if they are of the type that constructs mounds or 'anthills'. Termites can penetrate small spaces and destroy constructional timbers very quickly. They will also destroy landscaping, stripping trees and shrubs of bark. Where they are prevalent, allowance should be made for the need to replace a percentage of all landscaping due to termite damage. Termites may affect the soil profile, leaving a distinctive line of stones at the lower limit of their activity.



42.14 *Winged termite. Drawing copyright D G Mackean*

There are three main types of termites:

- *Dampwood termites* inhabit damp rotting logs or pockets of rot in dead or living trees. They obtain all the water they need from their habitat and do not need contact with the ground.
- *Drywood termites* are similar to wood-boring beetles found in temperate climates. They can fly into buildings or be introduced in previously infested timber. They can be deterred by the use of (expensive) naturally resistant timbers, by pre-treatment of timber with a wood preservative and by including physical barriers in the design, especially at roof level.
- *Subterranean termites* need to maintain contact with the ground and can survive in drier conditions than the drywood termites. They present the greatest risk to buildings. They can pass through fine cracks in slabs and mortar and construct mud galleries, linking their nest and a source of moisture underground with the cellulose food source within the building. Poorly ventilated, damp and dark spaces below floors and around the perimeter of the building will increase the risk of infestation. Landscaping can conceal activity, whilst disturbed soil or materials stored beneath the floor will facilitate it. Naturally resistant timber species are in short supply.

The options are to destroy the nest, and to use physical or chemical barriers. Low-pressure spraying of the ground with poison (usually the organophosphate chlorpyrifos or the pyrethroid bifenthrin) is generally considered the most effective treatment, but it must be continuous and not be compromised by later alterations or additions to the structure. In Australia, a fine-gauge stainless steel mesh is used as a barrier in any location, including below the floor slab. Smooth exposed faces of ground floor slabs (minimum 75 mm) assist detection and if constructed with sharp exposed corners, can deter termites, Figure 42.15.

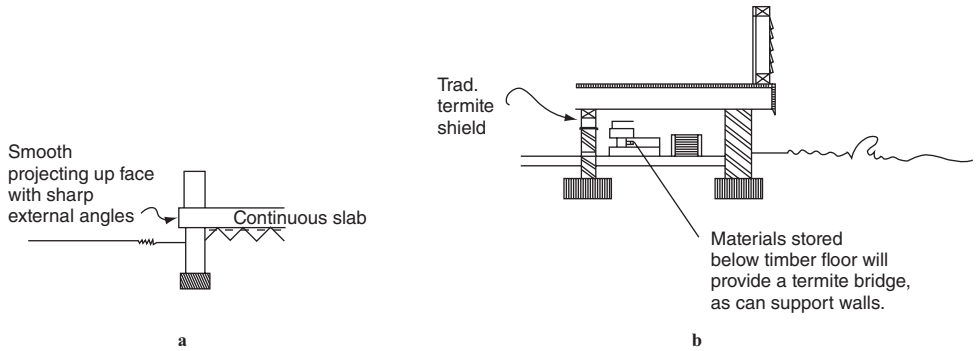
Materials used in the floor slab and lower courses of walls, including hardcore, building sand, mortar and render, are also usually poisoned with a pitch-based sealing compound and effective sealing of all cracks, joints and holes is essential. Termite shields are also used, but can be bridged and will become corroded, needing replacement. Chemical use should be by licensed persons who can also destroy nests by blowing arsenic trioxide into the colony using a hand blower. Regular inspection is essential.

2.13 Other essential design data

Design philosophy and practice

Be sensitive to local and regional practices and procedures, without producing a pastiche of the vernacular tradition.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



42.15 *Ground floor design can deter or encourage termites: a ground-bearing concrete floors; b suspended timber floor*

Anthropometrics and ergonomics
European anthropometrics data tends to be out of date (we have got taller and bigger); elsewhere, particular tribal and ethnic groups may have distinctly different characteristics, especially with regard to height and reach. If there is no data available, arrange for a local agency to obtain it, rather than trying to do it yourself – you might unwittingly cause offence.

Disabled access
Policies will vary, as will the numbers of disabled, especially in current and former war zones. Polio may also have left its mark.

Special factors in the design of the spaces around the building
National attitudes to land ownership, landscaping, public access, vehicular access and the use of public art can vary greatly. In some areas where there are no public facilities, indeterminate public spaces and open drains may be used as latrines.

Security
Abductions, muggings, desecrations or petty thefts may be problems that constrain design. Diplomats, and some nationals in particular, can feel extremely vulnerable and demand extreme measures, including 'safe rooms'. Burglar bars and other security measures may restrict means of escape in case of fire, boundaries may be marked by high walls topped with razor-wire enclosing a patrolled *cordon sanitaire*, and gates may be protected by armed guards.

Landscape design
Plant availability, local knowledge and expertise vary from country to country – look at the landscaping of public buildings to gauge attitudes and possibilities. There may be some protection of indigenous flora and restrictions on exotic (imported) species. Throughout most of the tropics, previous colonial administrators and later horticulturalist and landscape architects have imported species from all parts of the world. These can homogenise tropical landscaping and there is a move towards using indigenous species.

Irrigation may be a problem, in which case species that are drought-resistant must be used in dry or seasonally dry climates, where plantings needing irrigation should be restricted to designated 'watered' beds. Landscaping should support the environmental agenda of the building design – shade, air-flow, cooling, etc.; soft landscaping can harbour insects, snakes, and vermin and, as a consequence, some clients may insist there is no planting close to the building. Irrigation will cool the air but raise humidity.

Rainwater dispersal
In any climate where there are frequent heavy rains, it is inappropriate to fit the small gutters and down-pipes that are normally used in temperate climates. A short rainstorm may well cause a flash flood and the conventional solution in some countries is to discharge water from overhanging eaves into open dish drains which convey the water to large open storm drains which increase rapidly in width and depth as more inlets are added. It is imperative that these all drain effectively, without leaving standing water in which mosquitoes, bilharzia (*schistosomiasis*) and other diseases and bacteria can flourish. In public buildings and cities, where gutters normally will be used, they must be able to carry the heaviest rainfall or be able to overflow without causing damage or nuisance.

2.14 Desk study
It is essential that all these issues be investigated in a thorough desk study before detailed design work begins. Additionally, there will be an enormous range of built and documentary evidence, knowledge, expertise and experience within the country that can be invaluable in ensuring that an appropriate design solution is found. The architect who ignores this will compound the resentment of skilled local architects who have been overlooked when the commission to design the building was awarded. By including local expertise within the team, a whole range of subtle local factors may emerge, greatly enhancing the outcome.

3 CLIMATE-RESPONSIVE DESIGN: CLIMATE TYPES

3.1 Bioclimatic design
A careful evaluation of traditional and current aesthetic and technological local solutions will help to define the important design issues. In particular, if there is a highly evolved, almost iconic traditional building form, a detailed analysis of this form may prove particularly rewarding. Modern buildings and urban planning have usually derived from Western models and have not always been successful in resolving environmental problems or addressing social needs. The intention should be to reinterpret and add value to proven successful solutions, or to come up with different solutions that respond more effectively to changes in conditions or scale. A clear understanding of the issues and options is essential.

The international style of architecture seen around the world today is based on temperate-climate models and, like vernacular dry and arid climate architectures, it is enclosed, contained and defensive – based on solid geometry. Architecture in humid and composite climates, however, is often a fluid, unconstrained space under a canopy where people move in and out – through voids defined only by their upper surface. There is little physiological differentiation between being 'inside' and being 'outside' under a shady tree. In wall-less spaces, dramatic roof forms can make a much stronger statement.

In climates where much of daily life is conducted outside, it is common for buildings to take the form of a series of pavilions set in parkland and linked by covered walkways. In more congested sites, and where security is important, links between buildings may be semi-enclosed breeze-ways, walled with *brises-soleil* or some other form of defensive trelliswork.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table VI Climate responsive design strategies – hot dry desert climates (Baghdad, Alice Springs, Phoenix)

Indicators	Measurements	Design response
Latitudes	Between 15°and 30°N and S	Establish sunpath data; use to determine position of windows and other features
Location – within continental land mass	Altitude	
High daytime temperatures (up to 50°C), and cold nights (clear skies permit re-radiation of daytime solar gain)	Monthly mean maximum and minimum temperatures	Deep shade and high thermal mass with time lag to release warmth during cold night
High diurnal range		Stone and tiled floors will stay cool if fully shaded Use sound and sight of water for psychological cooling during the day
Low humidity, dry air	Average monthly relative humidity (RH) (from monthly mean maximum and monthly mean minimum) 10–55%	Use water for evaporative cooling
Low rainfall (precipitation)	Annual rainfall (range 50–155 mm)	Flat roofs, no gutters Provide for cleaning dust off the building envelope, especially windows
Two seasons, one hot, one cooler or cold	Monthly mean maximum and minimum temperatures	Use reduced solar altitude in winter to capture and store solar energy in trombe walls and on high mass paved floors. Reduce shading to permit solar gain in structure. Stabilise temperature with ground storage of water or energy.
Deep blue sky; glare from horizon worsens at end of dry season as dust in the atmosphere creates a haze	Solar radiation, luminance (1700–2500 cd/m^2, haze up to 10 000 cd/m^2)	Small windows placed at high level with view of deep blue sky (not facing into the sun's path) Use screens to cut glare (jail, mesh, masrabiya) with smaller apertures at lower levels to cut glare from horizon.
Air movement will contain dust and sand; whirlwinds will occur	Wind speed	Ventilation strategies depend on cooling and filtering air
Arid landscape with drought-tolerant species or desert conditions	Rainfall	Landscaping will depend on drought-resistant species or irrigation – but water use may be costly or restricted. Low humidity will affect growth.
Sandstorms	Wind speed	Defensive land-forming and building envelope with tight-fitting infill of openings (windows, doors, shutters, storm guards) Air vents and filters will require regular cleaning.
Variation – hot dry maritime desert climate (Kuwait, Karachi)		
Temperature – not as hot but with less seasonal variation)		
Relative humidity	50–90%	A particularly uncomfortable climate – encourage air movement with overhead fans. Air-conditioning may be needed.
Cloud cover – there may be a thin haze, causing glare	Sunshine hours per annum	
Local breezes, off the sea during the day, from the land at night	Wind speed	Orient openings to take advantage of daytime breezes.
Salty atmosphere – risk of corrosion	Distance from sea	Specify appropriate materials
Design solutions		
Individual buildings	Buildings are inward looking and defensive with thick walls and small high windows. Building mass should be efficient with as little of the envelope exposed to the sun as possible, especially on the west where the afternoon sun is the hottest. Internal courtyards are widely used, with the use of water for evaporative cooling and decorative screens to cut down glare. Roofs, walls, windows, terraces and courtyards can be shaded with canopies or secondary structures.	
Urban development	Buildings are packed close together – in particular, east and west facing party walls should be protected from the sun. This reduces travel distances – to markets, shops and services. Adopt strategies that reduce physical effort. Narrow streets running north–south will receive least sun. Wind towers catch the breezes and cool the air, drawing it over water into shaded courtyards.	
Landscaping	Create an artificial oasis by contouring land and planting shelterbelts with drought-resistant species. If irrigation is possible, other species may be grown. Soil may have to be imported. If so, it will need stabilising and protection or the wind will take it away. Use water for functional, decorative and psychological benefits. Shade paved areas to cut down glare.	

Generically, designers recognise three main climatic types: hot dry, hot wet and composite (with seasonal variation). In reality, most locations will have some seasonal variation and overlap with other types. Tables VI–VIII summarise the main indicators and design responses.

3.2 Design in hot dry and arid climates

The hot dry climate building needs to be ventilated whilst keeping out sand and dust, have a slow thermal response – achieved by high mass outer walls and should have small windows at high level, to cut down glare and solar gain, Figure 42.16. Traditional solutions achieve high mass by using thick walls of stone, air-dried mud bricks or rammed earth (*pisé de terre*). The unfired clay usually has a protective render or coating that will withstand occasional rain, provided it is repaired from time to time. Regional variations using the same materials can be quite distinctive – adobe in New Mexico, barrel vaults as used by Hassan Fathy in Egypt or tower houses in Iran. The same unfired materials recur in composite climates, but are protected from heavier, more persistent rain by deep overhangs, being placed on raised floor platforms and being repaired every year. In the dry tropics, there is a flat roof, often used for sleeping in the hottest weather. Any dense material may be used for the thick outer wall. Choice of material and wall thickness will depend on the desired time lag of the thermal response.

3.3 Design for hot wet and humid climates

The main requirements here are to maximise ventilation, shade and protection from rain, and to have a thin-skinned rapid thermal response building envelope, Figure 42.17. The maritime equatorial climate exhibits little variation over the year.

3.4 Design for composite climates

A composite climate has distinct seasonal variation. A decision needs to be made as to priorities in terms of climate-response, Figure 42.18. The seasonal variation in sunpath can be used to vary building response to the different climatic conditions, supplemented by movable elements, insulation and mechanical heating or cooling systems.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table VII Climate responsive design strategies - warm humid equatorial climates

(Lagos, Dar-es-Salaam, Colombo, Singapore, Djakarta, Quito)

Indicators	Measurements	Design response
Latitudes	Between 15°N and 15°S	High solar altitude with small seasonal variation enables specific shading solutions to be accurately designed; principal elevations should face north and south
Typical mean maximum daytime temperature 27–32°C and mean minimum at night 21–27°C; low diurnal range	Monthly mean maximum and minimum temperatures	Temperatures exacerbated by humidity – use thin-skinned structures to speed cooling and ventilation Design should include covered and fly-screened verandas, etc.
High humidity all year, around 75% but may range from 50 to close to 100%	Average monthly relative humidity (RH)	High humidity may necessitate the use of air-conditioners at night
High rainfall which may get heavier for a few months	Annual rainfall (range 2000–5000 mm)	Pitched roofs with deep overhangs; no gutters or wide gutters. Verandas, colonnades and covered walkways will provide protection from the rain.
Rainfall will increase insect nuisance (mosquitoes, etc.)		Verandas should be fly-screened Eliminate stagnant standing water and take other precautionary measures.
Little seasonal variation, with perhaps some increase in rainfall, wind or storm conditions from time to time	Precipitation, monthly mean maximum and minimum temperatures	Little need for seasonal variation in design use
Overcast sky persists; cloud cover varies between 60 and 90%. Glare is intensified by reflection off cloud and can be intense. Cloud traps warm air, preventing night	Sky cover and sunlight hours. Luminance range between heavy and bright overcast skies 850–7000 cd/m^2 radiation to sky.	Fly-screens, *brises soleil* and other screening devices will cut down glare, as will deep overhangs and verandas.
There is little wind movement, but gusts are occasionally recorded	Wind speed	Elevate buildings to maximise air movement; use louvre windows for maximum ventilation; rooms must have through ventilation.

Table VII (continued)

Indicators	Measurements	Design response
Lush landscape with tropical forests, buttressed trees and vines. Impoverished laterite soils produce vegetables with little mineral content.	Rainfall, albedo	Landscaping will need to be controlled or will become overgrown. Waterlogged sites may need draining or planting with appropriate species.
Variation – warm humid island climate (Caribbean, Philippines, Hawaii)		
Daytime mean maximum 29–32°C and mean minimum at night 18–24°C. Small diurnal and annual temperature ranges.	Monthly mean maximum and minimum temperatures	
Relative humidity	55%–almost 100%	Assist ventilation with design
High rainfall; storms may be heavy; sea spray may be a nuisance	Annual rainfall 1250–1800 mm	Roofs must be well constructed
Skies are clear or with broken cloud except during storms.	Clear sky luminance 1700–2500 cd/m^2	
Trade winds are regular; cyclones may be severe	Wind speed	Design for high winds
Salty atmosphere – risk of corrosion	Distance from sea	Specify appropriate materials
Design solutions		
Individual buildings	Roofs must be robust to withstand heavy rain, and usually have deep overhangs to shed the rain; thin-walled structures with rapid thermal response (cooling) and cross-ventilation (avoid back-to-back rooms and central corridors – circulation can be via perimeter verandas); habitable verandas, some fly-screened; main axis east–west; windows face north and south; use clerestory windows, vented ridges and wind towers to improve ventilation; shade trees should have high canopy but not block ventilation below the eaves; position structures to catch the breeze; anticipate damp and mould, insects and vermin.	
Urban development	Buildings should be positioned to obtain maximum ventilation; line buildings with verandas, colonnades and covered walkways.	
Landscaping	Dramatic landscaping is possible, but beware of wind rock in trees close to buildings.	

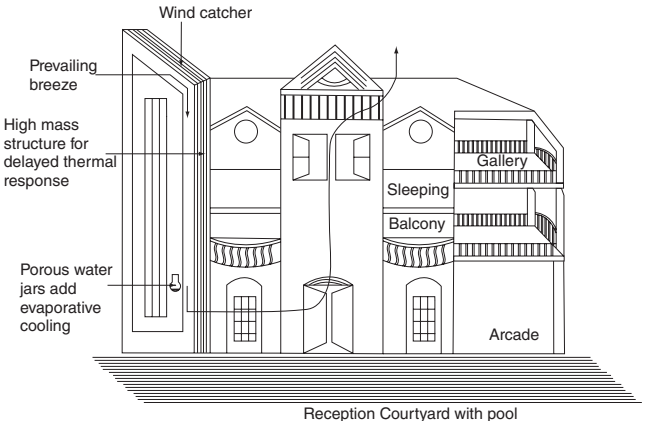
Table VIII Climate responsive design strategies – composite or monsoon climates

(*New Delhi, Kano***)**

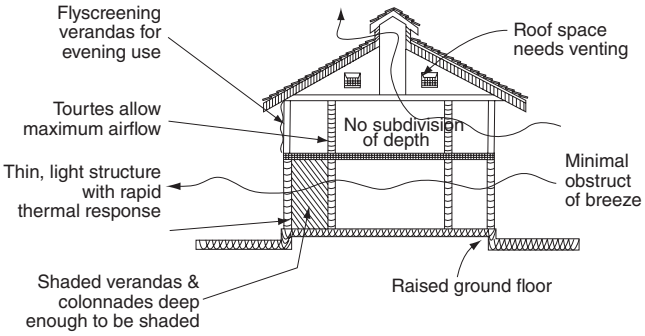
Indicators	Measurements	Design response
In large continental landmasses, close to the Tropics (23.5°N and S)	Latitude, altitude	Distance from equator results in seasonal variation and compromises in design
High daytime temperatures (up to 50°C), and cold nights (clear skies permit re-radiation of daytime solar gain)	Maximum and minimum temperatures	Design for different lifestyle, adjusted to suit climate; ensure daytime shade, night-time heat retention
High diurnal range Dry season humidity 20–55%; wet season humidity 55–95%	Average monthly relative humidity (RH)	If high humidity is short-lived, prioritise longer-term conditions, and use mechanical fans, etc.
Seasonal rainfall (monsoon) can be heavy and prolonged – up to 38 mm/h	Annual rainfall (range 500 – 1300 mm)	Pitched roofs with overhangs
Two seasons –hot-dry and warm-humid (21–43°C); further from equator, third season – cool-dry (4–27°C).	Monthly mean maximum and minimum	Include adjustable building elements; different spaces to suit different conditions; create micro-climate
Diurnal range up to 22°C Sky overcast during rains, clear deep blue during dry season, becoming dust-laden and hazy towards end of dry season	Solar radiation, luminance, cloud cover, sunshine days	Placement of windows; screening of windows

Table VIII (continued)

Indicators	Measurements	Design response
Monsoon winds strong and may come from different direction than winds at other times of the year; winds carry dust in dry season		Variable features; shutters and screens
Landscape changes appearance seasonally – lush in rains, becoming parched in dry season	Rainfall	Use drought-resistant species or irrigation
Termites are common	Anthills, nests	Use barriers, poison, appropriate design measures; expect high wastage.
Variation – Tropical upland climate (Bogota, Nairobi)		
Upland zones	Altitude 900–1200 m	
Distance from the equator increases seasonal variation	Latitude	Design will need to meet winter conditions, as well as summer.
Temperature reduces with altitude; diurnal range large, ground frost may occur	Weather data	Open fires, winter solar gain
Rainfall often heavy – up to 80 mm/h	Precipitation + 1000 mm	Pitched roofs, deep overhangs, storm drains
Heavy dew at night; radiation heat loss at night may cause radiation fog; hail; thunder and lightning	Weather data	Lightning protection, thermal insulation
Design solutions		
Individual buildings	Design depends on winter temperatures, duration of high humidity and duration of rains.	
Urban development	Colonnades and arcades provide shelter from rain.	
Landscaping	Many species will tolerate these climates, but may need irrigation unless resistant to seasonal drought. Risk of frost needs to be determined Termite damage can be considerable	



42.16 *The hot arid climate building is cool, shaded, and heat retaining. Its form prevents normal ventilation flows, so these must be induced by the use of wind-catching towers and wind vents, water placed strategically to provide evaporative cooling and the creation of temperature differentials within the central spaces to drive air movement*



42.17 *The hot humid climate building is airy, shaded and thin-skinned with a roof that can disperse torrential rain. All habitable rooms should have cross-ventilation*

4 ENVIRONMENTAL DESIGN STRATEGIES: PASSIVE DESIGN

4.1 General

There are two approaches to the provision of climate-responsive design – passive or active. Passive design is architect-driven and architectonic; it suits smaller, individual buildings, especially the one-off house; and it does not usually attract large research grants. Active design is the domain of the scientist and engineer: it is mathematical and appears more measurable; and it tends to attract government grants, the support of industry (there is a marketable product) and is used on prestige projects. In the 1980s, these two stances tended to polarise the specialists in this field, but today, there is more recognition that a mix of both is needed to get the best outcome. Design is becoming more integrated – and more pragmatic.

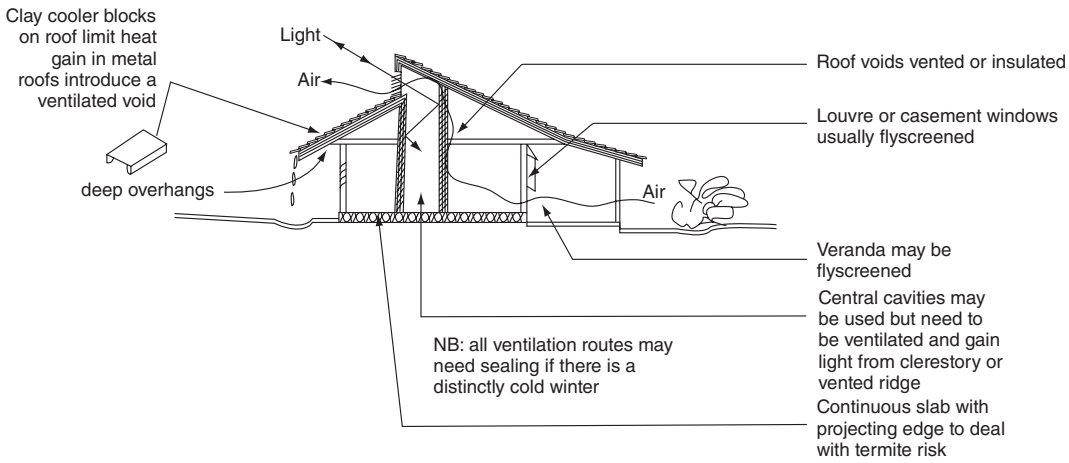
Passive design is the careful siting, orientation, design and detailing of buildings to ensure that maximum advantage is taken of aspect, sunlight, wind, contour and shelter to minimise dependency on fossil fuels and externally generated power, heat or artificial light, Figure 42.19. Passive solar design uses fixed elements of the building fabric and its environs to manage solar radiation and optimise natural heating or cooling. The benefits of passive design are a more comfortable natural environment, reduced energy consumption, reduced costs, lower maintenance and long-term viability as a building which will meet future higher energy regulations and which will remain economic to run as fuel prices increase. This topic is covered extensively in academic websites worldwide. Many of these are illustrated with regional design solutions.

4.2 Shading

The best way to control solar radiation is to use external shading. This must be designed with a thorough understanding of sunpath data, obtained with the aid of sun path diagrams and a shadow angle protractor (Section 7.1). Shading of buildings, windows and internal courtyards can reduce the cooling load on buildings and alter ventilation, glare and daylight levels. It may affect views out of the building.

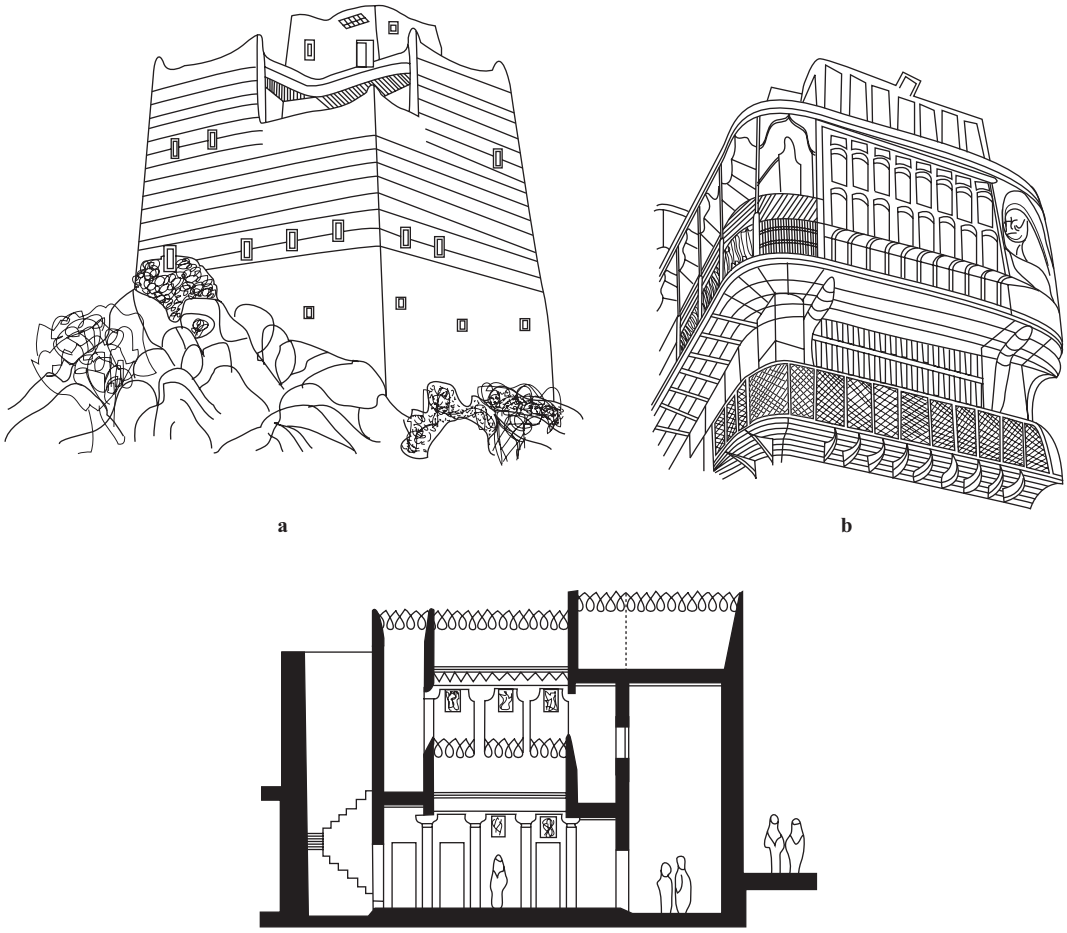
Passive shading, Figures 42.20, 42.21, may be achieved using:

- landscaping
- free-standing structures
- pergolas, porches, verandas and colonnades (Section 3.7)
- structural elements
- non-structural elements of the building envelope.



42.18 *The composite climate: different regions have different solutions depending on climate variables. This example is based on typical housing in Malawi at altitudes of 1000m. These houses are provided with an open fire in the sitting room. Cooler blocks are fired clay U-profile blocks loose-laid over profiled aluminium metal sheeting. They keep the worst of the solar radiation off the aluminium and create a ventilated space between the block and the roof-covering. Pitch is usually no more than 27.5°*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



a **b**

c

42.19 *Passive design in the hot arid tropics: a thick-walled defensive structures with small, high-level window apertures keep out heat, glare and dust; b traditional timber mashrabiỹa provide shaded and screened views into urban streets; c interiors are shaded and arcaded, with inner courtyards*



a *Landscaping* **b** *Free-standing structures* **c** *Porches, colonnades and pergolas* **d** *Structural elements* **e** *Non-structural elements*

42.20 *Passive shading options*

Passive shading elements, Figure 42.22, include:

- light shelves
- egg-crates
- screens (jail, mashrabiỹa, metal grillages, cascading planting on wire framing)
- overhangs
- fins.

Active shading, Figure 42.23, may be provided by:

- manually controlled awnings and blinds
- automatically controlled awnings and blinds
- shutters – which may be removable
- independent and temporary canopies.

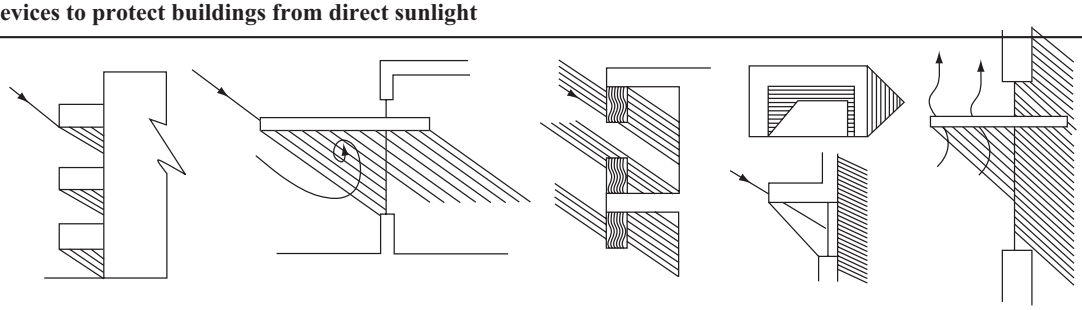
A recent project at Valletta in Malta has a sealed glazed roof that opens in hotter weather, Figure 42.24.

4.3 Porches, pergolas, balconies, verandas and colonnades

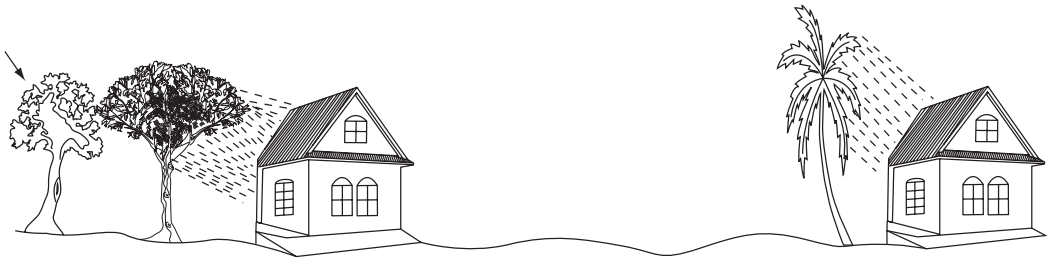
Any shaded or covered space around the edges of buildings or around internal courtyards will act as a transitional space which, depending on its particular function, can be seen as an extension of habitable space or as a barrier or a bridge between public and private space. In all cases, this shaded space will moderate temperature, keeping the sun off the main structure and maintaining a more consistent temperature in the interior. This interior will be glare-free and relatively dark, unless lit by clerestory windows, a split ridge, light scoops or light pipes, Figure 42.25. (Light pipes are highly polished metal tubes that reflect light gathered via a

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

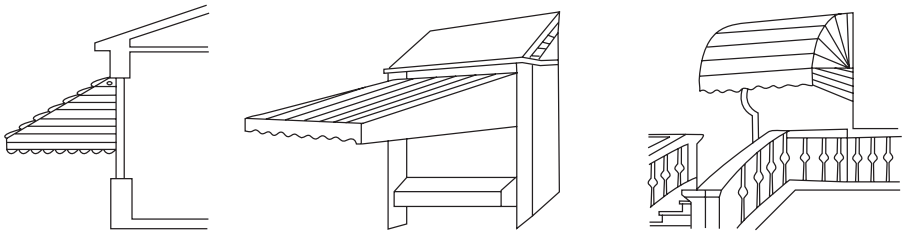
External devices to protect buildings from direct sunlight



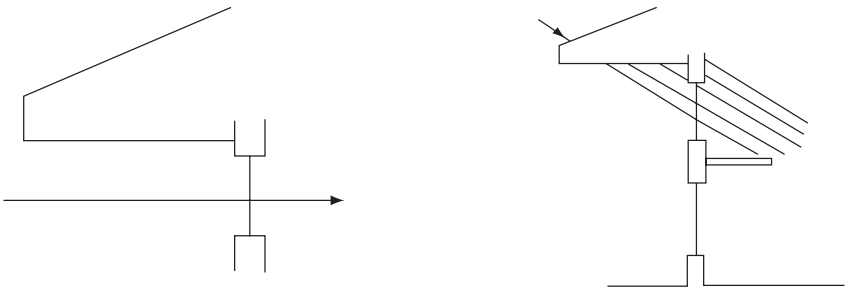
a External shading: *Balconies, light shelves, screening walls, window hoods, brises soleil, and other structural devices will provide shade, but should be designed not to trap heat.*



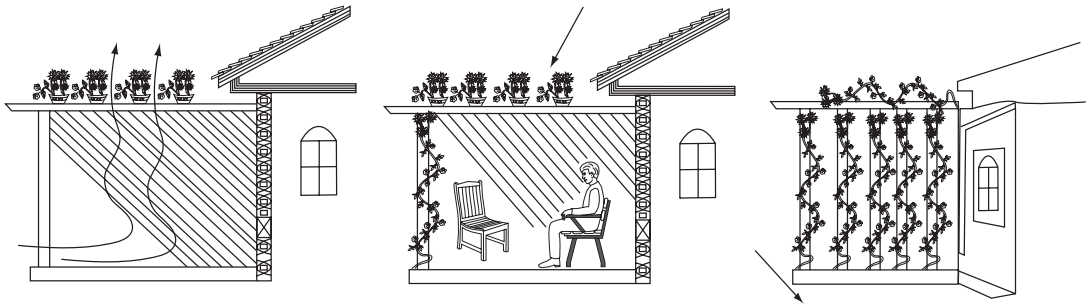
b Soft landscaping: *Trees may shade the roof, driveways, patios – the larger the better. Transpiration is evaporative cooling. All trees with foliage at high level permit low air movement.*



c Awnings: *Awnings are decorative, relatively cheap and adjustable. They block part of the view, can trap air and may suffer mechanical damage.*

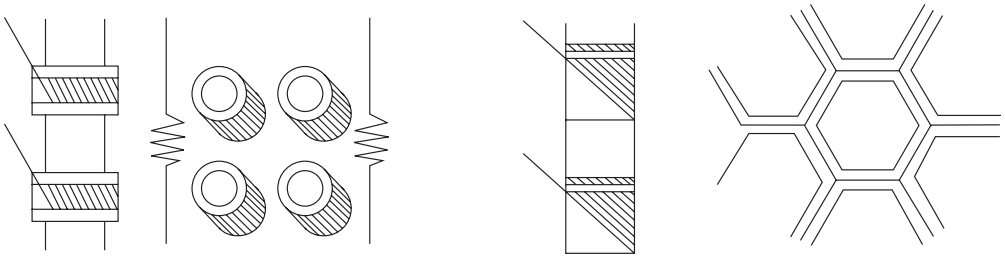


d Deep overhangs: *Overhangs do not provide relief for east and west-facing windows that face low sun. They will not shade the ground floor windows on a two-storey building.*



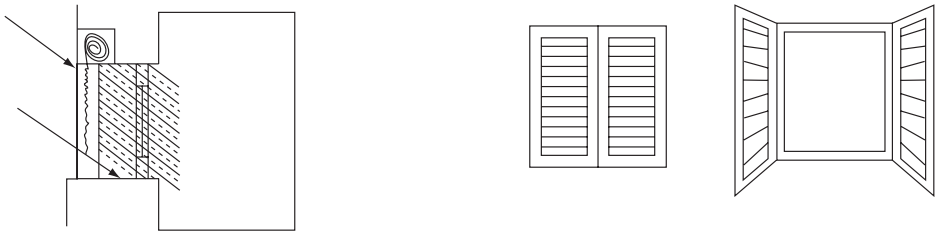
e Pergolas and trellises: *These permanent structures provide shade; climbing plants add evaporative cooling. If air conditioners and other electrical equipment are shaded, it improves their performance.*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

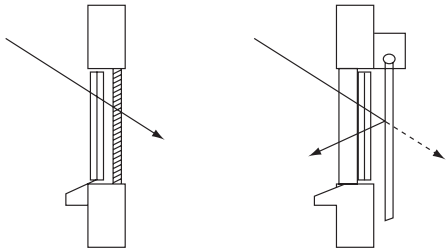


f Screen walling and 'egg crates': *Perforated screen walling can admit light and breezes whilst keeping out the sun and ensuring security.*

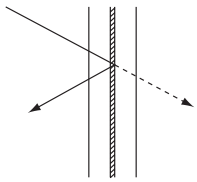
Devices at or within the window to protect from direct sunlight.



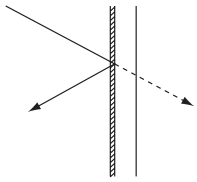
g Louvres and shutters: *External louvres and shutters will be more effective than internal ones. Metal shutters will become very hot and radiate heat into the building. The louvres on American shutters can be adjusted to retain some view and admit light whilst completely blocking the sun.*



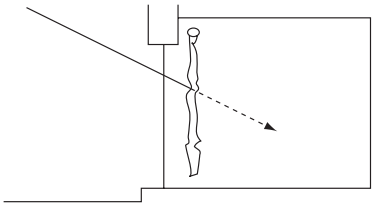
h Venetian blinds, etc: *Internal Venetian or roller blinds, or curtains (sheer or heavy drapes) should have a pale lining facing out to reflect heat back out of the window, fit tightly to prevent heat dispersing into the room, cover the whole window, and, for maximum effect, be made in a insulating material.*



i Special glass: *A wide range of solar control glass is available, in grey, gold, green, blue and pink tints, usually applied as the filling in a laminated sandwich. Outlook will be affected by the colour of the tint and degree of light reduction.*

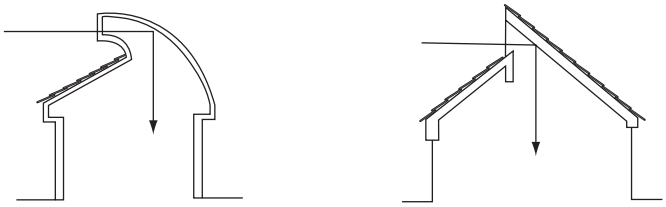


j Special films applied to the glass: *Plastic films containing gold and other minerals can be applied to achieve a wide range of effects. They are comparatively expensive and affect the outlook from the building.*



k *Curtains – sheers: Sheers will reduce glare, but will not significantly reduce solar gain.*

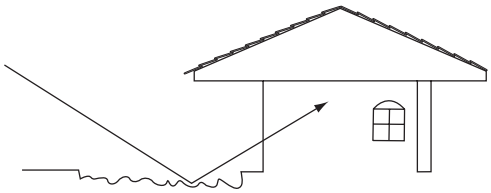
Devices to enhance light transmission (and reduce glare)



l *Light scoops*



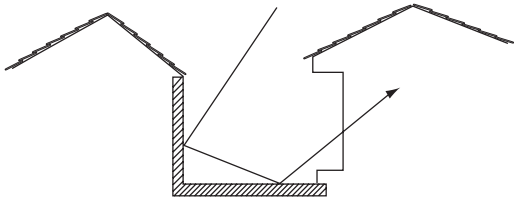
m *Sunpipes*



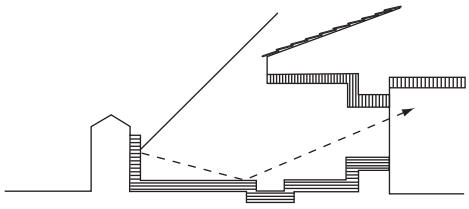
n *Water*

42.21 *Passive shading devices (contd.)*

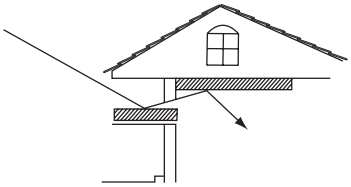
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



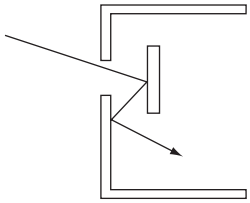
o *Bright external surfaces*



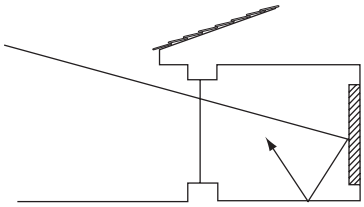
s *Colour – outside and in window frame and reveal*



p *Reflectors*

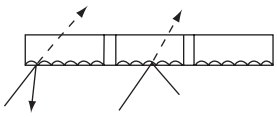


t *Light baffles*



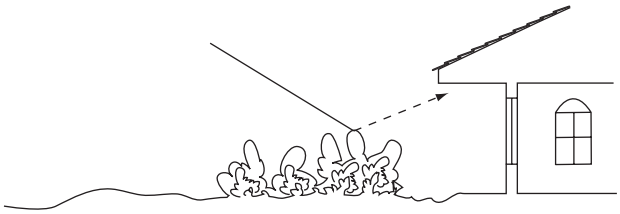
q *Mirrors*

White paint not used – take the 'bite' out of white by adding a touch of a dark colour.

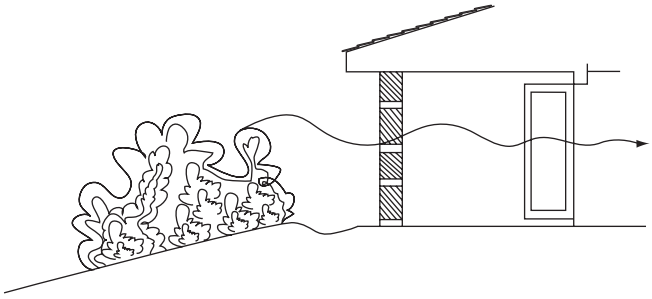


u *Light absorbing or deflecting glass or glass blocks*

Devices to reduce brightness and glare

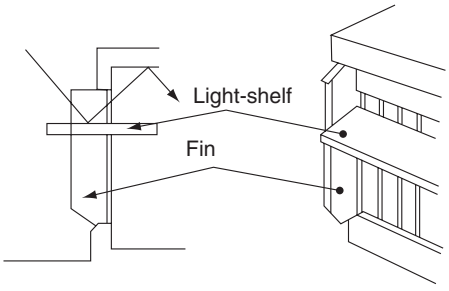


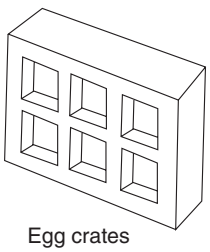
r *Planting*

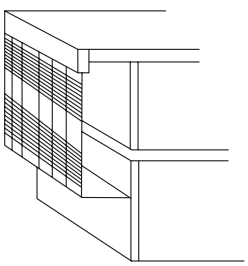


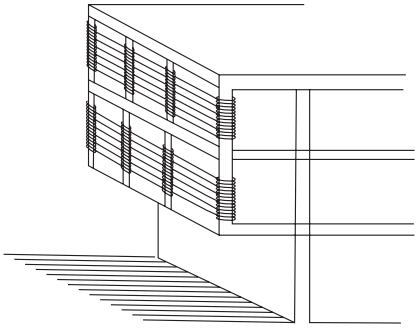
v *Screen walling*

42.21 *Passive shading devices (contd.)*



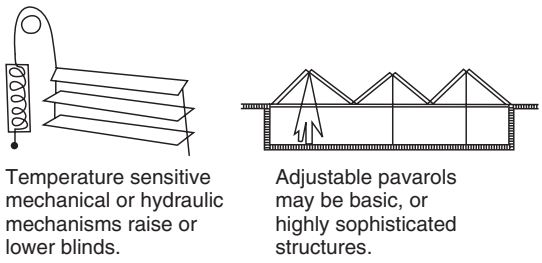




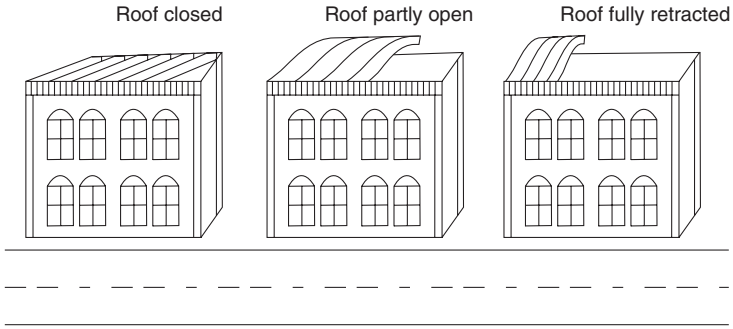


42.22 *Passive shading at windows must be designed to suit the sun path:*

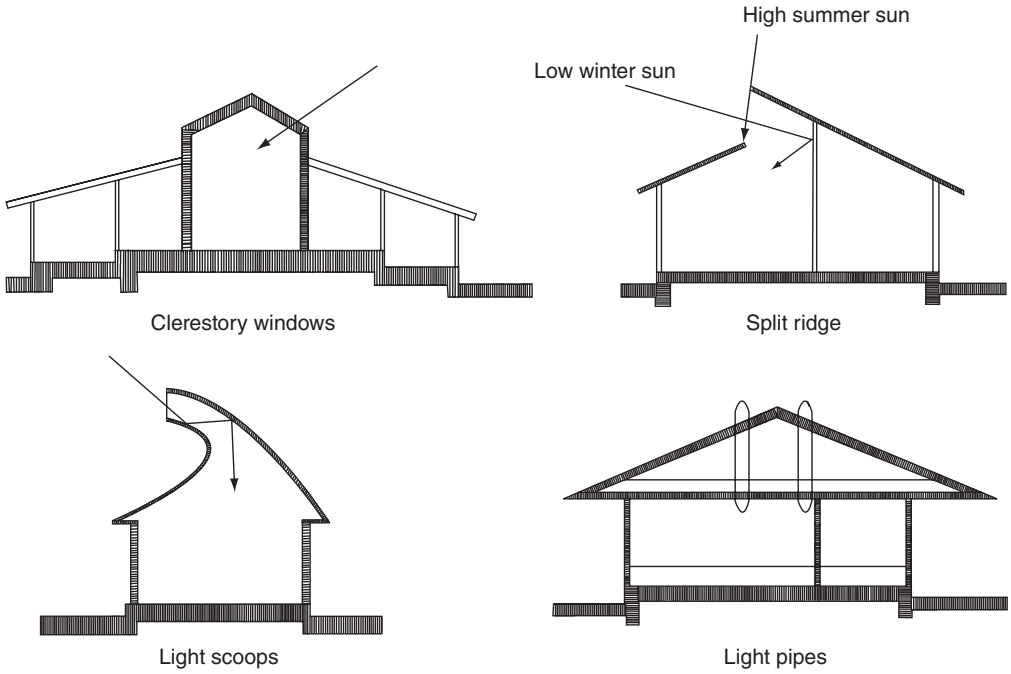
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



42.23 *Active shading devices are movable or adjustable, using techniques ranging from simple manual actions to very sophisticated computer controlled mechanisms that respond to changes in temperature or light intensity*



42.24 *The Manoel theatre, Valletta, Malta by Architecture Project has a retractable sealed, glazed roof over an inner courtyard that folds back in hot weather*



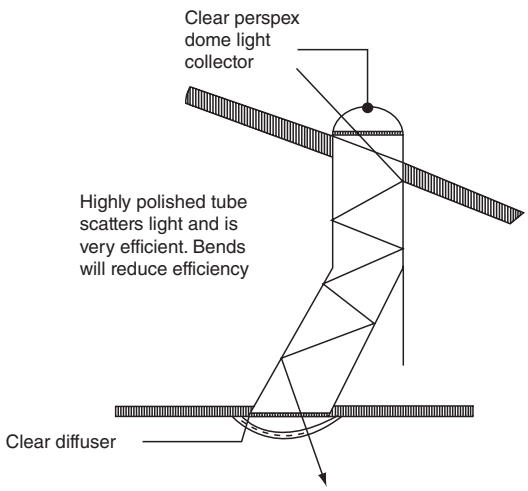
42.25 *Light-gathering strategies for dark interiors, all of which can be vented: clerestory windows, split ridge, light scoops and light pipes*

Perspex dome at roof level and discharged via a similar inverted dome diffuser into a dark interior space, Figure 42.26. They are economical, efficient and effective.)

The dark interior may be gloomy in cold weather, except when low winter sun penetrates to the inner walls, but this darkness is psychologically cooling and pleasant, provided that it does not necessitate the use of artificial light during the day.

The effectiveness of these shade-giving spaces will depend on orientation, latitude, depth, prevailing breezes and width/height ratio, Figure 42.27. In all hot climates, verandas may become the main living spaces for most of the year, and any building design should recognise the social and environmental importance of these spaces. Except in balconies to individual bedrooms, the covered space should have sufficient depth to allow a group of people to sit around a small table (private houses) or to allow people to work or promenade in comfort (public colonnades). The depth of shade should be sufficient to enable the anticipated activity to be carried out in comfort, Figure 42.28.

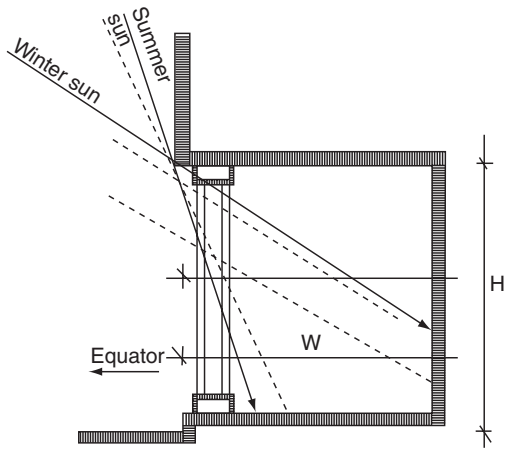
The iconic colonial bungalow has a veranda on all four elevations, with each one being used at different times of the day or year, Figure 42.29. In all climates with a marked seasonal variation in temperature, the main shaded space should be on the elevation facing the equator so that when the sun is overhead in the hot season, it barely penetrates into the space, but in the cold season, when the sun is lower, it shines into the recess, providing warmth, Figure 42.30.



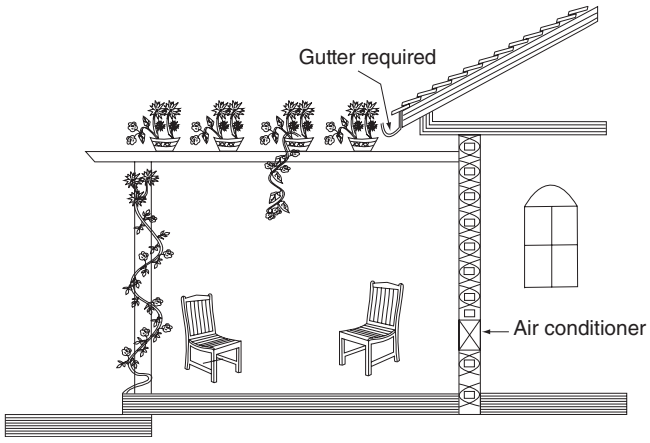
42.26 *The light pipe (which can also be enclosed in a vented duct with the clear domed toplight set within a louvred venting frame)*

In hot humid climates, conditions may be too unpleasant indoors, during both the day and the night. In the humid evening and night, flying insects are a particular nuisance, and one or more of the verandas will be fly-screened. This cuts down air

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

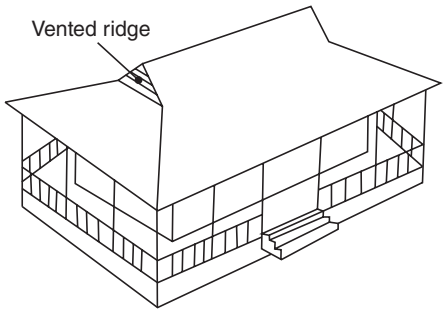


42.27 *The critical height/width ratio of a colonnade will depend on orientation, latitude and the particular use the space will be put to*

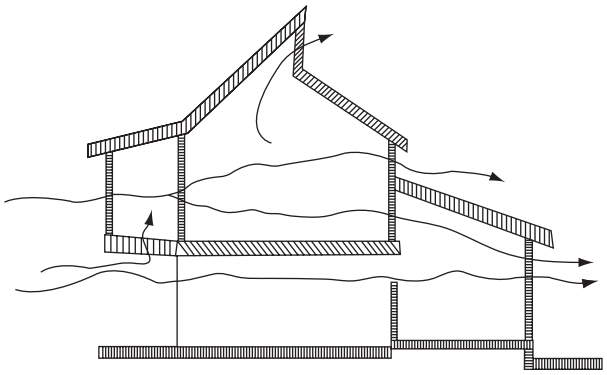


42.28 *Pergolas provide an attractive dappled shade. If used where they shade air conditioners, they will reduce intake temperatures and thereby reduce cooling load*

movement but is essential. In two-storey houses, a secure screened upper veranda may be used for sleeping on the hottest nights, Figure 42.31. In these climates, it is common practice to raise the house, sleeping areas and verandas as high as possible above the ground, to catch the night breezes. On cooler days, the dappled shade under a pergola supporting a vine or other climbing plant may be more pleasant than deep shade.



42.29 *The colonial bungalow with a veranda on all sides – the archetypical Australian farmhouse. Note the vented ridge, extending over the hip – a lesson learnt from the Indonesian lodge house*



42.30 *In summer, the overhead sun is kept out of the veranda, but in winter, the sun is lower and warms the spaces under the roof on cold mornings and evenings*

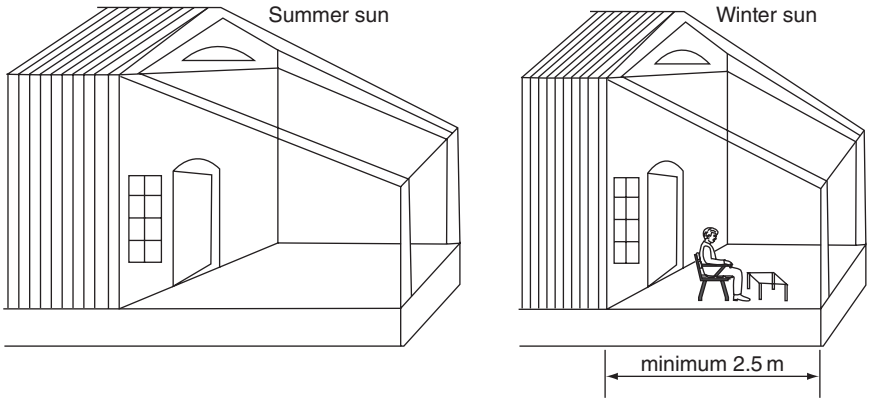
Security will be a consideration in the design of most external spaces.

4.4 Courtyards, patios and atria

Courtyards or patios, Figure 42.32, are traditional features in most hot climates and serve several purposes:

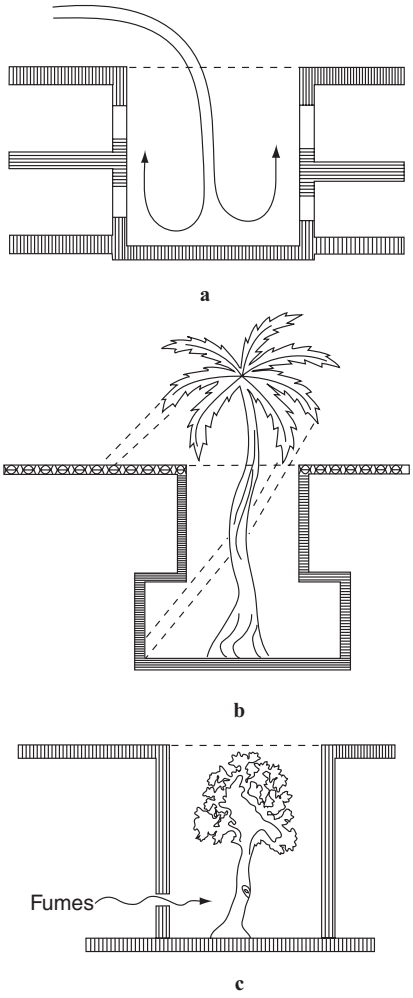
- they defend the occupants from the busy, noisy, smelly street;
- they ensure privacy;
- they reduce built depth and should increase through-ventilation, Table IX.

Courtyards may be lined with verandas or colonnades (as was the monastic cloister). The surrounding walls and roof will cast shade



42.31 *In hot humid tropical conditions, ventilated sleeping verandas may be essential for a comfortable night*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



42.32 *In courtyards, a at night, cool night air sinks into the centre, whilst warmer air trapped in the courtyard rises around the perimeter, warming the rooms alongside; b tall trees with canopies above the yard will give effective shading whilst allowing air movement; c trees with their canopy below the courtyard roofline may trap air and fumes from appliances. Trees and retractable awnings can improve the performance of the courtyard*

Table IX Courtyards

Benefits	Deficits
Courtyards:	Courtyards:
– will increase privacy from the street	– may reduce privacy for rooms facing one another across small courtyards
– will reduce noise from street	– may make sound ricochet around the space
– will reduce building depth	– will increase footprint and cost
– should have increased air flow through rooms as a result of reduced depth	– may trap air and restrict air movement
– may cool the building at night by drawing in cool night air and accelerating dispersal of warm air	– may accumulate pollutants dispersed into the courtyard
– with trees will be shaded and the trees will transpire in the evening to accelerate cooling (deciduous trees will admit sun in winter)	– with deciduous trees will need clearing of leaf litter
– can use water effectively to modify temperature	
– will effectively enlarge the habitable space, as they can be used for many social and working activities, and may have temporary or retractable coverings for weather protection, decorative effect or additional privacy.	– will have an enlarged and more complex building footprint and the more complex design will incur extra costs – to be offset against the many gains.

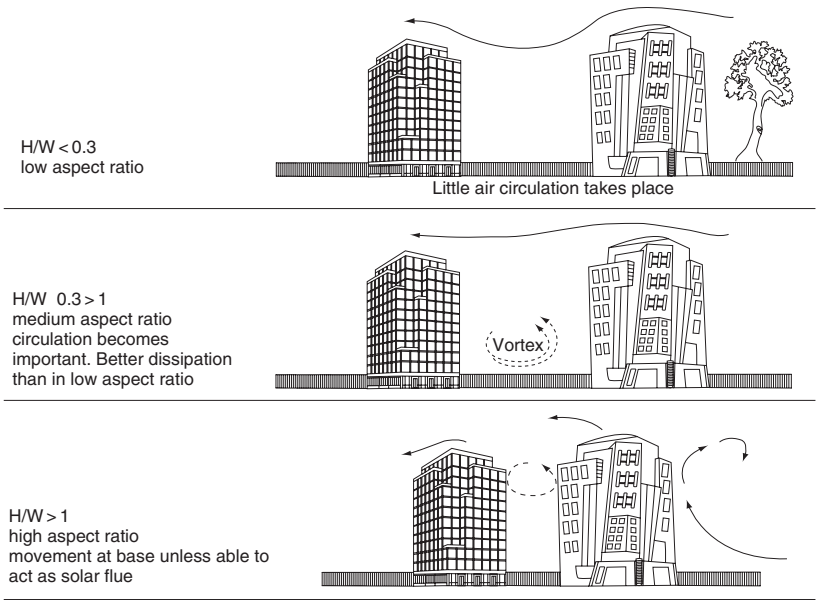
into the courtyard from the east in the early morning and from the west in the early evening. The courtyard itself may be shaded by tall trees, awnings or retractable canopies.

The aspect ratio, Figure 42.33, of courtyards is critical to their effectiveness.

Where H = height and W = width

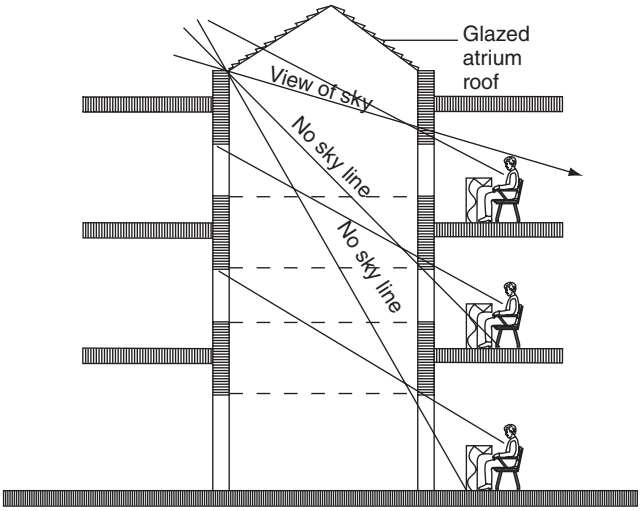
a low aspect ratio has $H/W < 0.3$
a medium aspect ratio has H/W between 0.3 and 1
a high aspect ratio has $H/W > 1$.

An atrium (a Roman open courtyard, but today the term usually means an inner courtyard roofed over with glass) may overheat in hot climates unless carefully designed. It will provide an attractive large space within a building that acts as a focus point and, like any lightwell, it will admit and reflect light into spaces that would otherwise have been dark. The fall-off in lighting levels will be quite rapid at lower levels, as the no-sky line is passed, Figure 42.34. It

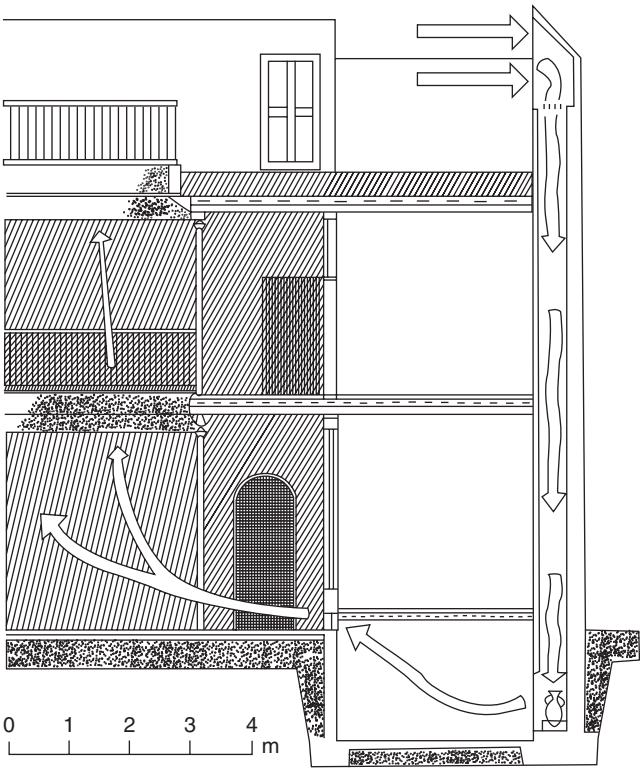


42.33 *Aspect ration of courtyards: a the low aspect ratio courtyard (H/W <0.3): access to external air is good, but there is little recirculation; b the medium aspect ratio courtyard (H/W 0.3–1): re-circulation becomes important; heat dissipation is better than in the low aspect ratio courtyard; c the high aspect ratio courtyard (H/W > 1): unless the courtyard acts as a solar flue, there will be turbulence at the top, but no air movement at the bottom*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



42.34 *The 'no-sky line' is the point at which the occupant is unable to see the sky: it is the point at which internal light levels drop off sharply*

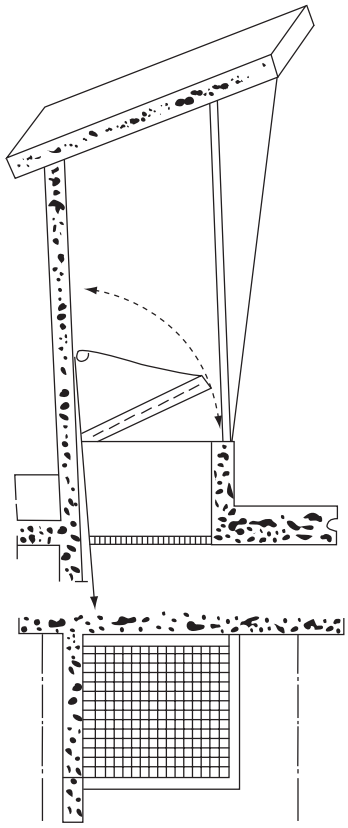


42.35 *A wind-catcher bringing fresh air into a basement. The air passes over the cool walls of the flue (shaded by neighbouring houses) and a porous jug containing water. Evaporative and contact cooling is effected*

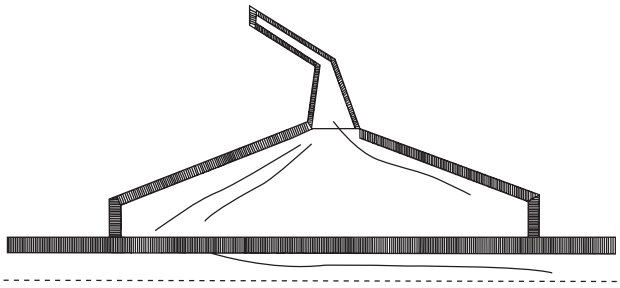
has the potential to act as a solar flue if adequately ventilated (naturally or mechanically), drawing stale air out of the surrounding spaces. In climates with regular rainfall, atria can provide considerable amenity as meeting, eating and sheltering spaces. Their height means that landscaping can include tall trees. Glare and brightness can be reduced by using blinds below the glazing, or temporary tented canopies above it.

4.5 Wind towers, wind scoops and wind catchers

Wind towers are air extract or inlet flues, used to ventilate and cool buildings. The origin of these towers is in the arid tropical climate of the Middle East, where they are used to ventilate and cool the lowest floors of town houses. Houses in these climates are enclosed, with few external openings, to keep out sand and dust,



42.36 *The trap on the wind-catcher can be closed and screens can be fitted to filter dust and leaves*



42.37 *The Bluewater Shopping Centre in Dartford, England uses giant revolving wind scoops, reminiscent of Kentish oast house*

as well as to minimise solar gain. They have a high thermal mass, which maintains some warmth in the cold winters.

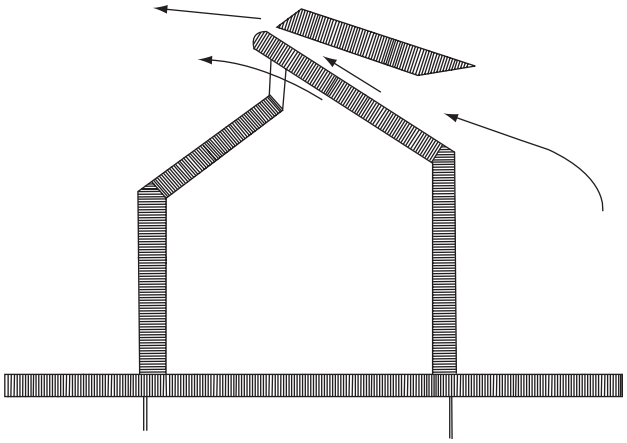
The prevailing breeze is caught and funnelled down into the base of the house through a duct or flue in a party wall. This flue does not receive any solar radiation, so it remains cooler than the rest of the house during the day. Incoming air is cooled by conduction during its contact with the cool walls of the flue and relative humidity is increased when it passes over porous water jugs, Figure 42.35.

In Iraq, the cool breeze is discharged into a basement, used for the afternoon siesta. During the hottest months, the roof terrace is used for sleeping at night. The top of the wind-catcher is capped to keep rain out, and usually can be closed in winter, when it will have the reverse benefit of keeping the house warmer. Screens keep birds and insects out of the flue, Figure 42.36.

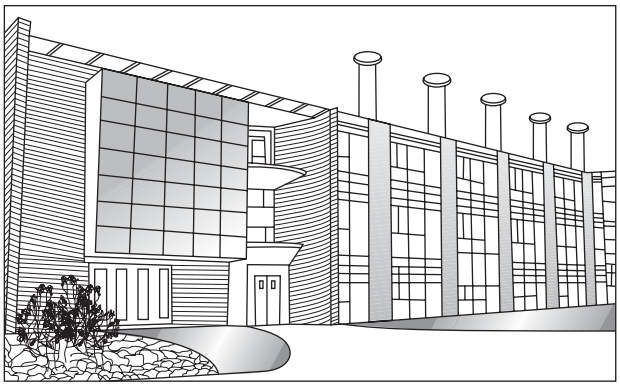
Urban wind towers

Air at street level in cities can be laden with toxic particulate matter and noxious gases. Air drawn from this environment will be polluted and will also introduce noise pollution. If we wish to use natural ventilation in city buildings, the cleanest air will be obtained from high level. Current UK government sponsored research focuses on the 'top-down' ventilation of urban buildings.

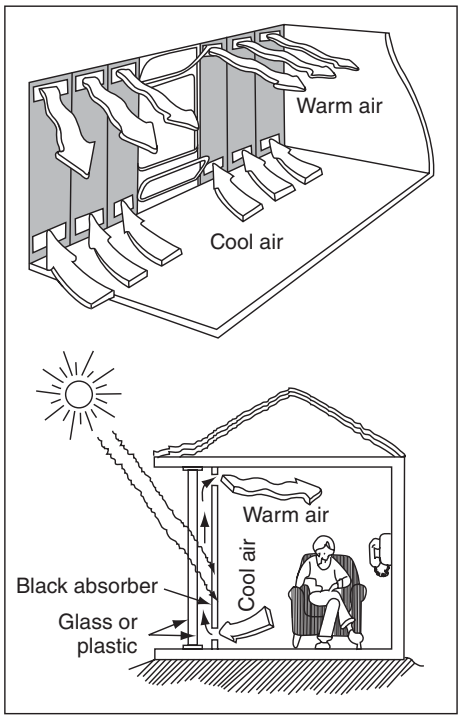
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



42.38 *Aerofoil shapes in conjunction with narrowing spaces act like aeroplane wings, creating pressure differentials that will draw air out of buildings*



42.39 *The Environmental Building at BRE, by Fielden Clegg Architects, is a demonstration/experimental building that makes use of solar flues*



42.40 *The Trombe wall: storing heat at the times of the year when it is needed. The Trombe wall (like the stone floor, in this instance) acts as a heat store, with the hot sun passing through glass onto both surfaces. The dense mass of these materials retains the heat and, after a time lag, releases the stored warmth into the room during the cold night (Bruce Anderson – The Solar House Book)*

In cities, the maze of streets, differing heights of buildings, levels of pollution, vortices, pressure differentials, etc. create local air movement patterns. Fixed wind-catchers can be ineffective in these situations, and scoops that can rotate with the wind become essential. The Bluewater development at Dartford, England uses large revolving scoops, Figure 42.37. Air inlets serving the flues may be windows, open courtyards, grilles, under-floor ducts (which can pre-cool the air) or wind scoops.

The use of wind towers reduces reliance on mechanical ventilation, chilling and air conditioning. Devices may also be used to accelerate air movement, and thereby improve ventilation, using aerofoils which catch the wind, Figure 42.38.

4.6 Solar flues

Solar flues are wind towers where air movement is achieved by heating the air in the tower or flue by intensifying solar radiation on the walls of the flue, as demonstrated by the Environmental Building at the BRE, Figure 42.39.

- the combination of the light-shelf and vertical fin will provide protection from lateral as well as overhead angles, but will trap hot air unless partially slatted to allow air movement;
- egg crates, or some other form of brises soleil can create a striking design which may also serve as a security screen, but keep horizontal elements away from eye level in habitable rooms as they can be visually disturbing;
- recent buildings in Europe have used metal screens suspended up to a metre away from the window. These can be visually striking and functionally effective. They may also have the effect of acting as a 'rainscreen';
- another recent development is the use of sophisticated tensioned wire 'rigging' which may be suspended over facades to provide a support for climbing plants. Plants may grow up from the ground or down from high level irrigated containers. They will provide an attractive dappled shade but will need maintenance.

4.7 Trombe walls

The Trombe wall is a thick dense wall within a building that receives and stores solar radiation (usually through the intensifying medium of glass) during daylight hours, and then radiates the heat into internal spaces during the evening. The wall is designed (material, thickness, location) to provide the desired time lag to provide the heat when it is most needed, Figure 42.40.

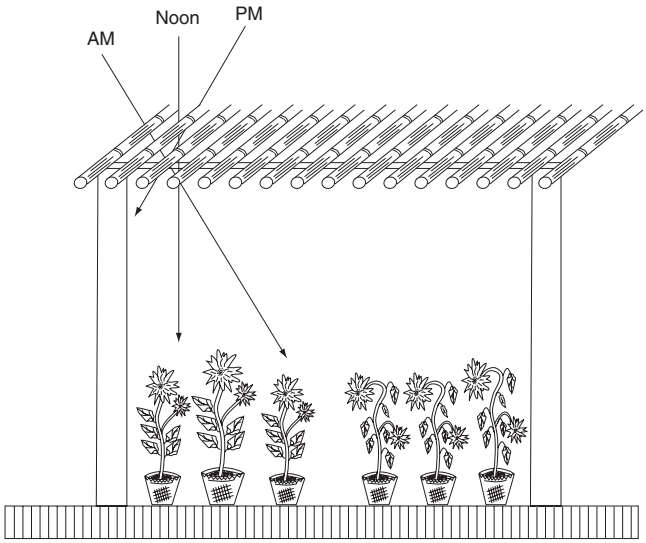
4.8 Site

Time and time again, in low and medium cost housing, the site layout is entrusted to a junior technician who has no concept of the importance of orientation or aspect. A house carefully designed to have principle elevations facing north or south is swung through 90° and meticulously lined up parallel to the next house so that there will be no breeze – and discomfort and dissatisfaction are assured. Orientation (and design to suit that orientation) are paramount, even if this conflicts with the normal good advice to follow the contour and keep substructure costs down. Building across the contour provides an opportunity to use a split-level plan, with associated discontinuities in the roofline to admit light and allow air movement.

4.9 Landscaping

Trees and lush landscaping, together with lakes, fountains, pools and other open bodies of water, are visually attractive and will induce cooling. Strategic planting of trees and shrubs can shade

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



42.41 *The shade house, roofed and walled with an open-woven split bamboo mat. Many tropical plants used in landscaping are forest species used to lower levels of light: using a slatted baffle allows a continual hit-miss pattern of daylight to pass over the plant as the sun moves across the sky, ensuring that the plants get adequate light on all sides, whilst being tricked into accelerating growth by the on–off daylight*

buildings and lower temperature, reducing energy costs in mechanical cooling by up to 40 per cent. This is achieved directly, by shading, and indirectly, through evaporative cooling induced by transpiration.

Plants grow quickly in the tropics and schemes can be established very quickly, but may require the establishment of on-site nurseries. Nurseries consume a lot of water and will require the construction of shade houses, Figure 42.41. The use of any hard or soft landscaping implies a commitment to irrigate, maintain, restock and clear leaf litter and rubbish from these areas, and to employ staff who will carry out these tasks. If sites such as roundabouts and the central strip of dual carriageways are to be landscaped, these will need a water supply, unless the landscaping is intended to be long-term and self-sufficient.

In some countries, landscaping is highly valued, state-supported and recognised as providing valuable employment; in others it is politically frowned upon, being seen as diverting funding from schools, hospitals and other socially important programmes. In either scenario, there may be a thriving agricultural industry that may include the cultivation of exotic species for exporting to distant world markets.

Soft landscaping that uses or integrates indigenous species will help to contextualise planting schemes and encourage use by wildlife. Whereas the mono-specific planting that is currently fashionable in Europe will not.

Hard landscaping strategies should take advantage of local materials and resources (such as local stone and specialised schools of carving and sculpting) and provide facilities for local cultural practices and acceptable activities (such as pavement cafes, street theatre, public exercise sessions, street traders and curio sellers). Public and company space may be required for sports (basketball, bowling, chess, football …). Some of these may need to be shaded. Sitting areas may need to be in the shade, rather than the sun, and drinking fountains may be required. Many activities, including produce markets, can be accommodated under shade structures, which lend themselves to simple but dramatic structural forms, such as shells or tents. Pergolas and shade trees, whether used for shading people or vehicles, should use species that give good dappled or deeper shade, have a root system that stays below paved surfaces, and that do not drop leaves, flowers, pods or fruit that will cause nuisance or damage.

An indicative list of tree and shrub species used in landscaping schemes is given in Table X. Unless listed as drought-resistant, most species will require irrigation in climates with a marked dry season.

4.10 Urban centres and street layouts

Temperature in cities

All large urban areas are hotter than the surrounding rural areas: people, industry, machines, vehicles, buildings – all generate heat, pollution and gases including CO_2. In hot climates, it is particularly important to incorporate heat sinks (lakes, parks, woodland) that can lower air and ground temperature.

Urban streets

Narrow streets are cooler than wide boulevards, unless these are planted with large street trees, Figure 42.42.

On streets running north–south, the higher the height to width ratio (*H/W* ratio), the less time the sun has on the street surface and on facades facing the street, Figure 42.43. The street will be cool in the morning and evening.

On streets running east-west, latitude becomes more important than *H/W* ratio, Figure 42.44. On or near the equator, the sun will be overhead or rising and setting on the street alignment. As distance from the equator increases, there is greater likelihood that in the hot season most of the street surface and the elevation facing the equator will receive solar radiation all day, whilst in the cold season, narrower streets and one elevation may be in shade all day, with the elevation facing the equator only receiving significant solar radiation when the sun is above the roof level of the buildings on the other side of the street.

Vehicles

Vehicles parked in open sunlight will become unbearably hot and petrol will evaporate. Car parking that is not inside or under buildings must be shaded by freestanding canopies, shade trees or pergolas. Parking areas and street layouts may need to take account of specialised vehicles (bicycle-rickshaws, horse-drawn cabs,

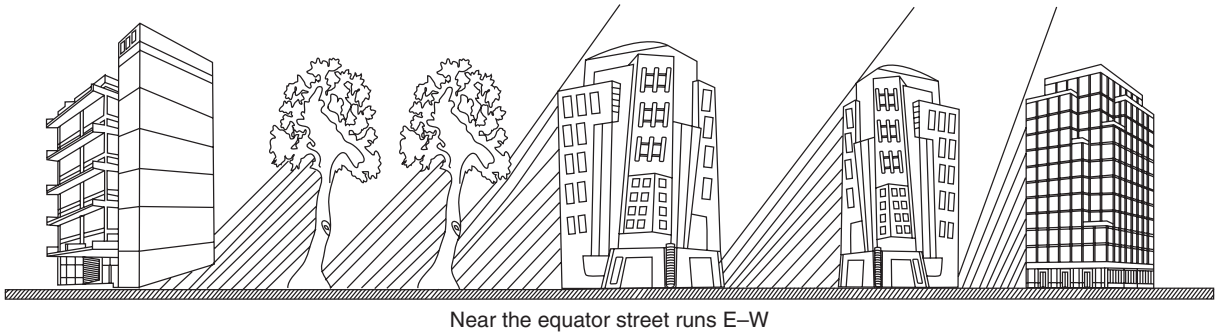


Figure 42.42 *The width of the spaces between buildings (in addition to their orientation) and the placement of large trees are critical to the amount of direct insolation they will receive*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table X Species used in tropical landscaping schemes

PLANT CHARACTERISTICS, REQUIREMENTS AND ORIGIN														SPECIES		
Plant species				**Habitat criteria**			**Continent of origin**									
Tree – **L**arge, **M**edium or **S**mall	Shrub – **L**arge, **M**edium or **S**mall	**C**limber	**H**erbaceous and other plants	Significant **F**lowers or foliage	Frost tolerant	Drought tolerant – **A**rid, **S**easonal	Altitude tolerant – Low, Med, High	Africa	Asia and Pacific	Australasia	Mediterranean Europe	North America	South and Central America and West Indies	Almost anything will grow in the tropics if it gets the right amount of water and humidity.		
														Species	**Description**	**Suggestions**
	M			O			H		✓					Acalypha wilkesiana (*Beefsteak plant, Jacob's coat*)	Medium sized shrubs with dramatic variegated foliage – predominantly green or brown with every leaf different – green/ yellow/cream/pink/red/brown. Leaves are large and obovate or narrow and dissected.	They are dramatic and reliable. It is easy to over-use them.
			H			A S								Agave americana (*Century plant*)	Large rosette-forming succulent with a sharp spine on the leaf tips, and a spiny cream margin. The flower spikes are up to 8m tall.	Agave species are used in mass planting, as specimens and as impenetrable hedges (traditionally around prisons).
			H					✓					✓	Aloe sp.	Tall spikes of massed small bell-shaped flowers rising from rosettes of agave-like fleshy leaves with spiny margins.	
S				F		S			✓					Bauhinia purpurea (Orchid tree)	Elegant fragrant purple, pink or white flowers. Erect tree, some varieties are more lax and have softer less waxy flowers. Pods long, thin and some split and spiral explosively.	Attractive small street or garden tree with beautiful flowers. Lax varieties wider spreading. Pods are noisy when they explode open.
		C				S							✓	Bougainvillea glabra	Vigorous spiny scrambler smothered in distinctive magenta bracts. Cultivars include white, orange, pink, yellow of varying vigour.	Can be trained to form mounds, will scramble up trees and over walls. Can damage foundations and roofs if planted too close to houses and not controlled.
						S			✓					Brugmansia × candida [Datura] (*Moonflower*)	Reliable shrub with powerful scent and pendulous trumpet-shaped flowers, usually white or cream, but occasionally pink or peach. There are double forms. Narcotic.	
														Caesalpinia pulcherrima (Pride of Barbados)		
S	S M									✓				Callistemon sp. (Bottle brush)	Evergreen small trees or shrubs. Upright or weeping forms. Lanceolate leaves and red bottle brush flowers of varying sizes.	

(continued)

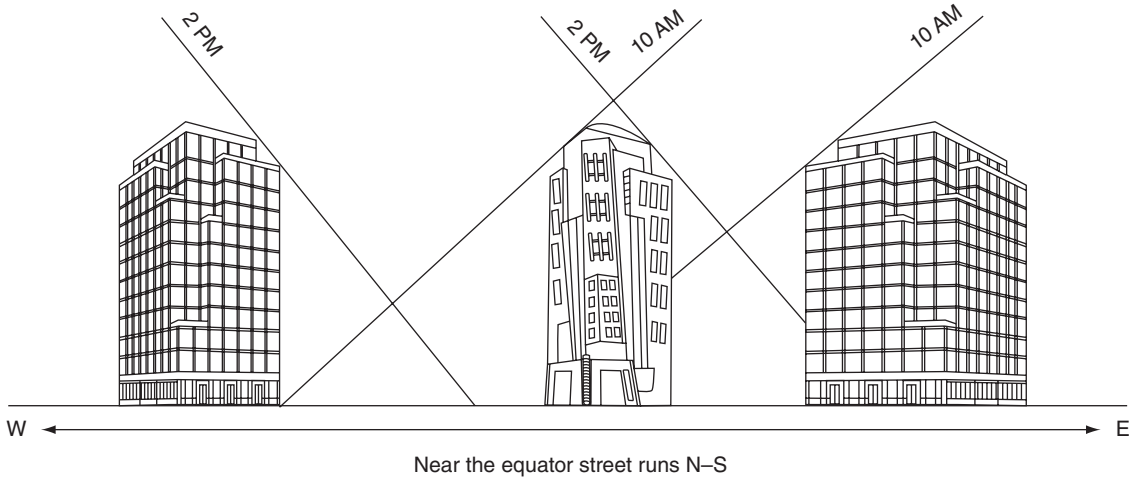
Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table X (continued)

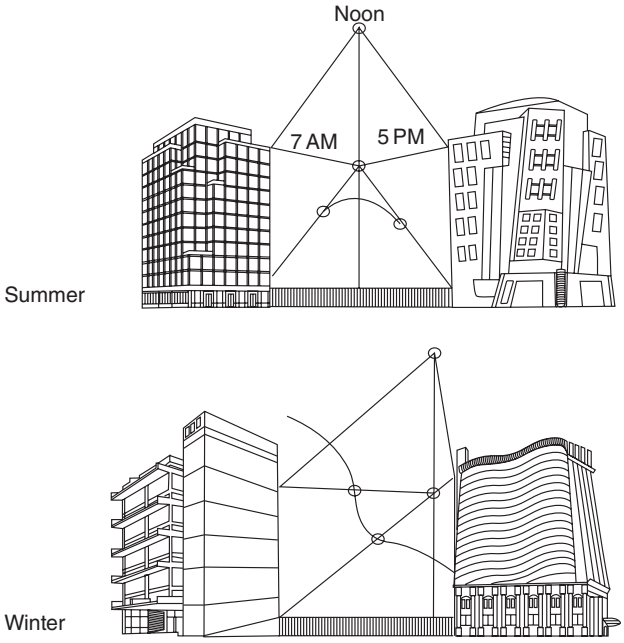
PLANT CHARACTERISTICS, REQUIREMENTS AND ORIGIN							SPECIES		
M		F		L M	✓		Cassia spectabilis	Fast-growing tree with dense umbrella shaped canopy and large pinnate leaves. Large upright panicles of sweet-scented bright yellow flowers.	So fast growing and spectacular, it will occasionally collapse under its own weight. Stunning as a street tree, where the regularity of size and form is exceptional.
M		G		L M		✓	Casuarina equisetifolia	Delicate foliage resembling a pine tree with long needles. Tolerates waterlogged ground and salt atmosphere.	Often planted on beaches as windbreaks and to stabilise the ground.
						✓	Cestrum nocturnum *(Queen of the night)*	Unexceptional shrub with sprays of narrow off-white tubular flowers that open at night with a very powerful scent.	Often planted too close to bedrooms. The scent can be overwhelming at close range.
		G			✓		Coedaium variegatura	Like Acalypha, but more upright, with smaller, thicker and glossier leaves and preferring a hot humid climate.	Attractive and reliable.
					✓		Congea tomentosa	A scrambling shrub with sprays of downy white to pinky-lilac bracts.	Looks spectacular on trellises or climbing up trees. The colour is subtle. Sprays can be dried.
L			S	L M H		✓	Delonix regia (*Flamboyant, flame tree)*	Elegant spreading tree with masses of bright red orchid-like flowers on leafless branches. Leaves are bi-pinnate, similar to the jacaranda, which it follows into flower. Wide range of climates and altitudes.	This stunning tree needs space to show off in and to be allowed to retain its carpet of fallen flowers. Surface roots prevent planting or development under the canopy.
					✓		Erythrina abyssinica	This large tree has distinctive red flowers and flat pods with decorative red seeds. Other Erythrina species are also used.	Occasionally used as a street tree, or in larger gardens.
						✓	Eucalyptus sp.		
	M	F	S				Euphorbia leucocephala *(snow bush)*	Medium sized shrub which is covered with spectacular rosettes of white bracts.	Spectacular in massed planting. Usually cut back hard each year to create a rounded bush about 1.5–2 m high.
					✓		Hibiscus rosa-sinensis	Shrub or small tree with showy red flowers. White, yellow, orange and pink varieties available.	Widely planted in the tropics. Best in humid lower altitudes.
L		F	S	M H		✓	Jacaranda mimosafolia	Stunning pale blue-violet flowers in clusters on leafless canopy in late dry season; large, airy bi-pinnate leaves with tiny leaflets.	Widely used as a street tree and in gardens; gives light dappled shade; surface rooter; grown at sea level and at high altitude in composite climates

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

PLANT CHARACTERISTICS, REQUIREMENTS AND ORIGIN									SPECIES		
	B			A	✓	✓		✓	Kalanchoe sp.	Large family of decorative flesh-leaved plants that put up a spike of bell-shaped flowers. Foliage is mostly grey, flowers mostly pink/orange.	Used for mass bedding without irrigation.
					✓		✓		Melia azedarach (*Neem tree*)	Large fast-growing tree with attractive but not spectacular racemes of pale lilac flowers.	Widely used as a street tree with lightly dappled shade. Found in any country with Indian (Asian) residents. All parts of the plant are poisonous.
									Nerium oleander (Oleander)	Pretty fragrant flowers on a shrub with lanceolate leaves.	
		C						✓	Petrea volubilis	Evergreen climber with pendulous racemes of beautiful star shaped lilac-purple flowers.	Covers walls, trellises and fences. Colour like the Jacaranda, which flowers at the same time, but more intense.
	L		F	S				✓	Poinsettia pucherrima	Large shrub with decorative bright red bracts. Many other species with a range of colours and forms. All are euphorbiacae – with latex sap.	Usually cut back hard after ‘flowering’. Avoid contact with latex. Needs 12 h of darkness to produce bracts.
		C						✓	Pyrostegia venusta	Vigorous evergreen climber with long flowering season. Clusters of bright orange tubular bell-shaped flowers.	Climbs tall trees, covers walls and looks spectacular as raised ground cover, trained over a wire framework.
								✓	Roystonea regia (Royal Palm)		
								✓	Russelia equisetiformis	Small tubular red flowers are set along the drooping rush-like stems.	Planted in raised beds, to allow it to droop.
s								✓	Solanum *(Potato tree)*		A decorative small tree.
		C						✓	Solanum jasminoides *(Potato creeper)*	Papery blue or white flowers on a shrubby climber to 5 m.	
L					✓				Spathodea africana (African tulip tree)	This large tree has erect terminal racemes of orange-red flowers emerging from hairy liquid-filled buds.	Street or specimen tree.
									Tecoma stans	Shrub with bright yellow bell-shaped flowers.	Widely used as a hedging plant. Withstands cutting well.
						✓			Thunbergia grandiflora *(Heavenly blue)*	A large climber. The flowers have five lilac-blue petals around a yellow tube.	Climbs over walls, fences and verandas.



42.43 *When streets run north–south, a narrow street near to the equator will only receive direct sunlight for a relatively short time – the principle used in the North African trading street – the souk*



42.44 *When streets near the equator run east–west, the sun will be shining into the street all day unless blocked by structures across the street*

articulated buses) and differing percentages of pedestrians, public transport, car ownership or bicycle use in cities.

Litter

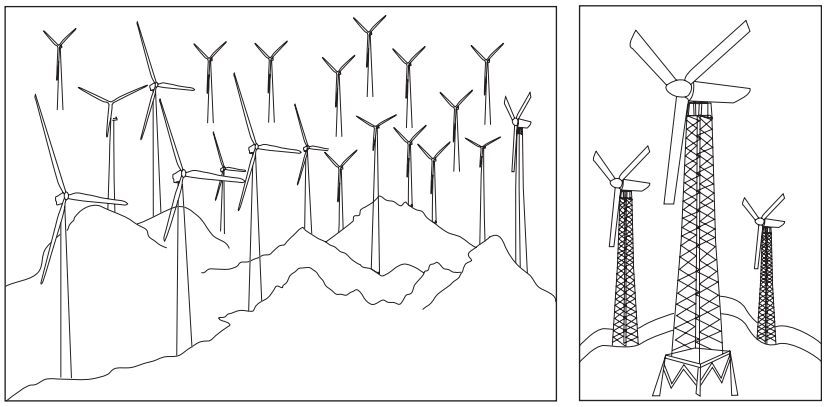
Some people generate more litter; some city administrations administer severe penalties for littering the streets (especially for dropping chewing gum or sugar cane waste).

5 ENVIRONMENTAL CONTROL STRATEGIES: ACTIVE MEASURES

5.1 Alternative energy

Energy supplies may be unreliable or non-existent on remote sites. Power may need to be supplied by a diesel generator, or some other means that capitalises on latent potential in or near the site, such as:

- *Biomass* – using crop and forestry wastes, slurries and rapid cropping trees and herbaceous plants which are dried, prepared and burnt, usually in a combination with gas, to produce energy.
- *Geothermal* – naturally occurring subterranean hot water and gas.
- *Biodiesel and biofuels* – ethanol may be a by-product of agroindustry (as in the conversion of sugar cane to granular sugar or cane spirit).
- *Solar power* – photovoltaics, water heating.
- *Water* – micro-hydro, estuarine and tidal mini turbines.
- *Wind* – free-standing wind pumps or building-integrated turbines, Figure 42.45.



42.45 *Wind turbines*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

5.2 Photovoltaics

Grid-connected BIPV are flat solar cells fixed to parts of the building envelope in an array that faces into the sun. They generate direct current (DC) which must be converted into alternating current (AC) and, although expensive and offering poor efficiency at present, can bring cost savings by downloading power to the national grid during the day, thereby reducing the cost of upload from the grid at night. These savings depend on an equitable arrangement with the national generating company, and on associated passive measures that use the building envelope efficiently. All photovoltaic cells use silicone, in various forms, and are either black or blue in appearance. The electrified arrays are dangerous, and must be installed, maintained and supervised by electricians with specialist expertise.

Photovoltaic slates have recently become available in the UK that appear no different to regular natural slates and which are claimed to achieve savings of up to 25 per cent on domestic energy consumption.

5.3 Wind turbines

If these are attached to buildings, the design must accommodate the swing of the turbine blades and the additional structural loading from vibration. Risk of damage and injury from broken blades must be assessed.

Turbines may be 500 mm or 50 m in diameter. Siting is critical. The Danish Wind Industry Association website gives extensive design guidance (www.windpower.org/en).

5.4 Ventilation and air conditioning

The need for mechanical aids and the costs in running and maintaining them will be reduced by passive design strategies that offer improved ventilation, shading and temperature management. Wherever possible, design out the need for mechanical solutions. Designers are increasingly using wind towers and solar flues to drive ventilation.

Ceiling fans

Allow adequate headroom below the blades of the fan. Ceiling fans give a wide distribution of blown air. Since the diameter of the fan is large, the fan can have a relatively low speed, reducing noise.

Typical installation:

- ceiling height 3.0 m minimum
- minimum blade height above floor 2.5 m
- fan diameter 1.0 m

Wall and floor-mounted fans: Because the blades are set within a cage, these can give higher air speeds and a more concentrated air stream. They may be fixed or can oscillate.

Typical data:

- mounting height 1.5–2.0 m
- angle of oscillation up to 60°
- 'reach' of blown air 3–4 m

Roof extract fans and passive stack vents: With light roof constructions, extract fans are used to remove hot air from the ceiling void and internal rooms. Internal air temperatures may be reduced by 3–5°C in climates where high solar radiation is combined with moderate air temperatures. The extract fan does not give perceptible air movement within the building.

Unit air conditioners: Room air conditioners are available with a cooling capacity in the range from 1.5 to 7 kW (Btus/h are commonly used to measure capacity as many manufacturers and designs originate in the USA). Specifications vary considerably and may include heaters and fan-only options, as well as chillers. They are usually accommodated in walls or under windows (often as afterthoughts). Unit air conditioners require external air for removing excess heat, a fresh air inlet and drainage for water removed from the air during cooling.

Split air conditioning units: Split air conditioning units have the following advantages over unit (or 'room') air conditioners:

- Minimal structural alterations if installed in an existing building or minimal requirements for new buildings: the two pipes connecting the condenser to the air handler will fit through a 100 mm hole.
- Greater security; important for banks, shops, etc.
- Reduced noise within the room, due to external position of condenser.
- Greater flexibility internally as air handler may be placed on internal wall or even ceiling.
- Improved external appearance as condenser may be placed on the roof, reducing problems of dripping condensate.

The disadvantage is:

- the condenser unit is unsightly and noisy and a space needs to be found for it: it may annoy the neighbours, rather than the room occupant.

6 STRUCTURE, SERVICES AND ENVIRONMENTAL DESIGN

6.1 Structural design

The structural form must be a viable economic choice and must facilitate the appropriate design response to climate. Hot arid climates suit dense masonry construction; hot humid climates suit a lightweight frame with a low mass ventilated infill. Composite climates require a mix – perhaps solid heat-storing floors with a lighter superstructure and adjustable shading. All structures must be able to withstand predicted climatic extremes that affect stability and structural integrity. There is less need for enclosure in all but the arid tropics and many structures will consist of a dramatic roof on exposed supports, with no permanent walls.

Concrete

Concrete is widely used in the tropics, where steel and other imported materials may be costly. Low-labour costs may have permitted the adventurous use of the plastic properties of concrete, in hypar, shell and other one-off forms (see the structures section). Use of concrete will depend on availability of cement and adequate water supplies. Taller buildings will need pumping capabilities. Hot climates may necessitate chilling of concrete (ice in tankers), the use of retarding agents and the shading and repeated wetting of poured concrete during the curing stage. Suitable formwork may be difficult to obtain.

Steel

Transportation costs may make steel structures uneconomic. Humid environments may necessitate special treatments. Steel doorframes and windows may be used in preference to timber, to reduce termite damage.

Timber

Timber should be from sustainable forests and must withstand termites, heat and desiccation or humidity, where applicable. Drying shrinkage and warping may be unacceptable. Seasoning may be required before timber can be used. The performance capabilities of each particular species must be known, especially for structural timbers. If large sections of structural timber are not available, glulam may be good alternatives (glulam – thin strips of timber built up in laminations to produce an attractive, consistent material with excellent structural properties). In some areas, profligate consumption of forest timber, in construction and as fuelwood, has left some forest species critically depleted. Converted timber, as plywood and other board products, may be available to locally established specifications.

Structural form

Design issues are highlighted in Table XI: Design of building elements.

Table XI Design of building elements

Element	Type	Advantages or purposes	Disadvantages or problems	Details
Structure	*Generally*	• Absence of freezing conditions • Regulatory controls may permit more imaginative solutions • Local expertise in alternative technologies may offer new design potential	• Climate extremes, including diurnal temperature range, wind and rainfall • Limited skills or technical knowledge in some places • Limited performance data on local materials (Are there local materials testing labs?) • Season restrictions on working (dust storm, monsoon, etc.)	• Check if in earthquake zone • Check windloading from cyclones, etc. • Obtain rainfall data for short-term loading on roofs, gutters, etc. • Consider sustainability of all aspects of design (embodied energy, consumption of non-renewable resources, environmental contamination and depletion, especially of water supplies)
	Loadbearing masonry	• Are bricks and stone local materials? • Is brickwork a local skill? • Is masonry part of the vernacular style? • Thermal mass • Able to accommodate small fillings and accommodate alterations	• Limited availability, quality and consistency of materials and accessories • Traditional clamp-firing may consume huge quantities of non renewable forest timber	• Check local practice • Is cavity wall construction used? • Establish strength and consistency of locally produced materials and materials testing regime
	Concrete frame and in-situ concrete work	• Is cement manufactured locally? • Is concrete construction a locally familiar technology? • Lower labour and formwork costs may facilitate one-off designs (hypars, etc.)	• Limited availability, quality and consistency of materials, plant and resources • Extreme care needed during curing	• Is/are formwork, reinforcement, mixing and transporting plant available? • Is there sufficient water for mixing, cooling, cleaning of plant?
	Steel frame	• Reusable material	• Limited availability, quality and consistency of materials and resources including skilled labour • Humidity	• What is the distance from foundry, workshop or supplier to site?
	Timber frame	• Timber produced locally? • From renewable forests?	• Resistance to humidity and termites • Effect of climate on lifespan	• Check windloading from cyclones, etc. • Strapping and bracing of timber elements
Floors	*Ground-supported floors*	• Use the delayed thermal flywheel effect of ground and/or floor mass to stabilise floor temperature and keep it cool (concrete, stone and ceramic floors always feel cooler and in some circumstances can be wetted to produce evaporative cooling – but this will increase humidity) • Reduce costs • Provide disabled access • Concrete floors are easy to clean – they are often waxed or polished in the tropics	• Seasonal flooding risk • Risk of rain splashback • Termites, vermin, snakes, etc. • Restricted structural option – concrete? • Suitability of ground conditions for foundation type • Risk of damp and mould growth • Concrete, stone and ceramic floors, if polished, can be very* slippery and cause accidents • Snakes may breed in poorly compacted hardcore under the slab	• Take precautions against termites and vermin penetrating the slab at junctions, changes of level, and points where the slab is penetrated by services or structure • The slab must be continuous (not split into bays separated by internal walls) • Keep termites out by poisoning soil (but avoid organophospates such as Aldrin or Dieldrin) or by using a special oversite steel mesh with a gauge too small for insects to penetrate (Australian solution) • Project slabs beyond foundations, with sharp external 90° angles which termites dislike • Floors with a high thermal mass should be kept shaded in hot weather, but can be allowed to absorb some solar radiation in the cold season to warm up the building (passive design).
	Suspended floors	• Keeps floor clear of seasonal flooding and splash-back from heavy rain • Keeps the floor away from termites and vermin • Use materials other than concrete, including open deck vented floors to improve air movement	• Floors should remain dry and free from damp • Security risk from below • Accessible soffit may be colonised by bats, snakes, etc. • Voids within the floor structure may be used by insects and small mammals (wasps, ants, etc.) • Termites may find timber and destroy it • In humid climates, damp and mould growth may accumulate unseen in sealed voids	• Low mass floors will maintain temperature closer to air temperature – an advantage in winter • All voids must be protected on the external faces by mesh strong enough to deter gnawing by rodents and of a gauge fine enough to keep out ants – except where bats, etc. are tolerated • Check timber floors (and structures) for fire risk from bush fires • Suspended floors may permit the introduction or seasonal use of vent stack/solar chimneys drawing cool air from shaded ground. • Leave underside of floor visible for inspection • Allow airflow and ventilation below the floor
	Raised access floors	• May be used to duct cooling air through a structure, or to recycle or remove heated air	• Do not contribute thermal mass • May be difficult to maintain • Insects and vermin may infest voids	• Failure of a raised access floor in an earthquake may critically affect escape from office buildings
	Intermediate floors and mezzanines	• Discontinuities in the building section, with mezzanine floors and variation in storey height, permit air movement	• Continuous floor slabs restrict vertical air movement • Structural continuity may be essential to maintain rigidity in earthquake zones	• Sound transmission • Spread of fire
	External floors, decks, platforms, balconies and terraces	• Can shade lower floors and walls • If in low mass materials (timber) and perforated, will reduce temperature and allow air movement	• May reflect light, glare and heat into buildings if light coloured and reflective, but if used as a light shelf, can shade windows whilst reflecting light off ceilings	• Outdoor living and sleeping in sun, shade or breeze should utilise roof spaces, courtyards, atria and the periphery of the building in a range of climate-responsive ways.
Ceilings	*Suspended ceilings*	• Ceiling may be used to deflect or reflect light • May contain heat or light sensors to adjust temperature, or the position of external or internal blinds	• Void may harbour insects and vermin – must be accessible • Void may trap hot air if poorly designed • Materials used for acoustic insulation in ceilings may be attractive to insects – avoid any containing cellulose	• Use wire or plastic mesh of appropriate gauge to keep out bats, birds, vermin whilst maintaining ventilation
	Exposed soffits; integrated ceilings	• Reduce costs	• Reduce options in servicing and air movement	

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Element	Type	Advantages or purposes	Disadvantages or problems	Details
Wall features	*Flyscreens*	• Essential in food preparation, kitchen and sleeping areas where any flying insect is a nuisance • In mosquito infected areas, *all* rooms should be fly-screened.	• Impede air circulation	• Usually green or black plastic or coated wire gauze – must be robust • Fix with timber bead or metal cramp
	Shutters	• Personal security • Protection from severe weather • Adjustable (American) shutters cut down glare • Cut down extraneous noise	• Trap heat	• Consider fixing and maintenance
Cladding	*Rainscreen*	• Allows use of rough finish to structure concealed behind rainscreen • Can be used over pisé/adobe	• Voids can harbour vermin and conceal defects and deterioration	• Consider fixing and maintenance
Roof	*Pitched roof*	• Essential in wet climates • Void can be used to vent inner rooms	• Can trap heat if not vented • Voids can harbour vermin and conceal defects and deterioration	• Large overhangs in wet tropics • Roof pitch, valleys, etc. must cope with intense rainfall
	Flat roof	• Can be used as sleeping platform	• Difficult to weatherproof against rainstorms • Climate change may cause unpredictable weather	• Security is increasingly an issue
	Double roof including aerofoil roof	• This structure places an open ventilated space between the weather-protection of the upper roof and the shaded element of the inner and lower roof, which may serve as a sleeping platform in hot weather • The aerofoil uses two converging and aerodynamically designed profiles to accelerate air movement over the roof	• May be vulnerable to storm damage in severe weather • There may be loss of security or privacy • Extra height • Extra cost • Aerofoil may need extensive modelling and testing to prove	• See Le Corbusier's houses in India and more recent European buildings

6.2 Design in earthquake zones

Earthquakes may occur anywhere on the globe, but are more common in the hotter regions. In earthquake zones, it is generally accepted that choosing the right type of structure is more important than minor variations in detail. Failures occur due to inelasticity – and these failures are difficult to model, especially in complex structures. Chilean good practice provides a good model: provide reliable strength, structural continuity and redundancy. Always work with a structural engineer. Always consider the impact of siting and landscaping and potential damage from surrounding structures and trees.

When designing buildings in earthquake zones, the following points should be noted:

Structural form

Use:

- simple, compact structural forms with continuous lines of structural force and inbuilt redundancies;
- compact symmetrical plans with maximum resistance to torsional stresses;
- symmetry in loading, fenestration, stair placement, cladding patterns and infilling.

Avoid:

- complex forms with irregular and diverted lines of structural force – H, L, T, U, X and E plan forms are particularly vulnerable, as vibration may differ along each axis;
- discontinuities in form, mass, storey height, materials, setbacks, overhangs, or in infilling, which may create a 'soft storey' at any level and precipitate failure;
- breaks in columns and shear walls – failure to continue upper floor columns and shear walls through the ground floor (creating a 'soft storey') have contributed to loss of structural integrity or serious progressive collapses in earthquakes (and terrorist bombings);
- windows within 600 mm of external corners.

Structural detail

- Engineers may adopt a weak beam/strong column philosophy to allow beams to flex more than columns.
- Corner columns are more at risk: elevations may act as plates and twist corners.
- The continuity, linking and placement of reinforcement can be crucial.
- Floor slab-to-column connections must resist punching shear.
- Continuous bottom reinforcement through slabs and beams will act as catenaries and resist collapse.
- Partial restraint of columns by partial height infilling can expose the remaining unrestrained section of the column to excessive shear at the expense of flexural yield, leading to failure.

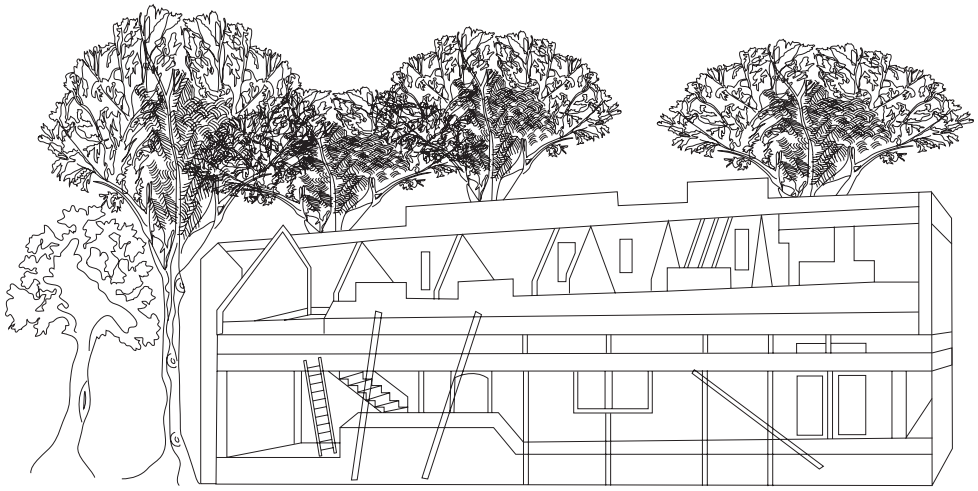
Damage and injury

- Some earthquake damage to the fabric will appear and must be accepted, but loss of structural integrity or collapse of inhabited buildings is never acceptable.
- All significant structural and non-structural elements (cladding, parapets, staircases, etc.) must be securely tied to the structural system.
- Protect escape routes from falling glass or cladding.

Non-structural elements

- Structural damage, gas explosions and fire can be caused by movement and failure of non-structural elements.
- Incoming gas services should have automatic safety shut off valves.
- Performance of structural elements can be compromised or altered by the action of non-structural elements.
- Injury and death can be caused by falling non-structural elements.
- Cost of repair of non-structural elements can render a building unviable.
- All large appliances, cylinders and tall furniture should be bolted or strapped in place and loose items such as crockery or books that could fall and cause injury should be stored at low level.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



42.46 *Braced timber-framed structures are likely to fail at their weakest point – usually where they are un-braced in their supporting storey of extended timber piles*

Concrete structures

- Concrete fill and landscaping soil on top of concrete slabs have no cohesion, no benefit and may cause excessive loads which contribute to collapse.
- Concrete structures shaken by successive earthquakes may suffer unseen and cumulatively worsening damage.

Steel framed structures

Assumptions that welded steel frames will have sufficient ductility to perform well during tremors have not been borne out by recent events in Kobe and California. Beam-to-column connections have cracked due to construction, material and bonding failures. Standards and codes have been revised in these areas.

Timber framed buildings

It is essential to create rigidity by using shear walls (studs stiffened by rigid ply panels) and to maintain continuity through the structure. Cripple walls, especially as aboveground substructure, form a 'soft storey' and are a regular point of failure, Figure 42.46. Structures built on top of piers must be securely restrained. Masonry chimneys set into timber framed buildings may collapse and upper floors with structural panels in the floor around the chimney will reduce the risk of injury.

6.3 Power

Mains power supply may be unreliable or only available in larger urban areas; however, many tropical countries have modern reliable utilities. Standards for voltage vary. The design of the distribution system is as for temperate climates except that high soil temperatures may lead to a requirement for cable sizes to be larger to avoid overheating and cables might need protection against termites and other hungry fauna.

6.4 Solar heating

At its simplest, a solar heater is a coil of hosepipe drawing water from the mains water supply which is set into a flat framed box set at an angle, usually on a roof, that will enable it to absorb the maximum amount of sunlight. In the box, the hosepipe is laid on a reflective surface, and covered with a sheet of heat-absorbing glass, both of which are designed to heat up the water in the hosepipe as quickly as possible. The heated water is drawn off as needed using separate taps, or is stored once a predetermined temperature is reached. These water heaters are simple and effective, but do not raise water temperature significantly on cold or heavily overcast days, when hot water is most needed. They also need maintaining, as the hose is subjected to extreme heat and has a relatively short life. Ready-made solar heaters use more sophisticated materials. The heated water is usually stored in a tank and drawn off as needed.

6.5 Water supply

Table XII gives standards that have been recommended by international organisations. However, the standards actually adopted must be related to local resources and conditions. In some countries, brackish water for irrigation is supplied by an independent system to conserve drinking water. Table XIII shows the large amounts of water required to maintain lawns and Western style gardens.

Where water supplies are erratic, scarce or costly, measures that reduce water consumption should be considered. These include using low-flush or dry toilets, showers in lieu of baths and the use of 'grey water'. Grey water is water that has already been used, in domestic washing, in chilling plant or in industry, and it is used to flush toilets and for uses other than drinking and cooking.

Design of a rainwater collection and storage system may be part of the building designer or services engineer's task. Water may be collected off expanses of sloping smooth surfaces, in seepage dams or in open tanks. Bacteria multiply at an astonishing rate in open water exposed to the sun.

Table XII Daily domestic water standards (litres per capita)

Distribution	Minimum (or reduced or temporary supply)	Normal	With wastage allowances
Standpipe for up to 100 persons	120	140	160
Single tap connections	120	160	180
Multiple tap connections	160	200	240
Multiple tap connections in areas of water shortage	100	150	–

Source: WHO, World Bank.

Table XIII Water supply for irrigation in hot dry climates

Type of vegetation	Water supply requirement	litres/hectare/day
Private gardens	Maximum	350 000
Private gardens	Average	225 000
Private gardens without grass		170 000
Irrigated vegetables	Average	80 000
Public parks		60–140 000
Tree plantations		2–7000

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

6.6 Sanitary installations and waste disposal

Sanitary appliances

Customary and religious practices vary. Some societies prefer the more ergonomically correct squat pan to the Western WC. Muslims wash in running water, so prefer the shower to the bath, and wash hand basins should have a mixer rather than separate hot and cold taps.

Foul sewerage

The capacity of piped systems will be related to the water supply standard. Where sewers are laid with low falls and where high soil temperatures exist, sewage may become septic and attack asbestos cement and cement pipes. Sewage disposal may be by pit latrine, aqua privy or septic tank in low-density development. Pit latrines require adequate space for replacements after the average life of five years, although this depends on soil conditions, etc. They should be stack vented. European toilets and septic tanks sized in accordance with Western data will not be able to cope with the bulky stools produced by a high-bulk cereal diet based on maize and similar cereals. Standard design data for septic tanks will be available. The length of tail drains depends on the soil type.

6.7 Storm and surface water drainage

Design rainfall intensities may not have been measured, making it difficult to calculate the size of gutters but indicative data could be collected on site. Tropical storms can have brief periods with rainfall intensities of 100 mm/h. Frequently, very heavy rain follows a long dry period during which drainage channels become blocked with sand and soil. In these zones, open or openable monsoon or storm drains are used to provide adequate capacity and ease of cleansing. Where piped systems are employed large sand traps are needed at each gully, and a minimum pipe size of 150 mm is necessary (200 mm is sometimes mandatory). Gradients should give a minimum self-cleansing velocity of 1 m/s. Roof gutters may not be provided at the eaves where torrential rains are experienced, as they cannot cope with the volume of water. Water discharges straight off the roof into open dish drains, or onto a wide concrete apron with a fall away from the building to prevent any splashback onto walls which may be single skin. Porches that redirect the water are needed at entrances. Mosquitoes would breed in shallow water lying in gutters with low falls. On larger buildings where gutters are provided, these may be in the form of heavy and costly concrete features, but large section gutters are becoming available in a range of materials, including aluminium and steel. Large gutters in GRP or other more flexible materials would need to tested for strength to withstand the full water load if not fully supported.

6.8 Controlling mosquitoes and other flying insects

Mosquitoes (and other insects, including moths) are attracted to bright lights, still air and water. Geckoes and chameleons eat them.

The normal means of deterring mosquitoes have been to:

- prevent insects from entering buildings at all times;
- attract insects away from buildings;
- protect the body at night, especially early evening – when mosquitoes are most prevalent;
- take measures to kill any insects that have entered buildings;
- increase air movement in and around buildings (mosquitoes like still air);
- eliminate breeding sites around buildings; and
- undertake mass spraying programmes over larger areas.

Design solutions include:

- fly-screening all windows and open doorways;
- using mosquito nets over beds;
- increasing air movement using fans, stack venting and wind funnelling devices;
- avoiding bright lights, especially in open sitting or dining areas;
- using exterior lighting to draw them away from occupied buildings;
- using electronic devices that use bright light or smell to attract and kill insects;
- eliminating all existing or potential areas of standing water where mosquitoes breed, which will include cutting back undergrowth and controlling landscaping.

Mosquito nets are essential, but they restrict ventilation. The net may be suspended from a timber or metal frame, like a lightweight four-poster, or from the ceiling on a frame or circular ring (a hospital net). The net should be long enough to tuck securely around and under the mattress.

The use of sprayed insecticides within buildings at night has traditionally included organo-phosphates and other cumulative poisons. Long-term use of these substances is harmful. All chemicals need to be treated with caution. In the tropics, spraying, on either the domestic or mass scale, may still be carried out using chemicals such as DDT, which are banned in the developed world.

Elimination of standing water is very important, and extends beyond the careful design of open gutters and drains to ensure that the fall is sufficient to take water away from inhabited areas. Some local authorities will have strictly enforced byelaws banning the planting of maize and other plants where the leaf forms a sheath around the stem, trapping water. Water used in landscaping should be agitated by fountains or the recycling mechanism and not allowed to become stagnant. Swimming pools and their overspill areas will need similar care, especially if not treating with the type of chemicals that keep insects at bay. Other breeding sites can include sedimentation ponds on sewage farms, agriculturally dammed fields (paddy fields) and the large lagoons that linger in low-lying areas after heavy rains or coastal storms.

7 BUILDING SCIENCE DATA

7.1 Sun path diagrams

The use of sunpath diagrams and shadow angle protractors is fully detailed in the texts listed in the Bibliography. When the sunpath diagrams for the northern hemisphere are used for the southern hemisphere, changes should be made to the time, month, azimuth, direction as shown in Table XIV. Shading coefficients are given in Table XV. Online sunpath calculation tools are available.

7.2 Albedo (also known as solar reflectance or ground reflectance)

Albedo is the percentage of solar radiation reflected from a surface, compared to the incoming (incident) solar radiation that the surface receives. The term signifies ‘Whiteness’ and therefore reflectance within the visible spectrum, but is usually taken to mean total short-wave energy. Albedo varies according to the colour, seasonal

Table XIV Changes for sunpath diagrams in southern latitudes

Time (solar time)		Date		Azimuth degree clockwise		Direction
North→South		North→South		North→South		North→South
4	20	28 Jan	30 July	0	180	
5	19	28 Feb	30 Aug	30	210	
6	18	21 Mar	23 Sept	60	240	North–South
7	17	15 April	15 Oct	90	270	
7	17	15 May	15 Nov	120	300	
11	13	22 June	22 Dec	150	330	East–West
12	12	30 July	28 Jan	180	360	
13	11	30 Aug	28 Feb	210	30	
13	11	23 Sept	21 Mar	240	60	South–North
17	7	15 Oct	15 April	270	90	
18	6	15 Nov	15 May	300	120	
19	5	22 Dec	22 June	330	150	West–East
20	4			360	180	

Table XV Shading coefficients: the quantity of solar radiation transmitted as a proportion of that transmitted through clear glass

Fenestration	Shading coefficient
Clear 6 mm glass	1.00
Glass with internal dark roller blind	0.70–0.80
Glass with internal dark Venetian blind	0.75
Glass with internal medium Venetian blind	0.55–0.65
Glass with internal white Venetian blind	0.45–0.55
Glass with external miniature louvres	0.50–0.10 (depends on angle of incidence)
Glass with dark canvas external awning	0.20–0.28
Glass with dense trees providing shade	0.20–0.30
Glass with movable louvres	0.10–0.20
Heat absorbing glasses	0.45–0.80

Table XVI Albedo of surfaces on and around buildings*

Category	Type	Albedo (%)
Soil	White sand	34–40
	Light clay	30–31
	Grey earth – dry	35–30
	Grey earth – moist	10–12
Natural vegetation and ground cover	Fresh snow	75–95
	Rock	12–15
	Tall grass	18–20
	Deciduous woodland	18
	Short grass – lawn	23–25
	Water – lakes, sea	3–10
Building materials	Weathered concrete	22
	Red cement tile	18
	White concrete tile – new	77
	Asphalt shingle – black	3.4
	Asphalt shingle – white	26
	Coated metal roofing – white	59
	Coated metal roof – slate blue	19
	Coated metal roof – various greens	8–24
	EPDM – grey	23
	Aluminium roofing – untreated	71

*Sources: Muneer (1997) [soil and vegetation] and Parker et al. of FSEC (2000) [building materials, except 'weathered concrete'].

variations in ground cover (snow, deciduous trees, crops) and, to a lesser extent, humidity of the surface covering. To avoid overheating, surfaces exposed to solar radiation will have low absorptivities and high emissivities (high albedo) and, to accumulate heat gains and act as heat stores, will have high absorptivities and low emissivities (low albedo). Table XVI gives the albedo for a range of surfaces.

For all materials:

$$\text{Reflectivity} = \frac{1 - \text{absorptivity}}{(\text{for radiation of a given wavelength})}$$

$$\text{Absorptivity} = \text{emissivity (for radiation of a given wavelength)}$$

$$\text{Albedo} = \frac{\text{reflected solar radiation}}{\text{incident solar radiation}}$$

Pale surfaces reflect the greatest percentage of incident radiation, thereby reflecting the associated heat away from the surfaces of the building or paving. This may make glare and heat gain worse in the adjacent building. The impact of albedo on the heat island effect in cities is an area of current research in many centres. Trees, with a low albedo, will lower temperature through different mechanisms – including metabolism and transpiration; bright surfaces reduce temperature by reflection. In the city, surfaces tend to be dark and with a low albedo (brick, asphalt, slate) so they absorb and store heat that can not easily be radiated back into the sky due to the canyon effect of city streets. These raised temperatures accelerate decay of the urban fabric, exacerbate pollution and worsen ozone concentration. Smog in the atmosphere above cities traps the hot air beneath it. It would appear that tree-planting in cities has greater benefits than high albedo of surfaces, especially as we know that raising albedo outside the city, by stripping tree cover and replacing it with cultivation, has the effect of lowering rainfall and increasing the risk of drought.

7.3 Sol air temperature

Sol air temperature is the temperature of the outside air that would give the same rate of heat transfer and the same distribution of temperature through a construction as the combined effects of solar radiation and air temperature. Sol air temperature will be higher than air temperature when a surface is subject to solar radiation:

$$\theta_{sa} = \frac{\alpha I}{f_o} + \theta_o$$

where

θ_{sa} = sol air temperature (°C)
α = absorptivity of surface to solar radiation
f_o = outside surface conductance (W/m^{2}K)
I = intensity of solar radiation (W/m^2)
θ_o = outside air temperature (°C).

The solar heat factor is the heat flow through the construction due to solar radiation, expressed as a proportion of the total solar radiation incident on the surface of the construction. When a building has large openings and is well ventilated to the exterior (as is often the case in the tropics), the solar heat factor is dependent on the *U*-value and absorptivity (the external surface conductance 'f_o' can be taken as a constant):

$$\frac{q}{I} = \frac{U\alpha}{f_o}$$

Surfaces will be hottest when wind velocities are low; therefore, external surface resistances for cold conditions should not be used. In hot conditions with low wind speeds, a recommended value for f_o is 20 W/(m^{2}K). If the solar heat factor is expressed as a percentage then:

$$\frac{q}{I} = \frac{U\alpha}{20} \times 100 = 5U\alpha$$

U-values may be increased if absorptivities are proportionately reduced, while still maintaining a constant solar heat factor. Most reflective surfaces require regular maintenance to remain effective, so if maintenance or repainting of surfaces cannot be assured, *U*-values should be decreased to obtain realistic standards.

A solar heat factor of less than 4 per cent will ensure that ceiling temperatures will not be more than 5°C above air temperatures and will not add to discomfort.

The approximate absorptivity of solar radiation of paints can be calculated if the Munsell value is known (as it is for colours in the BS range of paints for building purposes). The 'value' of the colour is given by the number which appears after the 'hue' letter in the Munsell number. This should be substituted for V in the formula:

Absorptivity = 100 − <V(V–1)] (for solar radiation)
Example: Munsell number 6.25Y8.5/13 (Yellow)
V= 8.5, Absorptivity = 38% (at low temperatures most paints have an emissivity of 80–90%).

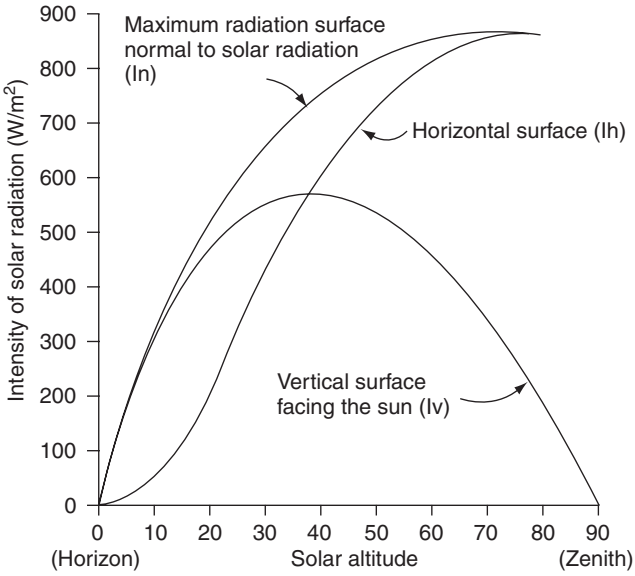
7.4 Solar radiation

The intensity of solar radiation on a surface depends on the altitude of the sun, the orientation of the surface in relation to the sun and the absorption of solar radiation by the atmosphere, pollution, cloud, etc., Figure 42.47.

Calculation: For vertical surfaces inclined at an angle θ to the azimuth (horizontal angle of sun on plan), the intensity of radiation on surface I will be:

$I_\theta = I_v \times \cos\theta$, where I_v is taken from Figure 42.47.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



42.47 *Intensity of solar radiation*

Table XVII Increase in solar radiation with altitude

Height above sea level	Altitude of sun in degrees				
	20°	30°	40°	60°	80°
900	1.14	1.12	1.10	1.08	1.08
1500	1.26	1.20	1.17	1.15	1.15
3000	1.30	1.31	1.28	1.25	1.23

Table XVIII Effect of cloud and atmospheric pollution on radiation*

Very low humidities and clear skies	1.1 (increase)
High humidities and pollution 'clear sky'	0.9 (decrease)
Overcast sky	0.1–0.3 (decrease)

*Varies greatly with cloud and solar altitude

Table XIX Illumination from a design sky

Latitude (N or S)	Design sky illumination
0°	17 000 lux
10°	15 000 lux
20°	13 000 lux
30°	9 000 lux
40°	6 000 lux
50°	5 000 lux

The altitude and azimuth of the sun can be found from sunpath diagrams or online calculation tools. The radiation from Figure 42.47 should be multiplied by the values from Tables XVII and XVIII to give total radiation at the appropriate altitude and/or for appropriate atmospheric conditions.

7.5 Illumination from sun and sky in the tropics

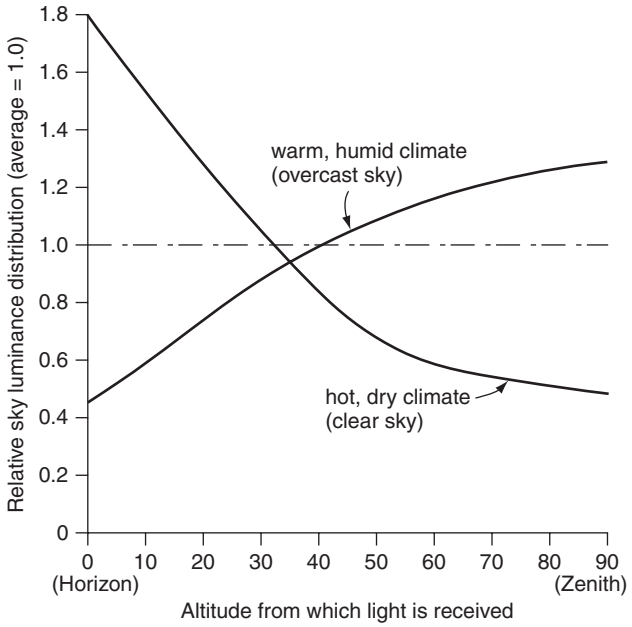
Illumination at work surfaces

The illumination required at the work surface for a given task is the same regardless of latitude. However, since light is associated with heat (both physically and psychologically), there is a case in the tropics for adopting slightly lower lighting standards to achieve higher levels of thermal comfort. In some countries, the cost of achieving high lighting standards may also be a factor.

The illumination from the sky is greater in tropical and subtropical regions so that a lower daylight factor can be used to achieve the same illumination at the work surface. The illumination from an overcast sky varies with latitude, altitude, degree of cloudiness and pollution. A guide is given in Table XIX.

Table XX Sun, sky and ground brightness

Hot dry desert conditions	Sky (away from sun)	3 000 lux
	Sun	50 000 lux
	Ground (20% reflectivity)	11 000 lux
Warm humid equatorial conditions	Sky (overcast)	10 000 lux
	Ground (20% reflectivity)	2000 lux



42.48 *Sky luminance distribution*

Position of windows – overcast skies

An overcast sky can be extremely bright and cause unacceptable glare from higher angular altitudes above 35°. Windows that offer a view below the 35° angle will increase comfort. In the warm humid equatorial regions, however, the luminance of the constant overcast sky may drop to 10 000 lux or below.

Position of windows – clear skies

Hot dry desert regions receive light mainly from direct sunlight and considerably less from the (usually) deep blue sky, so windows should allow a view of this high altitude deep blue sky rather than along the horizon, which can reflect glare from distant haze and the sunlit ground. The window must be protected from direct solar radiation, if facing into the sun's path.

Incidence of light

Table XX gives a very rough comparison of the relative amount of light from different sources. Figure 42.48 shows the relative sky luminance distribution in hot dry desert climates with a clear sky, and for warm humid climates with an overcast sky. (It is assumed that the warm, humid climate has a similar distribution to the CIE standard overcast sky.)

7.6 Glazing used in solar control

The best way to reduce solar radiation heat gain is to reduce window size (or provide external shading). Special solar control glass absorbs heat and this will cause thermal expansion, Table XXI. The high temperature of the glass may also cause physical discomfort. For comparison, a sheet of aluminium or an uninsulated concrete slab has been included in the table. Most special glasses will match these temperatures.

Body-tinted glass

Oxides are added to clear glass to change the colour and vary light and solar radiant heat transmission: iron oxide (green), cobalt oxide (grey and blue) and selenium oxide (bronze). Increased thickness darkens the colour and reduces light and heat transmission.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table XXI Solar heat gains through glass*

Fenestration	Visible radiation transmitted %	Direct solar radiation transmitted %	Total solar radiation transmitted %	Index of increase of surface temp. above air temp (clear glass = 1)
Clear float glass	85	80	84	1
Glass with reflective polyester film	18	17	25	2
	33	31	39	2
Solar energy reflecting glass	42	47	52	2.5
	58	59	62	4
Surface modified heat absorbing glass	50	56	67	3
	50	48	62	4
Tinted solar control glass grey	42	45	62	4
	42	40	58	4
	24	22	47	4
	19	16	43	4.5
	76	52	66	4
green	74	45	61	4
	62	30	51	4
Clear glass with open weave curtain internally	40	70	82	1
Corrugated aluminium (new)	0	0	9	2
100 mm concrete	0	0	15	4

* Ranges of products are given. Consult manufacturers for specific data.
Sources: Manufacturers' data; heat gains through fenestration. F. J. Lotz and J. F. van Straaten, CSIR: R/Bov 223.

Coated and surface modified glasses
A film of microscopically thin metallic oxides is laid on the surface of clear or body-tinted glass and is usually protected or sealed within a sandwich of two or more layers of glass. Film performance is independent of glass thickness. Coated glasses receive their coating in a vacuum chamber; surface modified glasses are produced during the float process, using clear glass.

These coated and surface-modified glasses may modify:

- light transmission
- solar radiation properties
- thermal insulation characteristics (by modifying surface emissivities).

Glass blocks
Glass blocks are available with different surface finishes that can diffuse, reduce or deflect light transmission. The mortar joint reduces thermal performance when compared to double-glazing, but they can also serve structural or fire protection functions. Most manufacturers recommend that glass blocks be used in shaded locations as the blocks can overheat or, in some cases, act as prisms with consequent risk of fire.

7.7 Wind

The Beaufort wind scale was initially developed for use at sea. It does not indicate wind speed and is usually replaced today by wind speed, measured 10 m above ground, in knots. Table XXII provides a conversion chart.

Wind loading on buildings varies with height, as friction with the ground slows down the wind at lower levels. This wind gradient is complex, but may be calculated. The American (USA) Building Codes give gradients levels of 300 m for cities, 400 m for suburbs and 500 m for flat open terrain. Structural engineers may use the power law wind speed profile given below:

Table XXII Beaufort scale: descriptors and equivalent speeds for use on land. Separate descriptors apply at sea

Force	Description	Miles/hour	Kilometre/hour	Knots	Specification on land
0	Calm	0–1	0–1.6	0–1	Smoke rises vertically
1	Light air movement	1–3	1.6–5	1–3	Direction shown by smoke but not wind vanes
2	Light breeze	4–7	6–11	4–6	Wind felt on face, leaves rustle
3	Gentle breeze	8–12	13–19	7–10	Wind extends light flags, leaves in constant motion
4	Moderate breeze	13–18	21–29	11–16	Raises dust and loose paper, small branches are moved, onset of mechanical discomfort
5	Fresh breeze	19–24	31–39	17–21	Small trees in leaf begin to sway, uncomfortable in urban areas
6	Strong breeze	25–31	40–50	22–27	Large branches in motion, telegraph wires whistle, umbrellas difficult to use
7	Near gale	32–38	31–61	28–33	Whole trees in motion, difficult to walk against wind
8	Gale	39–46	63–74	34–40	Breaks twigs off trees, generally slows down walking
9	Strong gale	47–54	76–87	41–47	Slight structural damage occurs, tiles and slates dislodged
10	Storm	55–63	89–101	48–55	Seldom experienced inland
11	Violent storm	64–72	103–121	56–63	Trees uprooted
12	Hurricane	73–83	122+	64–71	Rarely experienced, accompanied by widespread damage
13–17	Beaufort numbers from force 13 to force 17 were added in 1955 by the United States Weather Bureau in 1955 to accommodate the exceptional winds experienced during a hurricane.				

$$v_z = v_g \cdot \left(\frac{z}{z_g}\right)^{\frac{1}{\alpha}}, 0 < z < z_g$$

where:

v_z = speed of the wind at height z
v_g = gradient wind at gradient height z_g
α = exponential coefficient

Effect of internal wind speeds in warm humid climates
We can measure the effect of air movement within buildings, Table XXIII.

Hurricanes, typhoons, tsunami and tornadoes
Terminology varies from region to region. In addition to generating abnormally high wind loads, hurricanes, typhoons and tornadoes also cause extreme pressure differentials. Structural detailing and the fixing of non-structural elements must withstand the forces

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table XXIII Effect of internal wind speed in warm humid climates

Windspeed M/minimum	Effect
0–15	Not noticeable, less than 1°C of apparent cooling to the body
15–30	Cooling just noticeable – effect equal to a drop of temperature of 1–2°C
30–60	Effective and pleasant cooling
60–100	Maximum windspccd for cooling without undesirable side effects
100–200	Too fast for desk work; papers start to blow around
+200	Too fast and uncomfortable for internal conditions

Table XXIV Effect of wind on sand

Windspeed M/minimum	Effect*
200	Sweeping sand. Visibility not impaired. Sand blown along the surface or up to 1 m above the ground.
300	Driving sand. Visibility impaired. Sand rises up to 2 m above the ground.
600	Sandstorm. Particles of sand remain suspended in the air.

*Depends on size of sand grain and on sand humidity.

Table XXV Time lag for homogeneous materials (in hours)

Materials		Thickness of material (mm)					
		25	50	100	150	200	300
Dense concrete	minimum	–	1.5	3.0	4.4	6.1	9.2
	maximum	–	1.1	2.5	3.8	4.9	7.6
Brick	minimum	–	–	2.3	–	5.5	8.5
	maximum	–	–	3.2	–	6.6	10
Wood	minimum	0.4	1.3	3.0	–	–	–
	maximum	0.5	1.7	3.5	–	–	–
Fibre insulating board	ave	0.27	0.77	2.7	5.0	–	–
Concrete with foamed slag aggregate	ave	–	–	3.25	–	8	–
Stone	ave	–	–	–	–	5.5	8.0
Stabilised soil	ave	–	–	2.4	4.0	5.2	8.1

caused by the negative and positive pressure generated in these storms. Most countries experiencing these climatic events have appropriate building regulations concerning fixing and bracing for roofs, windows and structural design loadings. The risk of lightning strikes must also be considered. Electrical storms can be frequent and dramatic.

Sandstorms

Table XXIV shows the effect of wind on sand movements. This may vary with building height, sometimes becoming more severe at greater heights. Tight closing of all openings is required to reduce nuisance from blown sand. Finishes may need to withstand scouring and abrasion. Complete protection is not usually practical.

7.8 Ventilation

Data on ventilation requirements and on mechanical ventilation is now widely available from CIBSE and other professional engineering institutions.

7.9 Lag

Time lag is the phase difference (delay) between external periodic variations in temperatures and the resulting internal temperature variations. The period of variations is 24 h and the lag is measured in hours. Table XXV gives time lag for homogeneous materials. For composite construction, the order in which different layers are placed can change the time lag considerably. If insulation is placed on the external surface of a dense material, the time lag is considerably increased. Table XXVI gives the time lag of a range of constructions. Although the time lag indicates when the thermal impact of outside temperature swings will affect the interior, the actual internal conditions can only be calculated when the heat flow into rooms and onto all room surfaces is considered.

Table XXVI Time lag for composite roof constructions

Construction		Time lag (hours)
(described from the external surface inwards)		
40 mm	Mineral wool	
100 mm	Concrete	11.8
100 mm	Concrete	3
40 mm	Mineral wool	(same as concrete alone)
14 mm	Cement plaster	
165 mm	Concrete	
14 mm	Cement plaster	3.8
14 mm	Cement plaster	
50 mm	Vermiculite concrete	
115 mm	Concrete	
14 mm	Cement plaster	13
Any finish		
25 mm	Expand polystyrene any structural concrete slab	over 8
Any finish		
75 mm	Lightweight concrete screed	
100 mm	Concrete slab	over 8
30 mm	Concrete tiles	
20 mm	Motor bed waterproof membrane	
60 mm	Screed	
240 mm	Hollow pot slab	
14 mm	Render	12

8 BIBLIOGRAPHY, INFORMATION SOURCES AND FURTHER READING

Regional Building Research Institutes
Governmental Agencies (such as the local Ministry of Works)
Professional bodies
Centres with expertise, including aid agencies
Regional Trade Associations using locally sourced or manufactured materials
National Archives

Websites

Website references were correct at the time of printing, but are tiresomely ephemeral. Check copyright notices and disclaimers before using material. Most aspects of tropical design are extremely well covered on the Internet.

Alternative energy including Photovoltaics

CIBSE TM25 – Dr Rosemary Rawlings & Mark Roper (2000)
Understanding building integrated photovoltaics, CIBSE
Studio E Architects (2000) BIPV Projects: photovoltaics in buildings, DTI New & Renewable Energy Programme, London
The Centre for Alternative Technology – www.cat.org.uk
The Energy Technology Support Unit (ETSU) – www.etsu.com
The International Solar Energy Society – www.ises.org

Climate

Givoni, B. ed. (1969) *Man, Climate and Architecture*, Elsevier, London
Koenigsberger, H., Ingersol, T. G., Mayhew, A. and Szokolay, S. V. (1974) *Manual of Tropical Building and Housing: Part 1 – Climatic Design*, Longman, Harlow
Couto Erminda da C. G., Zyngier, Nicole A. C., Gomes, Viviane R., Knoppers, Bastiaan A. and Landim de Souza, Marcelo F. DIN and DIP budgets for Maricá-Guarapina coastal lagoons, Rio de Janeiro State Bureau of Meteorology, Australia – www.bom.gov.au/lam/climate
US Department of Energy
www.worldclimate.com
www.weathersite.com
The Met Office – www.met-office.gov.uk
www.millennium-debate.org/climatechange.htm

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Design

Fathy, Hassan (1986) *Natural Energy and Vernacular Architecture: Principles and Examples with Reference to hot Arid Climates*, The University of Chicago Press, Chicago

Fry, Maxwell and Drew, Jane (1964) *Tropical Design*, Batsford

Oliver, Paul ed. (1976) *Shelter in Africa*, Barrie and Jenkins Ltd

Hyde, Richard (2000) *Climate Responsive Design: a study of buildings in moderate and hot humid climates*, E & FN Spon

Konya, Allan (1980) *Design Primer for Hot Climates*, Architectural Press

Littlefair, P. J., et al. (2000) Environmental site layout planning: solar access, microclimate and passive cooling in urban areas, BRE

Tzonis, A., Lefaivre, L. and Stagno, B. eds. (2001) *Tropical Architecture: Critical Regionalism in the Age of Globalisation*, Wiley-Academy

Earthquakes

British Geological Survey – www.gsrg.nmh.ac.uk

US Geological Survey – www.earthquake.usgs.gov

National Earthquake Information Centre World Data Center for Seismology – www.neic.usgs.gov

Moehle, J. P. and Mahin, S. A. (1991) Observations on the behaviour of reinforced concrete buildings during earthquakes, American Concrete Institute publication SP-127, re-published by National Information Service for Earthquake Engineering – University of California, Berkeley – www.eerc.berkeley.edu/lessons/concretemm.html

The US Federal Emergency Management Agency (FEMA) has research on steel frame buildings – www.fema.gov

The American Plywood Association – APA Homeowner's guide to earthquake safeguards – www.mcvicker.com/twd/apa/eqguide/eqguid01.htm

Building Research Station Tropical building legislation: model building regulations for small buildings in earthquake and hurricane areas, 1966

Economics

Roberts, Peter (1995) *Environmentally sustainable business: a local and regional perspective*, London: Paul Chapman Publishing

Health

World Health Organisation – tropical diseases home page – www.who.int/tdr/

Hospital for Tropical Diseases, University College Hospital and Mortimer Market, London – www.uchl.org/services/htd/

Housing

NBRI Researchers (1987) Low Cost Housing, National Building Research Institute, Council for Scientific and Industrial Research, Pretoria, South Africa

Monographs

Taylor, Brian Brace (1995) *Geoffrey Bawa*, Thames and Hudson, London

Natural light (daylight, sunlight)

Online sunpath calculation tool – www.susdesign.com/sunangle/ – Read the disclaimers and shareware notices

Bartlett School of Graduate Studies (1998) Daylighting design in architecture: making the most of natural resources, BRESCU CIBSE LG10:1999 – Daylighting and Window Design, CIBSE

Lam, W. (1986) *Sunlight as Formgiver for Architecture*, Van Nostrand, New York

Littlefair, P. J. (1988) BRE IP 15/88: Average daylight factor: a simple basis for daylight design, Construction Research Communications, London

Muneer, T. (2000) *Solar Radiation and Daylight Models for the Energy-Efficient Design of Buildings*, Architectural Press, Oxford

Parker, D. S. et al. (2000) Laboratory testing of the Reflectance Properties of Roofing Materials, Florida Solar Energy Centre – http://www.fsec.ucf.edu/~bdac/pubs/CR670/CR670.html

Sharma, M. R. and Rao, K. R. Solar radiation protractors Central Building Research Institute. Rorkee, India. Equidistant projection 15°N–15°S; 15°N–35°N at 5 degree intervals (reproduced in Givoni Man, climate and architecture Elsevier 1969)

Solar charts and shadow angle protractor for daylight planning Catalogue no 374. Henry Hope & Sons. London. 1969. Stereographic projection 32°N–28°S at 4 degree intervals Richards, S. J. South African architectural record Vol 36 No 11. Stereographic projection 20°S–34°S at 2 degree intervals (reprinted by South African Council for Scientific and Industrial Research, Pretoria 1952)

AJ Handbook of Building Environment. Information Sheet-Sunlight 5, 30.10.68 pp. 1024–1035. Gnomic projection 040° (N or S) at 2 degree intervals

NB: All sunpath diagrams for the northern hemisphere can be used for the southern hemisphere by reversing the hours and months and rotating the azimuth scale by 180°.

Sustainable design

Edwards, Brian (2nd ed 1999) *Sustainable Architecture: European directives and Building design*, Architectural Press, Oxford

Smith, Peter F. (2001) *Architecture in a climate of change – a guide to sustainable design, Architectural Press*, Oxford

Termites

Australian Standard AS 3660-1993: Protection of buildings from Subterranean Termites – Prevention, Detection and treatment of Infestation, Standards Association of Australia

Ventilation

NatVent Consortium (1999) Natural ventilation for offices, BRESCU, BRE

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

43 Universities

Mike Hart and Rod McAllister

Mike Hart is an Education Design Consultant and Rod McAllister is a partner of Sheppard Robson Architects – both specialise in university design

KEY POINTS:

- *The UK higher education system is becoming increasingly diverse. This diversity is expressed in the use of space, particularly between teaching-led and research-led universities. Space will be subject increasingly to remodelling for new needs or to meet new standards. With imaginative design, space can be deployed flexibly to meet multiple uses*
- *Increasingly, more provision is being made for student-led and 'blended learning' (a mixture of face-to-face plus IT-mediated learning). This will demand more relatively small and adaptable spaces. IT developments are enabling more intensive use of space for teaching and learning*

Contents

1 Introduction
2 Layout guidance
3 Environment
4 Do's and don'ts
5 Briefing overview
6 Bibliography

1 INTRODUCTION

1.1 Definition

Universities are places of learning and research in a variety of subjects at the highest level and are often, therefore, described as being institutes within the Higher Education sector. Derived from the Latin *universitas magistrorum et scholarium*, which could be translated as a 'corporation of masters and scholars', the university was conceived as a place of academic freedom in contrast to specific training for crafts or trades in the medieval period. In time, universities were authorised to confer degrees and are now significant contributors to national and regional economies all over the world.

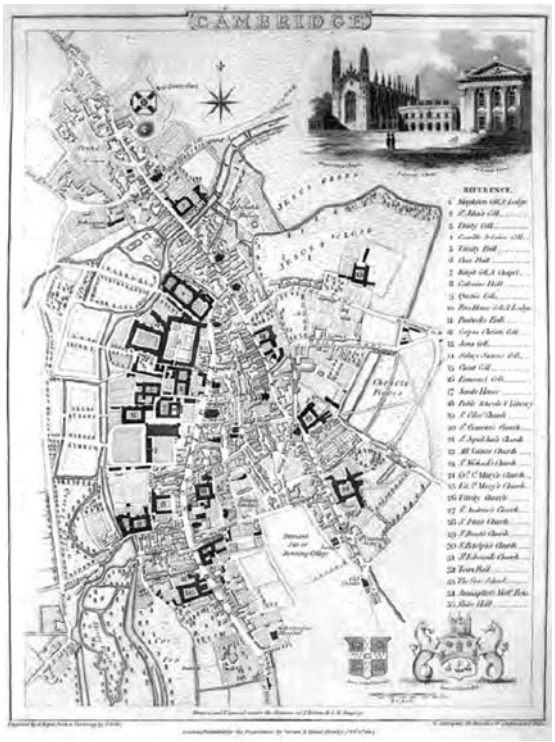
1.2 Scope

Modern universities vary hugely, having differing emphases on subjects and research. Their locations and student base are also diverse. This section of the handbook seeks to provide broad guidance for designers of new university facilities but this guidance could be extended to upgrading or extending existing buildings. The range of accommodation examined represents the typical core building stock of modern, Western universities. The figures provided represent average or recommended dimensions and values and would be subject to adjustment for more specific requirements.

1.3 Types

Urban universities

The traditional university model has been linked with city life in Europe since the Universities of Bologna and Paris were founded in 1088 and 1150 and later in Oxford (1167) and Cambridge (1209), Figure 43.1. The study of theology was central to university life and consequently these early institutes bore strong relation to monasteries in their arrangements being characterised by cloistered courtyards, chapels and refectories. Some would argue that Western universities may have been influenced by, or were based on, Islamic *Madrasha* schools in the ninth century Middle East as observed by crusaders.



43.1 *Cambridge town plan: Cole and Roper map of Cambridge, 1804*

Collegiate universities

Many universities evolved into college-based institutes, the earliest include Paris, Oxford, Cambridge and, later, Durham. In this model, formal lectures, governance and administration are provided by the university and residential, dining, tutorial and pastoral functions are provided by member 'colleges' or 'houses'. The non-college accommodation is normally organised into 'schools', 'faculties' or departments and some ceremonial buildings. Consequently, the host cities, or city quarters, developed around these universities and their colleges over many centuries and are largely defined by their presence.

Scotland established four 'Ancient' universities between 1410 and 1582. In London, a number of large and almost independent colleges were founded from 1826 onwards, each acting as a quasi-university. Some of these specialised in subject areas such as science and engineering as in the case of Imperial College London. Their buildings tend to cluster in city-centre sites later referred to as 'campuses' after the College of New Jersey (later renamed Princeton University).

Subsequent urban universities

There followed an explosion in university creation in major cities across the UK and Ireland from 1828 to 1909. Whilst these were not necessarily based on the collegiate model, some included colleges and most became important parts in inner-city life, often creating distinctive academic city 'quarters'. Their physical composition



43.2 *Red brick university: University of Birmingham*

moved away from the monastic model, through classic palatial and towards Victorian civic grandeur, Figure 43.2.

From 1992, over seventy new universities were created from former polytechnics, 'university colleges' and higher education institutes. Most of these occupy urban groupings that were consolidated from disparate buildings to create urban campuses wherever possible. In this way, many new universities have more in common urbanistically with the 'Ancient Universities' than those of the Victorian and Edwardian eras.

Rural and suburban campus universities
Waves of university construction following the World Wars, driven by government policy aimed at social mobility, led to a proliferation of sylvan campuses across Britain. Their compositions were varied and experimental, often laid out in response to masterplans by individual architects.

Further education
Further education (FE) is post-compulsory education that is distinct from education offered in universities, and has grown significantly to become recognised as a separate sector. It provides education, from basic training to HND or Foundation Degree.

Institutions considered part of the FE sector include:

- general FE and tertiary colleges;
- sixth form colleges;
- specialist colleges (e.g. land-based colleges);
- adult education institutions.

Further education is seen as forming one part of a wider learning and skills sector, alongside workplace education and other types of non-school, non-university education and training.

It provides 14–19-year-old learners the opportunity to progress to HE and skilled employment. It provides adult learners access to basic skills, training for work and learning for personal development. FE planning and design guidelines and best practice are significantly different from HE and are therefore not included in this chapter.

1.4 Circulation

It is essential to develop attractive and novel concepts for main entrances, external/internal wayfinding, connectivity, and the external spaces and links between buildings. Developing ideas for making the campus more inviting by creating selective transparency into student active zones/spaces should also be exploited.

External
It is desirable to determine the nature and scope of all vehicle and pedestrian circulation routes within and around the campus to minimise conflict, including movement on/off the site that is significant to the effective operation of campus facilities in order to establish proper access and egress arrangements, compliance with DDA, aggregation of flows of traffic, people and materials, and control and security provisions.

Internal
It is also desirable to develop concepts for improving the flexibility and quality of the internal spaces, particularly the de-institutionalisation of circulation routes with creative impromptu interaction spaces for students and staff, together with attractive and conducive internal vertical and horizontal circulation to enhance social contact, e.g. atria, galleries, 'streets'.

1.5 Sustainability

This is a brief summary of the key design issues to consider when developing a 'sustainable' university building. These issues may not all be relevant to the particular building, site or budget. Please note that this is written for a temperate UK/West European climate and will not be suitable for other locations.

Form
There are many matters to consider when designing the university form:

- Use narrower, open plan floorplates (12–13.5 m) if maximum daylighting and natural cross-ventilation is desirable.
- Use the building form to enhance passive/low energy strategies. Consider the use of atria, solar chimneys, lightwells and wind stacks to assist stack ventilation and make use of heat reclaim.
- Atria should extend well beyond the roof level to prevent warm, stale air build-up affecting the occupants of the upper floors.
- A compact form with a low ratio of envelope:floor area will have much lower heat loss or heat gain.
- Consider high floor to ceiling dimensions to increase daylight penetration and to prevent warm, stale air build-up at occupant level.

Orientation
- Orientate along east/west axis with primary north and south elevations.
- Eliminate solar gain as far as possible. South aspect is easier to control using screens, louvres and blinds. Also consider ratios of glazed:opaque envelope and translucent insulation.
- East and west elevations get low angled sun, which can cause problems with glare. This is very difficult to control using standard louvres.
- Specialist spaces with predominantly opaque walls (e.g. stairs, lifts cores, toilets) should ideally be positioned on east and west facades to reduce issues of glare and solar gain.

Energy use
- Primary energy use is for heating (50%), ventilation and cooling (30%), and lighting (20%). Deep plan air-conditioned buildings will have a higher proportion of ventilation and cooling costs.
- Maximise the integration of passive strategies to minimise the use of active systems that use energy (e.g. wind/solar assisted ventilation).
- Use thermal mass (preferably exposed in ceilings or walls) to absorb heat during the day and purge it at night to provide comfort conditions in the morning. This also reduces temperature swings within the space.
- Use natural or mixed-mode ventilation in preference to full air conditioning. Displacement ventilation is preferable, as it requires lower energy use for the same cooling capacity.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

However it also requires larger risers and underfloor voids. A strategy that uses the atrium space or double-skin cladding systems as a return air duct can increase net floor area.
- Optimise daylight whilst being aware of glare and solar gain. Consider narrow plan form, use of atria and lightwells, ceiling profile, high ceilings, prismatic glass and light-shelves.
- Recover waste heat for pre-heating winter supply air for heat exchanging with hot water supply.
- Ensure correct balance of insulation within the facades to minimise winter heat loss and reduce summer solar gain (south and west).
- Develop a low-energy artificial lighting strategy and integrate the system with the daylighting. Use low-energy light fittings and consider controls carefully (occupancy detection, daylight sensors etc.).
- Extract air through or close to light fittings to extend lamp life and reduce heat gains.
- A 'double-skin' wall may provide various energy-saving advantages using a combination of louvres, vents, reflectors, fans and controls to create an environment buffer that reacts to the changing external climate. Summer heat gains can be vented out before they reach the inner spaces (louvres are required between the two skins). In winter, this can also provide a thermal buffer. A 'double skin' to the east facade may be used to collect passive solar gain on winter mornings, which can be used to pre-heat ventilation air.
- Design the various facades in relation to their specific orientation. Each will require a different combination of glazed areas, opaque areas, types of glass, blinds, louvres and screens.
- The facade design should be carefully integrated with the design of the services in order to create an integrated building. Too often these systems work against each other, rather than together in harmony.
- Environmental systems do not need to be technologically complex. Often the most sustainable system is one that has minimum embodied energy, fixed components, reduced capital and life-cycle costs and minimum maintenance.
- Minimise internal heat gains through specification of low heat-emitting appliances and lighting.
- Ensure that the internal comfort criteria brief is realistic so that the services system is not over-designed for heat loads that may only occur during a few days of the year. This leads to inefficient operation when the plant is running at lower capacities.
- Ensure that the detail design maximises airtightness in cold weather as this is a major contributor to heat loss.
- Deciduous trees to the south will reduce summer heat gains whilst allowing for winter gains.
- Solar thermal systems can provide 40–60% of hot water requirements. They require roof or southerly orientation (within 30 degrees of south). The hot water can be used with an absorption heat pump to provide cooling through chilled beams/ceilings or underfloor systems (maximum output is available when the cooling is required most).

Water
- Maximise area of roof and landscaping for rainwater collection.
- Provide a storage tank within the landscape or basement for rainwater storage.

Health and wellbeing
- Provide user control of lighting, humidity, heating, and ventilation. This may be arranged by groups and linked to the telephone system and/or BMS.
- Provide openable windows where possible, as occupant control has psychological health and wellbeing benefits (if external noise is not a problem).
- Pay attention to landscaping and planting inside and out. This can be used to temper the environment through natural shading, cooling and humidifying. It has been shown that certain plants also improve air quality within a building.
- Create indoor and outdoor spaces that encourage interaction, social exchange and a sense of community.
- Integrate water and planting to improve air quality, natural humidity and improve occupants' sense of wellbeing.

2 LAYOUT GUIDANCE

The UK higher education system is becoming increasingly diverse. This increasing diversity is leading to diverging approaches to the use of space, particularly between teaching-led and research-led universities. Space will be subject increasingly to remodelling for new needs or to meet new standards. With imaginative design, space can be deployed flexibly to meet multiple uses.

'Learning space' is seen as one of these new needs, with more provision being made for student-led and 'blended learning' (a mixture of face-to-face plus IT-mediated learning). This will demand more relatively small and adaptable spaces. IT developments are enabling more intensive use of space for teaching and learning.

2.1 Key points

An educational building is an expensive long-term resource. The design of its individual spaces needs to be:

- Flexible: to accommodate both current and evolving pedagogies.
- Future-proofed: to enable space to be re-allocated and reconfigured.
- Bold: to look beyond tried and tested technologies and pedagogies.
- Creative: to energise and inspire learners and tutors.
- Supportive: to develop the potential of all learners.
- Enterprising: to make each space capable of supporting different purposes.

Learning space should be able to motivate learners and promote learning as an activity, support collaborative as well as formal practice, provide a personalised and inclusive environment, and be flexible in the face of changing needs. Technology plays a key role in achieving these aims.

2.2 General teaching and learning

General teaching spaces have been dominated by one type of design: tutor-focused, one-way facing and presentational, with seating arranged in either a U-shaped or in straight rows. Technologies have been added – interactive or conventional whiteboards mounted on the wall behind the main speaker, ceiling-mounted projectors with cabling to a laptop, a wireless network and/or wired computers – but these have rarely altered the dynamics of the design.

The formal lecture is still seen as an effective means of inducting students, delivering whole year (first year) courses and meeting increasing student numbers on popular courses. More creative design of lecture theatres is needed with better shaped layouts, better eye contact and easier to use technology to present material in a variety of formats. Many institutions are already using general teaching rooms more intensively by not only adopting timetabling regimes but also extending the teaching hours. The latter has access and catering implications to consider.

Formal teaching

The prevailing approach is moving towards active and collaborative learning, but the room design does not always reflect this. Effective dialogue is needed to establish what will be required from these spaces and what changes in approach are desirable. The design of most general teaching spaces will need to support both tutor-led and learner-led activities. These will include presentations, discussion, collaborative project work and information retrieval and sharing. These needs can be met in different ways, with separate rooms being allocated to different purposes in some models and, at the other end of the spectrum, teaching taking place in open-plan flexible 'learning studios'. Future technological and

pedagogic developments cannot always be anticipated but what is important is to ensure that design will accommodate change.

THE INTERACTIVE CLASSROOM
Replacing the standard combination of tutorials, lectures and workshops with learning sessions involving mini-lectures, videos, demonstrations and problem solving. Questioning and discussion replaces knowledge transfer as the main model of delivery. An electronic voting system to help students test their understanding of concepts in response to multiple choice questions, and collaborative discussion before and after voting. An integral pedagogic approach.

THE TEACHING CLUSTER
A centrally managed suite of rooms that includes interactive classrooms, seminar rooms and a teaching studio, providing a mix of peer instruction, problem-based learning and studio teaching. To gain maximum collaborative discussion, curved desks added in some rooms to increase interactivity.

CENTRALISED BOOKING
Centralised online booking systems are gaining ground in higher education as a means of increasing the effectiveness in managing space utilisation of general teaching space. Most institutes consider general teaching space as non-dedicated space, shared across faculties and even across the campus. This can present the need for more storage adjacent to support the variety of general teaching carried out. This presents location considerations, as these rooms will need to be central with convenient access to all users.

Some institutions have also adopted space charging as a measure against block booking of rooms.

TIMETABLED GENERAL TEACHING ROOMS
Centralised bookable (timetabled) general teaching rooms are generally:

- lecture theatres – large (250); medium (120); small (90)
- seminar rooms – large (60); small (30)
- IT rooms – various capacities used (30+).

TUTORIAL AND SMALL GROUP TEACHING SPACE
There is a trend, by some institutes, to remove tutorial space from within academic staff offices and provide conveniently located groups of bookable tutorial rooms that can also be used for other purposes – staff meetings, interviews, confidential work/discussion, private study, professional visitors, etc. In some institutes there is a move away from individual tutorials to small group tutorials (5–6 students). There is also a demand for bookable small group teaching rooms (10–15 students), in response to electives and short courses. These rooms can also be used for other purposes.

IDENTITY AND OWNERSHIP
The centralisation and timetabling of general teaching space means it has been designated non-dedicated accommodation, diminishing the identity and ownership of departmental accommodation. However, the identity and ownership of departments can be restored by the imaginative collocation of their specialist teaching and research space, staff, tutorial rooms, resource and support facilities to stimulate a sense of community.

Informal and social learning
Learning is a remarkable social process. It occurs not as a response to teaching, but as a result of a social network that fosters learning.

SOCIAL SPACES
Well-designed social spaces are likely to increase students' motivation and may even have an impact on their ability to learn. High quality space for informal learning will also enhance the profile of the institution. Social spaces could therefore be given a high priority in new designs. If catering facilities, common rooms, even circulation spaces ('learning streets'), are considered as social meeting and group learning environments, institutions could save on large-space provision and make a statement about their vision for learning as a pervasive and inclusive activity based on social interaction.

THE LEARNING STREET
'Learning streets' are emerging in designs. Alcoves are set into the sides of wide circulation spaces, where classroom activities can extend in informal group working, or learners can 'touchdown' to access work online before a class. They are wireless enabled, as is the entire building, in anticipation of more widespread use of mobile devices. Some alcoves have grouped arrangements of computers which learners can book online. Learning is visible and active.

THE LEARNING CAFE
The 'learning cafe' was originally an early experiment in the use of space to support problem-based learning and group work and has since become successful and developed even further. They are now running successfully in many institutions. The deliberate mix of refreshments, social activities and IT makes this a relaxing and friendly place where conversation and social interaction are seen as an essential part of learning. A variety of layout, furniture and IT access for group and individual work is made available together with a refreshment bar.

2.3 Specialist teaching and research
Specialist teaching and research spaces are:

- teaching spaces that by virtue of particular servicing, fit-out, or uses need to be dedicated to a particular function or school, but which could be accommodated in a standard structural shell; or
- teaching spaces that by virtue of particular dimensional, loading or servicing requirements cannot fit into a standard shell.

Libraries/learning centres
The concept of the learning centre is still evolving, usually blending with other previously distinct spaces to absorb more of their functions. Rethinking the learning centre has led to substantial new-build projects in universities, especially where the space is envisaged as the social and academic 'hub' of the campus. However, smaller scale learning centres are also appearing connected to teaching accommodation to form 'curricular clusters' or as a separate high-tech highly personalised learning environment or 'resource centre' managed by a department/school, in addition to the library.

More intensive use is being seen in longer library opening hours, with 24 hour opening during the working week becoming more common, especially where many students are part-time. Self-service machines have facilitated this trend. Learning space is also sometimes provided in the form of rooms with banks of PCs, printers, etc. available for general student use.

THE LEARNING CENTRE
The large central learning centre is now a multifunctional facility providing social spaces, student services and study support, book and laptop loan, access to IT, and different kinds of working environments, from comfortable seating for collaborative group work, to 'board rooms' for practice presentations. Elements of teaching may also take place within a learning centre environment. These varied purposes demand a clear vision for each area within the centre. Zones for different modes of learning are common strategies. Sound and visual clues, layout and style of furniture, and different technologies in different configurations can signal the different purposes of areas.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

The following lists some of the types of zones anticipated:

- Social zone – fairly noisy; variety of tables and informal seating; laptops used via wireless; catering available.
- Group zone – reasonably quiet but busy; group work; with or without IT; circular tables; open and closed 'pods' with (interactive) whiteboards.
- Study zone – quiet but not silent; individual work or 2–3; circular or rectangular tables; mixture of fixed IT workstations and spaces for laptops.
- Silent zone – silent individual study; physically enclosed.
- IT zone – busy space; high density IT provision; fixed workstations and printing.
- Touchdown zone – short tasks; standing spaces only; suitable for laptops, some fixed.

Will teaching benefit from migrating into learning centres? Maybe for some courses. However, bookable seminar rooms within centres can offer a compromise.

LIBRARY/LEARNING CENTRE SUPPORT FUNCTIONS

The following lists the types of space that will be needed for the library support functions:

- Library enquiry/information point – counter, desk, storage (satellite floor based enquiry desks);
- Library administration – offices, workrooms, storage;
- IT administration – offices, workrooms, storage;
- Open stack space – books, periodicals, DVDs, CDs;
- Compact shelving;
- Library support facilities – self issue/return, OPACs, printing/photocopying, collection bins;
- Careers section.

The following lists other support functions that can be within a learning centre:

- Learning advice centre – skills, language, academic writing;
- CCAV studio – pre/post production;
- Video conferencing;
- Staff resource area – prep online, video streaming;
- Archive reading room and collection;
- Student lockers.

Sciences, research and laboratories

TYPES OF LABORATORY

Research and laboratory space needs vary markedly between schools and departments, types of teaching or research being undertaken, and special equipment needs. There are a number of different types of 'primary' laboratories that exist on campus, including:

- Computer labs
- Wet labs
- Dry labs
- Studio or design-based labs
- Teaching labs
- Special large equipment labs

There are also a number of different 'secondary' labs and support spaces needed to support 'primary' labs, including:

- Temperature controlled rooms
- Specialist equipment rooms
- Special collection rooms
- Containment suites
- Prep rooms
- Chemical, radioactive, flammable and gas cylinder stores
- Write-up areas

SPACE PLANNING OF PRIMARY LABS

Comprehensive planning of new space should ensure flexibility, modularity and consistency in space allocation. While laboratory types vary markedly and can be so specialised to defy space-planning guidelines, there are some common themes to keep in mind in laboratory space planning. Some of these are as follows:

- Modularity – making laboratory design as modular and flexible as possible is key, particularly in terms of HVAC design, specialised systems and structural loading designs.
- Zoning – creating laboratory 'zones' which also enable flexibility and ease of operations is very important.

These themes will have different applications in laboratory design, depending upon the type of laboratory. Wet labs are very different to computer labs or teaching labs.

THE BASIC LABORATORY MODULE (MOST APPLICABLE TO WET LABS)

While laboratory needs vary widely between disciplines the principle is to configure laboratory space in as flexible and modular a way as possible because of the fact that teaching and research needs and methods change and evolve over time. Laboratory space is typically configured in standard modules, which become space denominators that are designed to meet a variety of teaching and research needs. These modules allow for flexibility in planning the following:

- mechanical, electrical and plumbing systems
- heating, cooling and ventilation systems
- special laboratory gases
- laboratory benching systems
- laboratory support spaces
- specialised functions
- partitions
- fume cupboards, etc.

Laboratory modules then become the building blocks for planning space. Aggregating a number of modules can create larger labs, and smaller labs are created by portions of modules. The planning module is repetitive and regular. The size, actual layout and zoning depends upon the specific laboratory function, teaching or research purpose, equipment required as well as the building floor plan. The relationship between laboratory and office zones or between laboratory and support zones will vary depending upon the type of teaching or research and laboratory need.

Refer to Chapter 26 for detailed laboratory planning and design guidelines.

TRENDS IN LABORATORY TEACHING

There is a consensus amongst students and academics that there is a need to make learning and teaching in the laboratory more challenging and engaging. Recently there have been novel laboratory exercises designed to enthuse and stimulate students through active learning. These innovative methods exploit computer-based approaches, encourage enquiry-based learning and many involve students in cutting edge research during undergraduate (UG) laboratory classes. Results of these exercises indicate there is a pressing need to re-think the traditional, didactic approach to laboratory teaching in HE. In particular to move away from 'spoon feeding' students during interminable, repetitive and boring practical classes that have highly predictable results.

ENQUIRY-BASED LEARNING WITH E-LEARNING IN SUPPORT

This is an approach where students use online learning that involves video clips, interactive simulations, virtual lectures or annotated digital slides to observe, understand and practice techniques before attending practical laboratory classes during which the material

is considered and then team based exercises are carried out that include student presentations and question/answer sessions.

COMPUTER MODELLING

There is a trend towards the replacement of laboratory work by computer modelling throughout science and technology. Space savings are achieved, however some laboratory space may still be required, and space is obviously needed for the computer work. An exception to this trend is in the progress of radically new science and technology. Currently an example of this is nanotechnology, which demands buildings or parts of them to be separate and purpose built to prevent external vibration as well as highly specialist equipment. Future radical scientific and technological developments may be so expensive that they will probably be concentrated at a small number of national or international centres.

Music

Music is studied at a department/school within a university faculty of performing arts, or at a specialist college, academy or conservatoire. There are many elements of accommodation that comprise a music department/school, and the guiding principles for locating the accommodation and planning the space. The spaces in a music department/school consist of a range of rooms of different sizes, with stringent acoustic requirements. Each department/school will individually decide how best to create and configure the range of spaces that will serve its current and future needs. There are a wide range of approaches to planning the accommodation reflecting different approaches and priorities. There are also many different ways to achieve a satisfactory outcome, so it is important that the briefing and design process is carefully detailed.

TYPES OF ACCOMMODATION

Music departments/schools include combinations of the following spaces:

- music classrooms (dedicated) – large learning and teaching spaces;
- practice rooms – solo, group, ensemble;
- music technology (digital) and keyboard rooms;
- instrument and other stores – department/school use, student use;
- music library and resource area – including music scores, CDs, DVDs;
- rehearsal studios;
- recital studios;
- recording/control studios;
- performance space (or shared use of a central university facility);
- small breakout spaces associated with music rooms;
- academic staff rooms and support.

ENVIRONMENTAL CONSIDERATIONS

Music spaces are for creating and listening to sound and therefore an appropriate acoustic environment is essential. Sound can travel through the building fabric or structure, even if it has a high specification. Doors, windows and vents are particularly difficult to insulate. In planning spaces it is essential to remember that:

- The aim is to enable people to hear music clearly, without distraction, and with suitable enhancement by the room acoustics.
- The two main acoustic concerns are sound quality and sound insulation.
- The main influences on the quality of musical sounds are room volume, room geometry and surface finishes.
- Successful sound separation between spaces depends on good planning, structure and construction detail.
- The location of the music department/school, relative to the rest of other department/schools (or neighbours), should be carefully considered.

SPACE PLANNING PRINCIPLES

Most music department/schools host a range of activities and events including performances outside the normal teaching day. All these activities will involve groups of people (students, staff, external musicians) arriving and leaving throughout the day. Therefore, the location of the department/school should make this as easy as possible, while maintaining security for the community. Important points to consider when planning space are:

- Acoustic issues – disturbance to and from neighbouring spaces, including external spaces.
- Ensuring music spaces are near to other facilities that will be used for musical activities.
- Creating easy access for the movement of musical instruments and equipment for performance in spaces outside the department/school.
- Locating the music department/school on or close to the main entrance.
- Providing a separate dedicated reception that can be used outside normal hours without compromising overall security.
- Allocating sufficient parking for the group sizes anticipated.

CRITICAL RELATIONSHIPS

When deciding how to arrange the layout of a music department/school, there are some critical relationships, or adjacencies, between dissimilar spaces – for example where percussion is practised. Percussion sounds are likely to cause the greatest potential disturbance to neighbours, because of the repetitive patterns and low frequencies, in particular drum practice groups. Buffering between dissimilar practice spaces can be achieved by relatively underused spaces, such as storerooms, corridors, resource centres. Some department/schools like to have group rooms directly accessed from classrooms for breakout activities. Recording/control studios are best placed adjacent to large group rooms, rehearsal, and recital and performance space. Windows in music spaces, if left open, are likely to cause a noise nuisance to neighbours. Therefore, window and ventilation strategies will need careful consideration.

Business schools

A business school can either be a school or department based within a university or an independent international graduate school and research institution.

UNIVERSITY-BASED BUSINESS SCHOOLS

Undergraduate (UG) teaching is usually undertaken in the university's centrally time-tabled general teaching accommodation – lecture theatres, seminar rooms and IT rooms. Depending on the university a dedicated UG workroom and lounge may be provided within the school.

Postgraduate (PG) teaching and research is usually undertaken in dedicated accommodation, and can comprise:

- lecture theatres (small) (stepped amphitheatre-style with continuous writing desks and fixed seating);
- seminar rooms (small);
- syndicate rooms (conference style);
- PGT group workspace (drop-in facility, with wireless connectivity);
- PGT PC lab (learning facility);
- PGR group workspace (cafe-style linked to syndicate rooms, with wireless connectivity);
- the school may also have dedicated PGR social space.

The MBA accommodation is usually planned as a dedicated suite of accommodation within the business school or department and comprises:

- reception, social/interaction/breakout space, refreshment bar/service;

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

- lecture theatres (small) (stepped amphitheatre-style with continuous writing desks in wide rows and mobile/revolving executive chairs);
- seminar rooms (small) (cafe-style with circular tables and mobile/revolving executive chairs, with wireless connectivity);
- syndicate rooms (mobile/revolving executive chairs around conference tables, with wireless connectivity).

A few schools may incorporate a dedicated Executive Training Suite offering custom training to professionals. The training suite may need to be easily accessible for evening customers and will probably comprise:

- reception, social/interaction/breakout space, refreshment bar/service;
- executive training room (small) (cafe-style circular tables with mobile/revolving executive chairs);
- reference/resource facilities.

A dedicated Bloomberg Suite is usually included in a business school to provide UG and PG students training in a simulated dealing room environment.

INDEPENDENT GRADUATE BUSINESS SCHOOLS

These institutions are pre-eminent global graduate business schools (e.g. Harvard, INSEAD, London Business School). They specialise in offering 'top-class' MBAs and executive education. They have complete operational independence and separate funding.

Depending on their vision, aims and objects they will each have different approaches and operational areas, e.g.:

- teaching – MBAs, EMBAs, MiFs, Executive Education (open and custom programmes), PhDs;
- research – faculty working on specialist research initiatives based on chosen subject areas;
- external relations – school brand/fundraising, alumni, communications, development, events;
- support departments – finance/accounts, information services, careers, facilities, human resources;
- outreach activities.

Comprehensive programmes of evening and day events will take place throughout the year, such as residential courses, conferences, corporate presentations, networking, ceremonies, distinguished speaker lectures, recruitment and alumni reunions. Most of these events will require good quality residential accommodation, conferencing, community networking and catering facilities.

The planning, design and range of accommodation and the quality of the physical space will be characterised by the spirit and ethos of the school, and the school's perceived international brand.

The range of accommodation for teaching MBAs will generally be similar to university-based schools except the quality and space standards will be higher. Similarly Executive Education accommodation will be of a higher quality and standard, more extensive and include a business centre, breakout and refreshment areas for delegates.

Additional facilities will include:

- conference centre – high quality large theatre/hall with cinema style seating, including reception/registration area, foyer/breakout space and hospitality service;
- large community networking space – at the centre of the school to encourage interaction/integration;
- a range of catering facilities – banqueting and hospitality (breakfast/lunch/dinner), restaurant with service, cafe, coffee bar/shop, and dispersed refreshment zones;
- teaching support – PC labs, library/resource centre and study spaces;
- student services/support facilities;
- alumni centre;
- offices – faculty, support, admin staff;
- school reception area – visitors, information, exhibition.

Environmental considerations for lecture/conference facilities:

- naturally lit and air-conditioned;
- programmable lighting and blackout;
- sound reinforcement, microphones and high quality acoustics;
- wireless network, video/filming facilities;
- interactive whiteboards, projection and LCD screens;
- control of environment from lecturer's desk/console.

Arts

Art is studied at a department or school within a university faculty of creative arts, or at a specialist art college. Art is a practical and creative discipline in which students learn through investigation, observation, analysis and experimentation. Students work in both two and three dimensions and at a range of scales.

TYPES OF ACCOMMODATION

Students select to specialise and develop techniques in a variety of media. These vary but may include the following studio or workshop spaces:

- drawing
- graphic design
- painting
- screen printing
- photography/moving image
- textiles/embroidery/fashion
- ceramics/glass
- jewellery
- sculpture
- digital media including desktop publishing, animation, multimedia.

Supplementary and storage spaces may include:

- resource areas
- dark rooms
- editing and production suites
- prep/cleaning areas
- screening room
- clay, damp and plaster stores
- kiln rooms
- wood, metal, stone, equipment stores
- media consumables store
- display/exhibition space
- students' work stores.

MAIN PLANNING CONSIDERATIONS

The location of the art department or school can effect the accommodation in a number of ways. Some of the main considerations are listed below:

- Quality and level of light – particularly important in art studios is orientation and floor level, which can effect the amount of daylight reaching the space.
- Ground floor location – direct access to sheltered outside areas for external work for messy or large scale projects.
- Views – from carefully placed windows can be a source of inspiration.
- Collocation – where overlaps in disciplines are likely plan relevant spaces close together to facilitate sharing of resources.
- Vehicle access – delivery of bulky or heavy materials needs to be considered.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

OTHER PLANNING CONSIDERATIONS
Additional issues to consider include:

- As daylight is important for art studios, consider the depth of spaces where daylighting is only from side windows.
- Grouping of art spaces into suites allows more efficient use of materials and equipment and provides equal access to resource areas.
- A display area for students' work provides a learning stimulus as well as a welcoming approach to the department or school.
- Store rooms should be directly accessible from the studio spaces.
- Views into an art studio can provide an attractive 'shop window' to the department or school.

Suites of art spaces are sometimes designed as open plan areas, which can create a sense of light and space, and with less definition between spaces can also increase flexibility. However, noise transmission or dust can be a problem in open plan areas between dissimilar disciplines, as in the case of ceramics, etc. where dust is less easily contained. Also more open plan areas can reduce the wall surface area, which is useful for display and as a large scale work surface.

BUILDING SERVICES
It is advisable to produce wall elevations of each space showing the location of building services (electricity, gas, compressed air, water, etc.) and fixed equipment. This will help to make the best use of available surfaces, which is important where walls are used extensively for display and as vertical work surfaces. Overhead supplies for mobile equipment may be considered an alternative system where appropriate for certain disciplines.

ENVIRONMENTAL CONSIDERATIONS
Some of the main factors to be considered are:

- Daylight – maximise daylight but control glare and solar gain, where fine detail and colour rendering is important. Increase ceiling heights and maximise surface reflectance.
- Artificial light – An even spread of light without glare. Adopt recommended luminance levels and colour rendering of lamps.
- Acoustics – noise disturbance between dissimilar disciplines working in the same or adjacent spaces.
- Ventilation – extraction systems needed for specialist activities and equipment including removal of heat, noxious gases/fumes, dark room chemicals, dust, aerosols/airbrushes.

Creative environments for teaching and learning
An initiative between two universities looked into what extent learning designs could promote innovative ways of thinking. The aim was to create a 'Centre of Excellence in Teaching and Learning' (CETL) – an experimental new teaching and learning space, the 'Creativity Zone'. The concept was to blur the boundaries between disciplines, between formal and informal learning, and between learning and creative practice.

In the 'Creativity Zone' ingenious partitions, screens and items of furniture were fitted into the fabric of the space. Multiple projectors, wireless connectivity and location-aware technology was embedded. Any part of the space could be varied to offer a progression of opportunity for interaction – with objects and participants. In this space real-world practices could be simulated, creating a cross-disciplinary experience that brings individuals from different disciplines together in one collaborative exercise. This concept could be a prototype for re-thinking the way forward for effective learning and teaching in the future.

2.4 Incubators
An incubator is a term given to a facility that fosters and encourages entrepreneurship and minimises obstacles to new business formation and growth. It provides the opportunity for 'start-ups' and 'spin-offs'.

Start-ups and spin-offs
The incentive confronting an individual or group that discovers a significant invention is a choice between start-up and spin-off. 'Startup' is the term given to the choice that keeps the intellectual property rights (knowledge) of the invention, acquires start-up capital or 'seed' funding and forms a new company to develop the invention. 'Spin-off' is the term given to the choice that transfers the knowledge of the invention to an existing company to gain substantial benefit via compensation, profits or shares from development of the invention.

2.4.2 University incubators
University incubators aim to:

- create a bridge between education and the economy;
- accelerate technology transfer between the university and companies;
- sponsor 'spin-off' from academia and create 'start-ups'.

Originally incubators were located in abandoned or underused university buildings, but have since grown rapidly and developed into new high quality purpose built 'centres' affiliated to universities. These 'centres' will vary in the facilities provided reflecting and influenced by the research focus (science, technology, business) of the affiliated university. Many UK universities have new build 'centres' and their growth continues. Within these centres incubator units will be planned on a modular basis and can vary in size from 10 m^2 to 500 m^2, with a mix of office, science or technology-type units, together with all the supporting facilities and services.

Types of accommodation will vary but may include:

- modular labs (200 m^2) fitted out with write-up and wet lab areas;
- flexi-labs (500 m^2) either wet lab, office, or combination;
- offices (10 to 200 m^2) for SMEs;
- workshop facilities;
- meeting rooms, conferencing and exhibition space;
- reception and visitor areas;
- mailing, faxing and copying services;
- computer services, including secure internet connections;
- cleaning and security facilities;
- kitchen facilities, local catering;
- business support links – finance, legal, public funding, banking, accountancy, patent agents.

To protect the confidential and novel nature of the research and development work being undertaken 24/7 high-level access and security control to the building is important, with additional dedicated access and security control to each of the inner modular incubator units.

2.5 Support facilities
Student
The provision of student support facilities may be allocated on a university wide basis, site/campus basis or faculty basis. The content and location will primarily be determined by the university's estate strategy and secondly by faculty need regarding other student support facilities.

The list of accommodation provided will vary. The following is a guide.

Student union

- Student union and association offices
- Club activities and social rooms
- Large multi-function events space

- Bar and cafe areas
- Storage (records, stationery, equipment).

Student services

- Student information centre (including reception and waiting area)
- Admissions and funding/finance
- Counselling, advice and guidance
- Careers and employment
- Student/learning support
- Heath services (outsourced), welfare and first aid
- Nursery
- Chaplaincy and multi-faith prayer rooms.

Other student support facilities

- UG student common room (including refreshments)
- UG student society office
- UG student group workroom
- UG student individual/quiet study room
- UG student computing labs
- PGT student study room
- PGT student computing lab
- PGR workrooms.

Similar functions, e.g. student union and student services, could be collocated to form a central focus for students on campus (a 'student centre') providing security, noise and confidentially is not compromised.

Staff

The provision of staff support facilities may be allocated either on a site/campus basis or faculty basis. The content and location will primarily be determined by the university's estate strategy and secondly by faculty need. The list of accommodation provided will vary. The following is a guide:

- staff common room (including refreshments)
- staff meeting and interview rooms
- storage (archives, records, stationery, equipment)
- staff print and post room
- porter's room
- computer systems manager's office
- technician's office/workspace/help desk
- faculty based staff resource centre
- faculty based externally funded research institute space (including reception).

Public

It is essential to develop attractive and novel concepts for main entrances and front of house facilities, not only for regular users but also to encourage visitors and the public to 'cross the threshold'.

The following accommodation is a guide:

- main reception desk area
- visitors waiting and collection area
- information and exhibition area (including displays of student output and future events)
- external affairs office (colleges/schools liaison)
- security control point
- security control office.

It is important that major facilities available to visitors or the public are easily accessible from the main entrance without compromising security or user movement.

Conference

Many universities desire conference facilities to showcase their profile and maintain external links by providing corporate and distinguished speaker events, presentations, symposia and conferences. Conference facilities are expensive facilities if underutilised. Therefore alternative uses for formal teaching of large and medium size cohort lecture groups ought to be considered.

The following accommodation is a guide:

- auditoria (300 seat and 150 seat)
- foyer/break-out/interaction/display space
- hospitality service room
- equipment/store room
- control room
- green room
- cloakrooms.

Catering

The provision of catering facilities may be allocated on a university wide basis or site/campus basis.

It will generally include a central facility supplemented by dispersed satellite refreshment facilities located in various academic buildings. The content and location will be determined by the university's estate strategy and generally franchised to outside catering specialists. Under this arrangement the university provides the built space with the catering specialist providing the supply and service of food/drinks, equipment and staff.

The list of accommodation provided will vary. The following is a guide for a central facility.

Informal and formal dining

- Food court – buffet style (including seating, servery, self-service islands and 'back of house facilities')
- Deli bar (including seating, servery, self-service gondolas and 'back of house' facilities)
- Coffee bar (including seating, servery, self-service dispensers and 'back of house facilities')
- Formal dining area (including seating area and finishing kitchen).

Main kitchen

- Prep, cooking and plating areas
- Wash-up area
- Utensils, cutlery and crockery stores
- Dry, cold and deep freeze stores.

Catering support

- Goods reception
- Catering office
- Staff toilets, changing and lockers
- Cleaner's store
- Bin storage area (external).

Retail

The provision of retail facilities may be allocated on a university wide basis or site/campus basis. The content and location will primarily be determined by the university's estate strategy and generally franchised to outside retail outlets. Under this arrangement the university provides the built space with the retail outlets providing the supply and service of goods, equipment and staff. Retail facilities are usually collocated in the form of a 'Mall' on campus. The list of accommodation provided will vary depending on the level of local competition. The following is a guide:

- bookshop (including DVDs/CDs)
- university memorabilia /giftware
- banking (including ATMs)
- newsagency/refreshments/stationery ('one stop shop')
- post office (or incorporated in 'one stop shop')
- whole foods store

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

- travel agency
- pharmacy (or incorporated in 'one stop shop')
- hairdresser.

2.6 Residential

Student

University student accommodation is usually called 'Halls of Residence' (commonly 'Halls'), except at Oxbridge type universities where they are incorporated in each College's complex and known as 'Rooms'. A brief description of Halls of Residence is included in this chapter.

HALLS OF RESIDENCE

Most universities provide halls for a high proportion of first year students. Standards of accommodation can vary.

Older accommodation is based on institution-type halls – long ('run-through') corridors with individual study bedrooms off each side (some incorporate a washbasin/vanity unit) and shared bathrooms. Usually there was a choice between self-catered halls (which incorporated shared kitchen/dining space) and catered halls (using central dining facilities).

Later accommodation is based on self-contained flat-type halls – 8 to 10 individual study bedrooms each incorporating en-suites with shared kitchen/dining and soft seating spaces. A variation on the flat-type halls is now the preferred option.

A percentage of disabled study bedrooms complying with planning guidelines need to be provided. Kitchen/dining spaces need to comply with environmental health authority standards. Halls need to incorporate support accommodation – laundry (self-service), linen store, luggage store, cleaner's store and refuse store.

Some universities provide a degree of residential accommodation on campus for married students in the form of two person flats incorporated in halls.

Conference

Most universities operate a comprehensive programme of conferences or similar events during key vacation periods to create an income stream. Some of these events will require residential accommodation as part of the package offered. Good quality student accommodation that can be vacated will be set up and used for these purposes. Therefore, it is important that some accommodation is planned to a standard to facilitate 'conference' use.

Staff

Some universities will provide residential accommodation for particular members of staff. These may be 2 or 4 person flats for Wardens attached to halls, and visiting faculty or eminent personnel in hospitality suites.

Refer to Chapter 23 for detailed planning and design guidelines for residential accommodation.

2.7 Sport and recreation

Indoor facilities

Indoor sport and recreation facilities will include:

- sports hall – 8 court badminton hall with lines for badminton, basketball, volleyball, handball, netball and tennis, provision for segregating the hall with net partitions;
- fitness suite – comprising cardio-vascular and resistance stations, small reception and dedicated storage;
- aerobics studio – used for dance, yoga and pilates;
- martial arts room;
- swimming pool – 6 lane 25 m pool and seating area;
- squash courts – with seating area to one/two courts;
- staff office – permanent and part-time staff;
- indoor sports (dry) changing/showers/toilets – separate male/female, number of private cubicles and lockers;
- pool (wet) changing/showers/toilets – separate male and female, private cubicles and lockers;
- equipment store – to accommodate sports hall equipment;
- mat store – fire resistant room;
- kitchen – small with storage, work surface and sink;
- treatment room – treatment bench and desk, may double as first aid room;
- store room(s) for sports clubs;
- bar, lounge, catering – optional;
- cleaner's room – close to sports hall, sink and storage.

Outdoor facilities

Outdoor sport and recreation facilities will include:

- sports pitches – rugby, football, cricket, hockey;
- sports courts – 5-a-side football, hockey, netball, tennis (AWPs);
- outdoor sports changing/showers/toilets – separate male/female, including lockers;
- external referees' changing/showers/toilets – separate male/female, including lockers;
- equipment store – posts, nets, etc.

Other considerations

The following should be taken into account:

- operational and management aspects of the sports facilities will impact upon the use, planning and design of the facilities;
- other users – will it also include community, corporate memberships, clubs, etc.?
- graduations, examinations, exhibitions;
- car parking;
- compliance with Sport England/Northern Ireland/Scotland/Wales competition standards.

Refer to Chapter 38 for detailed planning and design guidelines for sports and recreation facilities

2.8 Administration

Academic offices

The provision of academic office accommodation is a sensitive topic probably in every institution. Individual academic offices in pre-1992 universities were provided on the assumption that they would be used for tutorial teaching of 2–4 students at a time. The academic office was therefore a complex environment: private study, semi-public teaching space, small staff meetings, and reception of professional visitors. However, tutorial groups are now often larger and academic offices are too small for teaching them.

INDIVIDUAL OR SHARED OFFICES

In many institutions, the need for all academic staff to have their own office is seen as an important aspect of academic life. However, it is often considered by management that offices are too large for one member of staff. Where remodelling or new building takes place individual academic offices may be replaced with shared offices. There then needs to be a conveniently located set of small rooms, which can be used for meetings and tutorials. This arrangement may be particularly appropriate when academic staff are out of their offices a great deal because of high class contact hours, visits to students on work placements, professional practice of various kinds, or specialist facility based research work. The acceptance of shared offices may be enhanced if good common room facilities are provided, such as a reception area with secretarial staff and other support service facilities.

A BALANCED APPROACH

A model of provision promoted by one institute and accepted by staff involved a compromise between individual and shared offices for full time staff: 25% of the offices were allocated for individual academic staff (Dean 20 m^2, HOD 15 m^2, other 10 m^2) with the remaining 75% allocated to shared offices split equally between offices for 2 academic

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

staff (16 m^2) and offices for 4 academic staff (32 m^2). The faculty could decide how to allocated their offices to academic staff. A set of small, bookable rooms were provided for tutorials, meetings, etc.

Open plan shared 'hot-desking' offices were provided for part-time staff (4 m^2/50% of PT staff).

Administrative offices

Demand for administrative space (administration and central services) in HE has grown. This reflects the creation of essentially new functions such as quality assurance, marketing, central fundraising, and widening participation work, together with the provision of more sophisticated services in established areas such as finance, research administration and student support of various kinds. It is likely that there will be further growth in demand for administrative space, as students become more demanding users of services. Other services related to more market orientated HE organisations will also demand more space. A typical list of university administration and central departments includes:

- University management
- Finance
- Human resources
- Marketing
- Quality assurance
- Business development
- IT systems support
- Registry, admissions and exams
- Student and academic services
- Estates and facilities.

OPEN PLAN OFFICES

New buildings offer an opportunity to collocate administrative functions to improve efficiency, offer an enhanced service to academic staff and students and save space. Space savings can be achieved by arranging administrative departments or functions in suites of large open plan offices, which include small-embedded offices or 'pods' where privacy, confidentiality or breakout time is needed. Creatively and appropriately designed open plan offices can provide flexibility and a conducive and effective environment for team working, interaction and communication.

2.9 Operational requirements

The briefing process should not only capture the functional requirements of the project but also just as importantly include a statement of the institute's relevant operational requirements that will have an impact upon the planning and design of the project.

Checklists of operational requirements are listed below for discussion with the relevant departments of the institute.

Each should include a summary of the current arrangements and proposed future requirements.

Security
- Whole site
- Site entry
- Car parks
- Building facades
- Entry for staff, students, visitors and deliveries
- Reception desk
- Access points and circulation within building
- Control room

Waste and recycling
- Paper and packaging
- Glass
- Food and catering
- Manufacturing
- Solvents and oils
- Radioactive

Catering
- Status/type
- Franchised areas
- Sittings
- Seating area
- Other uses

Materials handling
- Loading bays
- Central stores
- Designated stores
- Handling modes
- Distribution

Post
- Post/sorting room
- Delivery arrangements

Maintenance and cleaning
- Site
- Building
- Equipment
- Central storage
- Local storage
- Changing/locker/showers
- Offices/labs/workshops

Archives
- Policy
- Holding areas
- Materials and methods of storage
- Retrieval

Communications
- Telephone
- Data
- IT
- Audio visual

Deliveries and storage
- Central/local
- Loading/unloading
- Types of storage

Staff welfare
- Medical
- First Aid
- Creche
- Fitness

Parking and commuting
- Staff
- Students
- Visitors

Environmental health and safety
- Low energy
- Natural ventilation
- Minimise pollutants
- Maximise daylight
- Green materials and construction

2.10 The virtual campus

Definition

The concept of a virtual campus refers to a specific format of distance education and online learning in which students, teaching staff and even university administrative and technical staff mainly 'meet' or communicate through technical links. A virtual campus can also refer to the online offerings of a university where course work is completed

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

either partially or wholly online, often with assistance from a tutor, teacher or teaching assistant. Although the phrase 'virtual campus' is an important concept in education, there is no theoretical framework for it. There appears to be a lot of variables involved in the concept with different technologies involved. The general view is that it can involve both campus-based e-learning and distance e-learning.

e-University
In 2003 the e-university was launched as a single vehicle of UK universities' HE programmes over the internet. Following its launch it attracted just 900 students against a target of 5,600. In effect it failed and HEFCE decided to switch to support the development of e-learning in universities that provided coherent progress. Failure in part was due to an over-confident presumption about the scale of demand for wholly based e-learning.

Embedded e-learning
The failure of the e-university has impacted on e-learning and shown the importance of holding a narrowly skewed focus or definition of e-learning. A learner-centred approach not a technology-driven approach is now considered the way forward. This is known as 'embedded e-learning'.

Information communications technology
Technologies used in learning, such as interactive whiteboards, personal learning environments, wireless networks and mobile devices, plus the internet and high-quality digital learning resources, and the ability to access many of these from home and the workplace, are altering the experience and aspirations of learners.

MOBILE AND WIRELESS TECHNOLOGIES
Mobile and wireless technologies have increasingly widespread use in HE and the current trend is towards planning innovative methods in which to incorporate these technologies into e-learning. Key benefits in their use are seen as:

- portability and anytime, anyplace connectivity;
- flexibility and timeless access to e-learning resources;
- immediacy of communication;
- empowerment and engagement of learners;
- active learning experiences.

MOBILE AND WIRELESS LEARNING
'Mobile and wireless learning' is an adopted term for the broad concept involving many of the same technologies and facilities as e-learning, but with access via mobile devices or wireless networks rather than cable networks. Mobile and wireless devices have supported presentational, interactive and creative forms of learning, and when combined with e-learning, multi-media opportunities have resulted. Current best practice has been with the most well known technologies: USB storage devices, PDAs, laptops, tablet PCs, mobile phones and electronic voting. The reason for adoption of these is:

- wider availability
- ability to support a range of functions
- desktop functionality
- ease of use
- acceptance by learners
- potential to support pedagogical aims.

The easier the mobile device can become the property of the learner the more it is used. However, provision needs to be made for equipment booking, battery charging, induction and IT support systems.

ON-LINE EXAMS AND ASSESSMENTS
Technology is also being used for regulated online computer-assisted assessments and exams replacing paper-based methods at many universities. This is proving very successful with students. It will require supervised and controlled environments within the university in the form of dedicated secure rooms.

e-learning
As mentioned above, across the sector the general expectation is that e-learning at a distance will not wholly supplant face-to-face teaching in a significant way. However, campus-based e-learning will continue to develop and allow students to work more flexibly, on and off campus. At any one time students can work elsewhere on their projects, using their laptops or mobile devices linked to the campus wireless network.

DISTANCE LEARNING
Distance learning, sometimes called e-learning, is a teaching and learning system designed to be carried out remotely using electronic communication. It offers opportunities in situations where traditional education has difficulty in operating. It is more flexible in time and can be delivered anywhere. Popular technologies are CDs, MP3, webcasts, DVDs, video conferencing and internet. There is student-teacher interaction with feedback. The Open University, other universities and distance learning centres specialise in supplying distance learning courses, home study courses, online training and courses in a variety of subjects to gain nationally recognised qualifications.

DISTRIBUTED LEARNING
Distributed learning, also called IT-mediated instruction, is an instructional model that involves using various information technologies to help students learn. It encompasses technologies such as video or audio conferencing, satellite broadcasting and web-based multi-media formats. It can be implemented in various forms and scales, for example:

- Course enhancement – instructional technologies embedded in traditional classroom settings can be made available for students to consult before or after class sessions via the website making learning less dependent on time and location.
- Hybrid delivery – a web-based multi-media lecture made available to students to view online before attending a class session, and also made available for use in other courses multiplying their usefulness.
- Virtual classroom – 'any time, any place, at any pace' of learning. A course can be packaged on a CD-ROM, including prerequisite online lectures and the PowerPoint presentations coupled with audio for distance learners.

Other modes of learning
WORK-BASED LEARNING
Workplace-based learning is expected to increase although the expectation is that it will remain a minor aspect of HE activity. Some institutions are likely to become more involved in this work, particularly at foundation degree level and with tailor-made masters courses delivered on organisations' premises. There will be a saving on teaching space, but not support space.

PARTNERSHIPS
In some fields, notably creative arts, staff and students are becoming more itinerant, using cities' cultural infrastructures, and practitioner workplaces. Partnership arrangements of this kind are often involved and unlikely to lead to a saving on teaching space.

3 ENVIRONMENT
Environmental, economic and social issues form an integral part of the decision process in planning new educational facilities. Applying sustainable solutions where appropriate to education projects that reduce environmental impact is an important consideration. Some of the issues to be considered are:

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

- Zoning of space to minimise mechanical and cooling requirements.
- Creation of open plan, flexible and adaptable environments to reduce churn.
- Facades that significantly reduce incident solar gains, moderate external noise, provide opportunities for natural ventilation, and allow user control to provide satisfactory comfort conditions.
- Facade U-values that exceed building regulations.
- Material specifications that select recycled materials and products from sustainable sources.
- Robust materials requiring low maintenance.
- Low energy artificial lighting and controls, via presence detectors and daylight linking, to maximise the use of daylight and provide a visually comfortable space.
- Low energy cooling and mechanical ventilation systems, via displacement air systems, with heat recovery to reduce energy use.
- Low maintenance requirements during the operational life of systems.
- Introducing measures to reduce water use such as dual flush WCs, low pressure water systems and aerating taps.
- Rainwater recycling to reduce consumption of potable water.
- Integrating photovoltaic arrays to reduce energy consumption.
- Providing cycle and subsidised public transport networks to discourage private vehicle use and reduce carbon emissions.
- Using local suppliers and contractors to support local economy and minimise carbon emission.
- Using fuel cell powered site vehicles.

3.1 Space planning

The following are some key issues to consider when space planning new educational facilities:

- Adopt a modular planning system, clear and simple to use, with the ability to maximise the range of plan alternatives needed by the university that meet the objectives of functionality, cost effectiveness and adaptability. A modular system that offers practical and economic advantages during design, construction and the life of the building.
- Distinguish between those parts of the building designated to be fixed or unchanging – the structure, primary circulation, services cores; and those parts designated to be flexible or permit changes – usable teaching spaces, local servicing systems, internal partitions, flooring and ceiling systems.
- Consider non-cellular construction techniques, using large span framed structures, creating column free flexible space.
- Plan space in terms of broad categories of use, with provision not only suitable for its foreseen purpose but easily adaptable.
- Make fuller use of general purpose teaching space, by in addition to adopting appropriate ranges of room sizes, using partitions between rooms that can be moved without major disruption.
- Locate general teaching rooms in a common pool for timetabling and sharing between departments/schools.
- Locate accommodation used by large numbers of students at lower levels of the building, with less used and discreet areas located at upper levels.
- On a broader scale, plan boundaries between departmental areas to be adjustable without major adaptations, with accommodation not planned in rigidly separate categories, the differences and boundaries being flexible.

3.2 Design criteria

The following space norms and space standards exclude figures for pre-clinical and clinical medicine and dentistry.

Space norms

Space norms used to be published by the University Grants Committee (UGC) and the Polytechnics and Colleges Funding Council (PCFC). They were based on observations and assumptions about how students in different disciplines were taught – number of hours, type of teaching activity, staff/student ratio, and area per workplace. They were widely used by institutions and UK HE Funding Councils to inform the size of new building projects, but there have been no new or updated norms published for decades. Although there has been a shift away from them many institutes still use space norms or space weightings often with modifications.

UGC SPACE NORMS

UGC space norms were expressed as an 'allowance' of net usable area per FTE student for departmental academic areas. The allowance was made up of different types of space:

- general teaching space (excluding lecture theatres);
- academic offices and research labs;
- non-academic offices and stores;
- teaching and PG research labs;
- lab ancillaries.

There were also space norms for non-departmental academic areas expressed as an 'allowance' of net usable area per FTE student for:

- lecture theatres;
- library;
- administration (including maintenance);
- social, dining, health centres;
- sports facilities (building) – indoor and outdoor.

The norm varied according to academic discipline and was a guide to quantifying overall space requirements as a basis for project briefs. A recent survey carried out by the UK HE Space Management Group (SMG) suggests that while some HEIs do not want updated norms, others would welcome them. So in 2003/4 the SMG carried out a feasibility study in updating UGC norms taking into consideration the changes in academic delivery and decline in the amount of space need. The analysis found on average the HE sector is operating at 80% of UGC norms. The SMG updated UGC norms in Table I were published in 2006.

PCFC SPACE NORMS

The PCFC introduced a new system of space norms for PCFC institutions (Polytechnics and Colleges) in 1990 with reduced area

Table I SMG updated UGC space norms (net usable m²/FTE student)

Subject group	Academic staff: student ratio	UG	PGC	PGR	Allowance inc. for academic staff
Biological sciences	1:6.8	8.2	10.6	16.1	3.6
Psychology	1:14	6.0	7.8	15.0	1.9
Agric. & Forestry	1:7.7	7.8	10.2	15.7	3.2
Physical sciences	1:6.3	8.6	10.6	15.5	3.8
Mathematics	1:12.2	2.8	2.8	3.9	0.9
Computer sciences	1:15.1	5.3	7.6	8.4	1.3
Engineering & Technology	1:9.3	7.7	13.1	14.2	2.5
Architecture, building and planning	1:16	6.9	6.9	6.6	0.9
Geog. & Economics	1:12.6	4.4	5.5	5.7	0.9
Social studies	1:17.3	1.6	1.6	3.6	0.7
Business	1:22.2	2.1	2.1	3.5	0.5
Languages	1:14.6	2.4	2.4	3.8	0.8
Humanities	1:15.7	1.8	1.8	3.8	0.7
Archaeology	1:8.8	4.5	5.6	5.9	1.3
Art, design, music & drama	1:16.4	6.7	6.7	6.4	0.9
Education	1:19.1	3.5	3.5	3.4	0.6
Catering & hospitality management	1:21.4	5.8	8.1	13.6	1.1

allowances to reflect the practice at the time. These norms were around 15% less than previous DES methods of calculation. They included:

- specialist and non-specialist areas
- general teaching spaces
- libraries
- staff, administration
- sports and catering facilities.

There was no allowance for research space.

The SMG carried out a similar study in updating PCFC norms and found institutions were operating at 20.5% below the 1990 area allowances. The SMG updated PCFC norms in Table II were published in 2006.

Table II SMG updated PCFC space norms (net m²/FTE student)*

Programme area	
Engineering	11.9
Built Environment	7.6
Science	11.9
IT & Computing	8.7
Business	6.4
Health & Life Science	8
Humanities	6
Art & Design	11.1
Education	7.6

*Areas are net of circulation

Space standards

Space standards are area guidelines per (student or staff) workplace for the various types of activity or accommodation – general teaching, offices, laboratories, libraries, etc. They should be regarded as an overall check against functionality and will need adjustment in many situations to suit the specific needs of the activity carried out and the occupation levels. Both UGC and PCFC used a series of space standards for given activities or accommodation. These are listed in Table III.

However, most institutions have since adopted their own indicative space standards, which vary from the UGC/PCFC guidelines. Examples of these are listed in Table IV.

Area definitions

Five definitions of floor area are used in construction projects in HEIs, Figure 43.3:

- Gross external area (GEA)
- Gross internal area (GIA)
- Net internal area (NIA)
- Net usable area (NUA)
- Balance area.

It is imperative that any area stated is qualified by one of these definitions.

GEA – for planning applications: the area of the building measured externally at each floor level, including all spaces within the building, and perimeter wall thicknesses, external projections, loading bays and garages. It excludes open balconies, canopies and roof terraces.

GIA – for building costs estimation: the area of a building measured to the internal face of the perimeter walls at each floor level. It includes all spaces within the building, internal structure, walls and partitions, loading bays and garages. It excludes voids over atria.

NIA – equivalent of net lettable area: the area within a building that comprises usable areas (including built-in fixtures that occupy usable space) and primary horizontal circulation. It excludes common entrance halls, atria, landings and balconies, toilets, bathrooms, cleaners' rooms, plant spaces (rooms, ducts and stores), vertical circulation, internal structure (walls, columns, piers, etc.), loading bays and garages.

NUA – area available in rooms for people to use: the area within a building available for people to use. It excludes primary horizontal circulation in addition to all of the above.

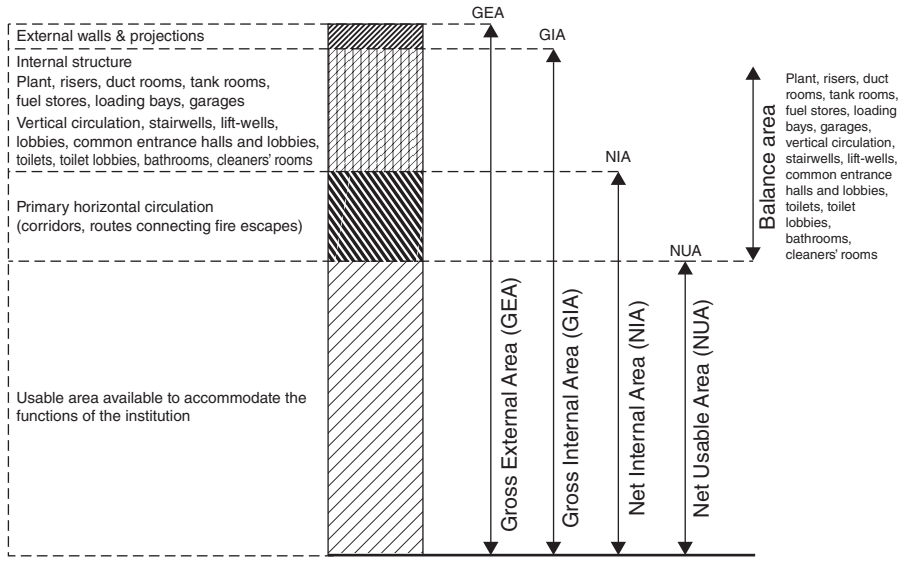
Table III UGC and PCFC Space Standards (net usable m²/workplace)

Space types	UGC	PCFC
General Teaching		
Lecture theatres and lecture rooms		
Raked or flat with close seating in rows	1.0	1.0
Teaching rooms		
Flat with close seating with writing flaps in rows	1.2	
Teaching rooms		
Flat with informal seating	1.9	1.8
Tutorial rooms		1.8
Seminar rooms		
Flat with tables and chairs	2.3	2.3
Teaching rooms		
Flat with demonstration facilities		2.5
Teaching Laboratories (UG and PGT)		
Languages	2.8	
Geography, Archaeology	3.3	
Experimental Psychology	4.0	
Biological Sciences-general purposes	4.0	
Biochemistry & PG BS	5.0	
Physics	3.7	
Physics-final year and PG	7.5	
Chemistry	5.0	
Engineering	4.6	
Engineering-final year & PG	6.5	
Computer Studies	5.0	
Information Technology		2.8
Science (Biology, Chemistry)		3.6
Art and Design		4.0
Management and Business Studies – management suite		5.1
– work study		4.6
– accounting		2.8
Science and Technology (large scale)		5.6
Engineering		5.6
Mathematics		5.3
Research Laboratories		
Experimental Psychology, Biology, Physics, Chemistry		
– PG and research fellows	9.5	
– staff	11.0	
Engineering	11.0	
Computer Studies	6.8	
Offices		
Professors, including small group space	18.5	
Tutorial staff, including small group space	13.5	
Non-tutorial staff (e.g., researchers, secretaries)	7.0	
Work study space for PGR (range 2.3 to 4.0)	3.4	
Administrative staff		0.44/FTE
Academic staff		0.69/FTE
Non-Academic staff		0.3/FTE
Research staff		0.58/FTE
Libraries/learning		
Library	1.25/FTE	0.8/FTE
Addition for law students	0.8/FTE	
Reader seat	2.3	
Studies	4.0	
Library/resource centre		2.5
Terminal room		3.0
Open access – books	4.7/1k vols	
Open access – journals	9.4/1k vols	
Fixed closed access – books	4.0/1k vols	
Fixed closed access – journals	8.1/1k vols	
Rolling closed access – books	2.1/1k vol	
Rolling closed access – journals	4.1/1k vols	

Table IV Examples of indicative space standards used by institutions (net usable m²/workplace)

Space type	net usable m²/workplace
Management offices	20
Single offices	9
Other office space	7
Professors and Heads of Schools	20
Academic staff	15
Support staff	8
Non-academic staff	10
Standard computing area	3.5
Office space overall average	6–8
Office space per FTE	10
Offices	7
Laboratories	3

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.



43.3 *Diagram illustrating area definitions: RICS Code of measuring practice (6th ed.)*

Balance area – area to enable the building to function: the floor area planned to enable the building to function. It includes primary horizontal and vertical circulation, entrance lobbies, atria, foyers, lifts, toilets, cloakrooms, cleaners' rooms and stores, plant spaces (rooms, ducts, stores), loading bays and garages, internal structure (wall, columns, piers, etc.).

Gross Floorspace (GIA) Area Breakdown
Guidance now recommends that new-build projects should target the following GIA floorspace area breakdown:

- Net Usable Area 70%
- Balance Area 30%
- Total (GIA) 100%

4 DO'S AND DON'TS

4.1 Do's
It is advisable to consider the following:

- *Culture and aspirations.* Interpret through discussion with the Client/User a clear perception of the qualitative needs derived from their ethos/vision that must be embraced by the project.
- *Needs analysis.* Review with the Client/User their academic and administrative operational and business needs and the impact/influence on the project.
- *Functional content.* Establish with the Client/User the complete range of academic, administrative and supporting functions to be accommodated.
- *Space requirements.* Discuss and agree with the Client/User the space standards and space provision to be applied to the various space types.
- *Organisational requirements.* Review with the Client/User the optimum organisational models to be applied to the accommodation to suit functional and operational needs.

4.2 Don'ts
It is advisable to consider the following:

- *General teaching accommodation.* Locate general teaching accommodation used by large numbers of students at higher levels of the building. Locate at the lowest levels to avoid congestion/disruption and excessive movement through the building.

Disperse and embed general teaching rooms in various faculties/departments. Group together in a 'common pool' to assist timetabling and ease of sharing between faculties/departments.

- *Modular planning.* Adopt a restrictive modular planning system. Adopt a flexible planning system that is able to maximise the range of plan alternatives needed by the university to meet functional objectives and future adaptability.
- *Space planning.* Plan space in a multitude of fixed categories of use. Distinguish between parts designated as fixed or unchanging and those parts designated to be flexible or to permit changes.
- *Construction techniques.* Adopt restrictive cellular construction techniques. Large span framed structures create a column free flexible planning space.

5 BRIEFING OVERVIEW

5.1 The client brief
In its broadest sense the client brief is a 'model' of the functional components of the client organisation, which are to be accommodated in the planning or design proposal.

It will comprise qualitative and quantitative descriptions of aspects of the client's objectives and requirements, which are salient to the development of a planning or design proposal.

Developing the brief
The development of this 'model' is an integral part of design. It has the following characteristics:

- The more comprehensive the guidance and the more certain the criteria, the greater is the probability that the planning or design solution will provide an appropriate and satisfactory framework for the client's function.
- Each stage of brief development must establish guidance and criteria, which are salient to the progress of the design to a higher level of certainty and detail.
- Brief development, like design itself, is an iterative process. A brief in some form must precede design, but the sequence of events and interaction between briefing and design must accommodate widely varying preferences, working methods and levels of expertise in different clients.

Briefing stages
In general, however, the development of the brief takes place in clearly defined stages, which establish approved guidance and criteria for corresponding planning and design stages. The stages generally are:

- Strategic brief: Strategic plan; master plan; feasibility study
- Concept brief: Concept design; preliminary design
- Scheme brief: Scheme design; final design
- Detail brief: Detail design; production information.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

A preliminary version of the relevant stage brief should be approved before planning or design work is started on the corresponding design stage.

Scope and content of the brief

- The content and structure of the brief will vary according to the needs and customs of each client. Public bodies in particular have to follow guidelines and procedures prescribed by central government.
- The scope and level of the brief will also vary according to the client's business and the type of facility for which the brief is intended.

5.2 Briefing process summary

The briefing process is an iterative process necessitating the engagement of key 'client' personnel. A summary of the process is described below.

Steering group

- The 'client' brief and the schedule of requirements must reflect the strategic aims and objectives for the project.
- It is therefore recommended that key client representatives be nominated from both the 'user' and 'technical' groups selected from within the range of education stakeholders to form a 'Project Steering Group' under the direction of a 'Project Sponsor'.

Vision statement and background

- It is important and recommended that at the outset of the briefing process a high level meeting be held with selected senior representatives of the education institute.
- At this meeting the senior representatives should present an overview of its vision, aims and objectives, operational and delivery aspects for the project.
- A statement of need for the project should also be presented together with the release of relevant background briefing information and documents covering previous work undertaken and pertinent to the project so these can be studied.

Interview meetings

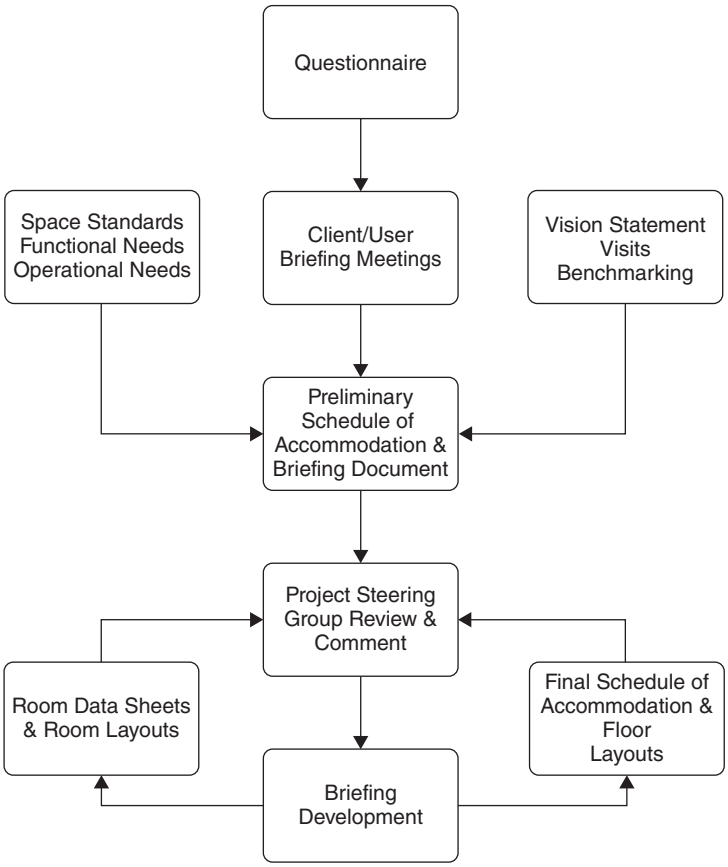
- Following the high level meeting a meeting should be held with the 'Project Sponsor' to agree the list of key personnel within the education institute to be interviewed as the first step in the process of collecting and developing the brief for the project.
- A suitable timetable for the interview meetings should be agreed.
- The key personnel to be interviewed should be asked to prepare and forward an outline statement covering a profile of the proposed requirements for discussion during the interview meetings.
- The interview meetings should be based on a structured format.

Questionnaire proforma

- Prior to the interview meetings the key personnel should be issued with a standard questionnaire proforma to complete and bring to the meetings for review and discussion during which further data will also be gathered.
- Following the meetings the data gathered should be developed as the basis for defining the preliminary space need, space relationships and space modelling options.
- At this early stage in the briefing process the questionnaire proforma should seek to obtain the essential data sufficient to inform preliminary space planning and design.

Visits and benchmarking

- During the interview process all the existing functional space relevant to the project within the institute should be visited to understand how the existing space is being used and to seek comments on the good and bad aspects of how the existing accommodation meets functional and operational requirements (Figure 43.4).
- Existing comparative projects should also be visited as part of a benchmarking exercise which should involve undertaking a quantitative and qualitative analysis of current standards and criteria that represent best practice in the HE sector.
- This should also include analysing HEFCE/DELNI/SFC/HEFCW published space planning and design guidelines.



43.4 *Briefing Process Diagram*

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Preliminary briefing document

- A complete record should be made of all the meetings held from the outset of the briefing process in the form of briefing notes, a vision statement, a description of functional and operational requirements, structure charts, population schedules, schedules of accommodation (assuming shared/non-shared facilities), preliminary activity space data, significant/desirable functional relationships and process flow diagrams.
- The above should be incorporated into a preliminary briefing document prepared for review and discussion with the 'Project Steering Group' for 'client' comment and approval.

Briefing development

- Following approval of the preliminary briefing document the planning and design process should develop concept options based on the preliminary brief for review with the 'Project Steering Group'.
- The concept options can then be tested against the preliminary brief as part of the process of determining the most appropriate design proposals for the project.
- The briefing process should continue in parallel as needed to obtain all the briefing criteria needed for the subsequent design development, with more detailed schedules of accommodation and detailed room data being incorporated within the development of subsequent briefing documentation for discussion with the 'Project Steering Group' and for client comment and approval.

6 BIBLIOGRAPHY

6.1 Legislation and standards

Designing Space for Effective learning
JISC Development Group, HEFCE
A guide to 21st century learning space design.

Innovative Practice with e-Learning
JISC Development Group, HEFCE
A good practice guide to embedding mobile and wireless technologies into everyday practice.

Design with distinction
CABE
Studies the value of good building design in HE.

Learning Spaces
EDUCAUSE
Focuses on how learner expectations influence learning spaces.

Effective learning and teaching in UK higher education
TLRP, Institute of Education
Studies the effect of a more inclusive and connective approach to learning and the impact on space planning and layouts.

Space planning guidelines
Stanford University, USA
Comparative example of guidelines and layouts for offices, classrooms, computer clusters, conference rooms, research and laboratory space.

Space planning guidelines
AAPPA.
Benchmark basis to assess space requirements.

Case studies
UK Higher Education Space Management Group
Investigates aspects of general and specific design topics through three different case studies.

Review of space norms
UK Higher Education Space Management Group
Results of a study into providing updated space norms for HE.

Impact on space of future changes in higher education
UK Higher Education Space Management Group
The future impact of changes in teaching methods, widening participation and research activity.

Promoting space efficiency in building design
UK Higher Education Space Management Group
Identifies aspects of building design contributing most to optimum space efficiency in HE projects.

Space utilisation: practice, performance and guidelines
UK Higher Education Space Management Group
Review of space use practice and performance, and scope for updating guidance.

Managing space: a review of English further education and HE overseas
UK Higher Education Space Management Group
Assesses how LSC and overseas HE space guidance could add value to UK HE space guidance.

6.2 Web sites

www.hefce.ac.uk
www.delni.gov.uk
www.sfc.ac.uk
www.hefcw.ac.uk
www.smg.ac.uk
www.aude.ac.uk
www.architecture.com/UseAnArchitect/PublicBuildings/UniversityClientForum/HigherEducationDesignQualityForum.aspx
www.educause.edu/learningspaces
www.sconul.ac.uk
www.breeam.org/

This page intentionally left blank

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Appendix A
The SI system

Table I Base units of the SI system

Quantity	Name of unit	Unit symbol
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin*	K
Amount of substance	mole	mol
Luminous intensity	candela	cd
Supplementary units		
Plane angle	radian	rad
Solid angle	steradian	sr

Table II Derived SI units

Quantity	Name of unit	Symbol	Remarks
Frequency	hertz	Hz	1 Hz = s^{-1}
Force	newton	N	1 N = 1 kg.m/s^2
Pressure	pascal	Pa	1 Pa = 1N/m^2
Stress			
Energy	joule	J	1J = 1 N.m
Work			
Quantity of heat			
Power	watt	W	1W = 1 J/s
Radiant flux			
Electric charge	coulomb	C	1C = 1 A.s
Quantity of electricity			
Electric potential	volt	V	1V = 1 W/A
Potential difference			
Tension			
Electromotive force			
Capacitance	farad	F	1F = 1 C/V
Electrical resistance	ohm	Ω	1 Ω = 1 V/A
Electrical conductance	siemens	S	1 S = 1 $S2^{-1}$
Magnetic flux	weber	Wb	1 Wb = 1 V.s
Magnetic flux density	tesla	T	1 T = 1 Wb/m^2
Inductance	henry	H	1H = 1 Wb/A
Celsius temperature	degree Celsius	°C	1 °C = 1 K
Luminous flux	lumen	lm	1 lm = 1 cdsr
Illuminance	lux	lx	1 lx = 1 lm/m^2

Table III Multiples and submultiples of SI units

Power of 10	Prefix	Symbol
24	Yetta	Y
21	Zetta	Z
18	Exa	E
15	Peta	P
12	Tera	T
9	Giga	G
6	Mega	M
3	Kilo	k
2	hector	h
1	Deca	da
–1	Deci	d
–2	Centi	c
–3	Milli	m
–6	Micro	μ
–9	Nano	n
–12	Pico	p
–15	Femto	f
–18	Atto	a
–21	Zepto	z
–24	Yocto	y

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table IV Approved SI units, multiples and submultiples together with other units commonly in use

Based on BS 5555:1981 An asterisk indicates a unit outside the SI system currently recognised by the CIPM for a specific use

Item no in ISO 31:1992	Quantity	SI unit	Recommended multiples and sub-multiples	Other units which may be used	Remarks
1 Space and time					
1–1	Plane angle	rad (radian)	mrad µrad	degree (°) = p/180 rad minute (′) = (1/60)° second (″) = (1/60)′ grade (G) = p/200 rad	Radians are principally used in purely mathematical situations. In practice, degrees and its subdivisions are normally used in the UK. The symbol °,′ and ′′ are exceptions in that there is no space between the value and the symbol. Decimal subdivisions of the degree are preferred to minutes and seconds; this facilitates the using of pocket calculators. On continental Europe, the grade (or its alternative name, the gon) is often used, always decimally subdivided.
1–2	Solid angle	sr (steradian)			
1–3	Length	m (metre)	km, cm, mm, mm, nm, pm, fm	*nautical mile 1 n mile = 1852 m exactly	The statute mile is currently intended to stay for the moment on road signs in the UK 1 mile = 1.609 344km exactly. On road signs the mile is confusingly abbreviated m, ml is preferred.
1–4	Area	m^2	km^2, dm^2, cm^2, mm^2	*hectare (ha), *are (a) 1 ha = 10^4 m^2 1a=10^2m^2	The square foot is still used by commercial estate agents in the UK 1 sq ft = 0.092 290 304 m^2 exactly. The acre is also commonly found in the UK 1 acre = 0.404 685 6422 ha exactly
1–5	Volume	m^3	dm^3, cm^3, mm^3	* litre (l), *hl, *cl, *ml 1 hl = $10^{-1}m^3$ 11=$10^{-3}m^3$ = $1dm^3$ 1cl = $10^{-5}m^3$ 1ml=$10^{-6}m^3$ = $1cm^3$	The abbreviations l and L may each be used for litre; the full name is often used to avoid confusion. The imperial pint (pt) has been approved for continuing use in the UK, but only for draught beer and for milk in bottles (not cartons!). 1 pt = 0.568 2451
1–6.1	Time	s (second)	ks, ms, ms, ns	minute (min) 1 min = 60s exactly hour (h) 1h = 60min exactly day (d) d = 24h exactly	Other units such as week, month and year (a) are in common use; definitions of month and year often need to be specified
1–8.1	Angular velocity	rad/s			
1–10.1	m/s	m/h kilometre per hour (km/h) 1 km/h = (1/3.6) m/s			1 *knot = 1.852 km/h exactly (no abbreviation approved) Miles per hour (mph) are continuing on UK road signs 1 mph = 1.609 344 km/h exactly
1–11.1	m/s^2				
2 Periodic and related phenomena					
2–3.1	Frequency	Hz (hertz)	THz, GHz, MHz, kHz		
2–3.2	Rotational frequency	s^{-1}		min^{-1}	revs per min (r/min) and revs per sec (r/s) are also used
2–4	Angular frequency	rad/s			
3 Mechanics					
3–1	Mass	kg (kilogram)	Mg, g, mg, mg	tonne (t) unified atomic mass unit (u)	1 t = 10 kg tonne in the UK also called metric ton 1 u approx = 1.660 540 x 10^{-27} kg
3–2	Volumic mass Density Mass density	kg/m^3	Mg/m^3 kg/dm^3, g/cm^3 (all the same)	t/m^3, kg/l (kg/litre), g/ml, g/l	
3–5	Lineic mass Linear density	kg/m	mg/m		1 tex = 10^{-6} kg/m = 1 g/km The tex is used for textile filaments
3–7	Moment of inertia	$kg.m^2$			
3–8	Momentum	kg.m/s			
3–9	Force	N (newton)	MN, kN, mN, µmUM		
3–11	Moment of momentum Angular momentum	$kg.m^2$			
3–12.1	Moment of force	N.m	MN.m, kN.m, mN.m, µN.m		Moment of force is often called simply moment or bending moment
3–15.1	Pressure	Pa (pascal) Pa	GPa, MPa, kPa, hPa, mPa, µPa	*bar = 100kPa exactly 1 mbar = 1 hPa bars are used only in fluid pressures	
3–15.2	Normal stress		GPa, MPa, kPa		1MPa = $1N/mm^2$
3–23	Dynamic viscosity	Pa.s	mPa.s		poise (P) 1cP = 1mPa.s The poise is only used in conjunction with CGS units
3–24	Kinematic viscosity	m^2/s	mm^2/s		stokes (St) 1 cSt = $1mm^2/s$ The stokes is used only in conjunction with CGS units
3–25	Surface tension	N/m	mN/m		
3–26.1	Energy	J (joule)	EJ, PJ, TJ, MJ, kJ, mJ	electronvolt (eV) 1 eV = (1.602 10 ± 0.000 07) × 10^{-19} J eV, MeV and GeV are used in accelerator technology	
3–26.2	Work				kilowatt-hour (kW.h) 1 kWh = 3.6 × 10^6 J = 3.6 MJ W.h, kW.h, MW.h, GW.h and TW.h are used in the electrical power industry
3–27	Power	W (watt)	GW, MW, kW, mW, µmUW		1W = 1J/s
4 Heat					
4–1	Thermodynamic temperature	K (kelvin)			

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Item no in ISO 31:1992	Quantity	SI unit	Recommended multiples and sub-multiples	Other units which may be used	Remarks
4–2	Celsius temperature	°C (no space beween value and symbol)			1 °C = 1 K The temperature in °C is the temperature expressed in kelvins minus exactly 273.15 K
4–3.1	Linear expansion coefficient	K^{-1}			
4–6	Heat, quantity of heat	J	EJ, PJ, TJ, GJ, MJ, kJ, mJ		
4–7	Heat flow rate	W	kW		1 W = 1 J/s
4–9	Thermal conductivity	W/(m.k)			
4–10.1	Coefficient of heat transfer	W/(m.K)			
4–11	Thermal insulance	m.k/W			
4–15	Heat capacity	J/K	kJ/K		
4–16.1	Massic heat capacity (was specific)	J/(kg.K)	kJ/(kg.K)		
4–18	Entropy	J/K	kJ/K		
4–19	Massic entropy	J/(kg.K)	kJ/(kg.K)		
4–21.2	Massic thermodynamic energy (was specific energy)	J/kg	MJ/kg, kJ/kg		
5 Electricity and magnetism					
5–1	Electric current	A (ampere)	kA, mA, µA, nA, pA		
5–2	Electric charge, quantity of electricity	C (coulomb)	kC, µC, nC, pC		1 A.h = 3.6 kC
5–3	Volumic charge, charge density	C/m^3	C/mm^3, GC/m^3, MC/m^3 or C/cm^3, kC/m^3, mC/m^3, $\mu C/m^3$		
5–4	Areic charge, surface density of charge	C/m^3	MC/m^2 or C/mm^2, C/cm^2, kC/m^2, mC/m^2, $\mu C/m^2$		
5–5	Electric field strength	V/m	MV/m, kV/m or V/mm, V/cm, mV/m, µV/m		
5–6.1	Electric potential	V (volt)	MV, kV, mV, V		
5–6.2	Potential difference tension				
5–6.3	Electromotive force				
5–7	Electrical flux density	C/m^2	C/cm^2, kC/m^2, mC/m^2, $\mu C/m^2$		
5–9	Capacitance	F (farad)	mF, µF, nF, pF		
5–33	Resistance to direct current	Ω (ohm)	GΩ, MΩ, kΩ, mΩ, µΩ		
5–34	Conductance of direct current	S (siemens)	kS, mS, µS		1 S = 1/Ω
5–36	Resistivity	S/m	GΩm, MΩm, kΩm, Ωcm, mΩm, µΩm, nΩm		µm = 10^{-2} Ωm (µmUmm²)/m = 10^{-6} Ωm = µmUΩm are also used
5–37	Conductivity		MS/m, kS/M		
5–38	Reluctance	H^{-1}			
5–39	Permeance	H (henry)			
5–49	Active power	W	TW, GW, MW, kW, mW, mW, nW		In electric power technology active power is expressed in watts, apparent power in volt amperes V.A and reactive power in vars (var)
5–52	Active energy	J	TJ, GJ, MJ, KJ		1 W.h = 3.6 kJ exactly TW.h, GW.h, MW.h, kW.h
6 Light					
6–3	Wavelength	m	µmUm, nm, pm	*ångstro¨m (Å)	1ÅR = $10r^{-10}$m= 10^{-4} µm Um= 10^{-1} nm
6–7	Radiant energy	J			
6–10	Radiant power energy flux	W			
6–13	Radiant intensity	W/sr			
6–15	Radiant exitance	w/m^2			
6–29	Luminous intensity	cd (candela)			
6–30	Luminous flux	lm (lumen)			
6–31	Quantity of light		lm.h	1 lm.h = 3600 lm.s exactly	
6–32	Luminance	cd/m^2			
6–33	Luminous exitance	lx (lux)			
6–35	Light exposure	lx.s			
6–36.1	Luminous efficacy	lm/W			
7 Acoustics					
7–1	Period, periodic time	s	ms, ms		
7–2	Frequency	Hz	MHz, kHz		
7–5	Wavelength	m	mm		
7–8	Volumic mass Mass density Density	kg/m^3			
7–9.1	Static pressure	Pa	nPa, µPa		
7–9.2	(Instantaneous) sound pressure				
7–11	(Instantaneous) sound particle velocity	m/s	mm/s		
7–13	(Instantaneous) volume flow rate	m^3/s			
7–14.1	Velocity of sound	m/s			

(continued)

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table IV (continued)

Item no in ISO 31:1992	Quantity	SI unit	Recommended multiples and sub-multiples	Other units which may be used	Remarks
7–16	Sound power	W			
7–17	Sound intensity	W/m^2	mW/m^2, mW/m^2, pW/m^3		
7–18	Acoustic impedance	$Pa.s/m^3$			
7–19	Mechanical impedance	N.s/m	Mechanical impedance		
7–20.1	Surface density of mechanical impedance	Pa.s/m			
7–21	Sound pressure level		bel (B), dB	1 dB = 10^{-1} B	
7–28	Sound reduction index		B, dB		
7–29	Equivalent absorption area of surface or object	m^2			
7–30	Reverberation time	s			

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Appendix B
Conversion factors and tables

Table I Conversion factors

Bold type indicates exact conversions. Otherwise four or five significant figures are given.

Quantity	Conversion factors	
General purposes		
Length	1 mile	= 1.609 km
	1 chain	= **20.1168** m
	1 yard	= **0.9144** m
	1 foot	= **0.3048**m = **304.8** mm
	1 inch	= **25.4**mm = **2.54** cm
Area	1 square mile	= 2.590 km^2 = 259.0 ha
	1 hectare	= **10 000**m^2
	1 acre	= 4 046.9 m^2 = 0.40469 ha
		= **4 840** yd^2
	1 square yard	= 0.8361 m^2
	1 square foot	= 0.09290 m^2 = 929.03 cm^2
	1 square inch	= 645.2 mm^2 = 6.452 cm^2
Volume	1 cubic yard	= 0.7646 m^3
	1 litre	= **1**dm^3 = **1000**cm^3
	1 m^3	= **1 000** litres
	1 millilitre	= **1**cm^3 = **1000**mm
	1 cubic foot	= 0.02832 m^3 = 28.32 litre
	1 petrograd standard	= 4.672 m^3
	1 cubic inch	= 16 387 mm^3 = 16.387 cm^3
		= 16.387ml = 0.016387 litre
Capacity	1 UK gallon	= 4.546 litre
	1 UK quart	= 1.137 litre
	1 UK pint	= 0.5683
	1 UK fluid ounce	= 28.413 cm^3
	1 US barrel (for petroleum)	= 159.0 litre
	1 US gallon	= 3.785 litre
	1 US liquid quart	= 0.9464 litre
	1 US dry quart	= 1.101 litre
	1 US liquid pint	= 0.4732 litre
	1 US dry pint	= 0.5506 litre
	1 US liquid ounce	= 29.574 cm^3
Mass	1 UK ton	= 1.016 tonne = 1016.05 kg
	1 US (or short) ton	= 0.9072 tonne = 907.2 kg
	1 kip (1000 lb)	= 453.59 kg
	1 UK hundredweight	= 50.80 kg
	1 short (US) hundredweight	= 100lb = 45.36 kg
	1 pound	= 0.4536 kg
	1 ounce avoirdupois	= 28.35 g
	1 ounce troy	= 31.10 g
Mass per unit length	1 UK ton per mile	= 0.6313 kg/m = 0.6313 t/km
	1 lb per yard	= 0.4961 kg/m
	1 lb per foot	= 1.4882 kg/m
	1 lb per inch	= 17.86 kg/m
	1 oz per inch	= 1.1161 kg/m
Length per unit mass	1 yd per lb	= 2.016 m/kg
Mass per unit area	1 ton per square mile	= 392.3 kg/km^2 = 0.3923 g/m^2
		= 3.923 kg/ha
	1 ton per acre	= 0.2511 kg/m^2
	1 hundredweight per acre	= 0.01255 kg/m^2
	1 lb per square foot	= 4.882 kg/m^2
	1 lb per square inch	= 703.07 kg/m^2
	1 oz per square yard	= 33.91 g/m^2
	1 oz per square foot	= 305.15 g/m^2
	1 kg/cm^2	= 10t/m^2
Mass density (mass per unit volume)	1 ton per cubic yard	= 1329 kg/m^3 = 1.3289 t/m^3
	1 lb per cubic yard	= 0.5933 kg/m^3
	1 lb per cubic foot	= 16.02 kg/m^3
	1 lb per cubic inch	= 27.68 g/cm^3 = 27.68 t/m^3

Table I (continued)

Quantity	Conversion factors	
Area coverage	× square yards per ton	$= \frac{1}{x}$ × 1215kg/m^2
	× square yards per gallon	$= \frac{1}{x}$ × 5.437 litre/m^2
Volume rate of flow	1 cubic feet per minute	= 0.4719 litre/s
		= 471.9 cm^3/s
		= 0.0004719 m^3/s
	1 cusec (cu ft per sec)	= 0.02832 m^3/s ('cumec')
	1 cu ft per thousand acres	= 0.06997 litre/ha
		= 0.006997 m^3/km^2
		= 6997 cm^3/km^2
	1 cubic inch per second	= 16.39 ml/s
	1 gallon per year	= 4546 cm^3/a^* = 0.004546 ^{3}/a
	1 gallon per day	= 4546 cm^3/d
	1 litre/s	= **86.4** m^3/d
	1 million gallons per day	= 0.05262 m^3/s
	1 gallon per person per day	= 4.546 litre/(person day)
	1 gallon per sq yd per day	= 0.005437 m^3/(m^2.d)
		= 0.000062928 mm/s
	1 gallon per cu yd per day	= 0.005946 m^3/(m^3.d)
	1 gallon per hour	= 4.5461 litre/h
	1 gallon per minute	= 0.07577 litre/s
	1 gallon per second	= 4.5461 litre/s
Fuel consumption	1 gallon per mile	= 2.825 litre/km
	1 mile per gallon	= 0.354 km/litre
	× miles per gallon	$= \frac{1}{x}$ × 282.5 litre 100 km
Velocity	1 mile per hour	= 1.609 km/h = **0.44704** m/s
	1 foot per minute	= **0.3048** m/min = 0.0051 m/s
	1 foot per second	= **0.3048** m/s
	1 inch per second	= **25.4** mm/s
	1 UK knot	= 0.5148 m/s = 1.853 km/h
		= 1.00064 international knot
Acceleration	1 foot per sec per sec	= **0.3048** m/s^2
	1 mile per hr per sec	= **0.44704** m/s^2
	1 g (standard gravity)	= **9.806 65**m/s^2
Heating Temperature	× Fahrenheit	$= \frac{5}{9}$ × (**x** – 32) ° Celsius
Temperature interval	1°F	= 0.5556 K = 0.5556°C
Energy (heat)	1 British thermal unit	= 1055J = 1.055 kJ
	1 Therm	= 105.5 MJ
	1 calorie	= **4.1868** J
	1 kilowatt–hour	= 3.6 MJ
	1 foot pound–force	= 1.356 J
	1 kilogram force–metre	= **9.806 65**J
Power (also heat flow rate)	1 J/s	= 1W
	1 Btu per hour	= 0.293 07W
	1 horsepower	= 745.70 W
	1 ft–lbf per second	= 1.356 W
	1 kgf–metre per second	= **9.806 65W**
	1 calorie per second	= **4.1868 W**
	1 kilocalorie per hour	= **1.163 W**
	1 metric horsepower	= 735.5 W
Density of heat flow rate	1 Btu per square foot hour	= 3.155 W/m^2
Quantity Thermal conductivity k value	Conversion factors	
	1 Btu inch per square foot hour degree Fahrenheit	= 0.1442 W/(m.K)

Table I (continued)

Quantity	Conversion factors	
Thermal transmittance or coefficient of heat transfer or thermal conductance or *U* value	1 Btu per square foot hour degree Fahrenheit	= 5.678 W/(m²K)
Thermal resistivity 1/k value	1 sq ft hr °F per Btu inch	= 6.933 m.K/W
Thermal or specific heat capacity	1 Btu per lb °F	= 4.187 (kJ.K)
	1 Btu per cu ft °F	= 67.07 kJ/(m³.K)
Calorific value	1 Btu per pound	= 2.326 kJ/kg
	1 Btu per cubic foot	= 37.26 kJ/m³ = 37.26 J/litre
	1 Btu per gallon	= 232.1 J/litre
Refrigeration	1 ton	= 3517W
Lighting	1 foot–candle	= 10.76 1 ×
Illumination	1 lumen per sq ft	= 10.76 1 ×
Lumination	1 candela per square inch	1550 cd/m²
	1 candela per square foot	= 10.76 cd/m²
	1 apostilb	= $\frac{1}{\neq}$ cd/m = 0.3183 cd/m
Structural design (All tons are UK tons)		
Force	1 pound–force	= 4.448 N
	1 kip–force	= 4.448 kN
	1 ton–force	= 9.964 kN
	1 kilogram–force	= 9.807 N
	1 kilopond	= 9.807 N

Table I (continued)

Quantity	Conversion factors	
Force per unit length	1 pound–force per foot	= 14.59 N/m
	1 pound–force per inch	= 175.1 kN/m = 175.1 N/mm
	1 ton–force per foot	= 32.69 kN/m
	1 kilogram–force per metre	= 9.807 N/m
	1 kilogram–force per centimetre	= 0.9807 kN/m
Force per unit area or	1 lbf per square foot	= 47.88 N/m² = 47.88 Pa
		= 0.04788 kN/m²
Stress or Pressure	1 lbf per square inch	= 6.895 kN/m² = 6.895 kPa
	1 tonf per square foot	= 107.3 kN/m² = 107.3 kPa
	1 tonf per square inch	= 15.44 MN/m² = 15.44 N/m² = 15.44 MPa
	1 kgf per square metre	= 9.807 N/m² = 9.807 Pa
	1 kgf per sq centimetre	= 98.07 kN/m² = 98.07 kPa
	1 bar	= **100** kN/m² = **100** kPa
	1 millibar	= **100** N/m² = **100**Pa
	1 standard atmosphere	= **101.325** kPa
	1 inch of mercury	= 3.386 kPa
	1 foot of water	= 2.989 kPa
		= 300 mbar approx
Bending moment of torque	1 pound–force foot	= 1.356 Nm
	1 pound–force inch	= 0.1130Nm = 113.0Nmm
	1 kip–force foot	= 1.356 kNm
	1 kip–force inch	= 0.1130 kNm = 113.0 Nm
	1 ton–force foot	= 3.037 kNm
	1 ton–force inch	= 0.2531 kNm = 253.1 Nm
	1 kilogram–force metre	= 9.807 Nm

* a (for annum) is the symbol for year.

Table II Inches and fractions of an inch to millimetres ($^1/_{16}$ in increments up to 11 $^{15}/_{16}$ in)

		$^1/_{16}$	$^1/_8$	$^3/_{16}$	$^1/_4$	$^5/_{16}$	$^3/_8$	$^7/_{16}$	$^1/_2$	$^9/_{16}$	$^5/_8$	$^{11}/_{16}$	$^3/_4$	$^{13}/_{16}$	$^7/_8$	$^{15}/_{16}$
	Inches	**Millimeters**														
0	–	1.6	3.2	4.8	6.4	7.9	9.5	11.1	12.7	14.3	15.9	17.5	19.1	20.6	22.2	23.8
1	25.4	27.0	28.6	30.2	31.8	33.3	34.9	36.5	38.1	39.7	41.3	42.9	44.5	46.0	47.6	49.2
2	50.8	52.4	54.0	55.6	57.2	58.7	60.3	61.9	63.5	65.1	66.7	68.3	69.9	71.4	73.0	74.6
3	76.2	77.8	79.4	81.0	82.6	84.1	85.7	87.3	88.9	90.5	92.1	93.7	95.3	96.8	98.4	100.0
4	101.6	103.2	104.8	106.4	108.0	109.5	111.1	112.7	114.3	115.9	117.5	119.1	120.7	122.2	123.8	125.4
5	127.0	128.6	130.2	131.8	133.4	134.9	136.5	138.1	139.7	141.3	142.9	144.5	146.1	147.6	149.2	150.8
6	152.4	154.0	155.6	157.2	158.8	160.3	161.9	163.5	165.1	166.7	168.3	169.9	171.5	173.0	174.6	176.2
7	177.8	179.4	181.0	182.6	184.2	185.7	187.3	188.9	190.5	192.1	193.7	195.3	196.9	198.4	200.0	201.6
8	203.2	204.8	206.4	208.0	209.6	211.1	212.7	214.3	215.9	217.5	219.1	220.7	222.3	223.8	225.4	227.0
9	228.6	230.2	231.8	233.4	235.0	236.5	238.1	239.7	241.3	242.9	244.5	246.1	247.7	249.2	250.8	252.4
10	254.0	255.6	257.2	258.8	260.4	261.9	263.5	265.1	266.7	268.3	269.9	271.5	273.1	274.6	276.2	277.8
11	279.4	281.0	282.6	284.2	285.8	287.3	288.9	290.5	292.1	293.7	295.3	296.9	298.5	300.0	301.6	303.2

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table III Feet to millimetres (up to 200 ft)

	0	1	2	3	4	5	6	7	8	9
Feet	**Millimetres**									
0	–	304.8	609.6	914.4	1219.2	1524.0	1828.8	2133.6	2438.4	2743.2
10	3048.0	3352.8	3657.6	3962.4	4267.2	4572.0	4876.8	5181.6	5486.4	5791.2
20	6096.0	6400.8	6705.6	7010.4	7315.2	7620.0	7924.8	8229.6	8534.4	8839.2
30	9144.0	9448.8	9753.6	10058.4	10363.2	10668.0	10972.8	11277.6	11582.4	11887.2
40	12192.0	12496.8	12801.6	13106.4	13411.2	13716.0	14020.8	14325.6	14630.4	14935.2
50	15240.0	15544.8	15849.6	16154.4	16459.2	16764.0	17068.8	17373.6	17678.4	17983.2
60	18288.0	18592.8	18897.6	19202.4	19507.2	19812.0	20116.8	20421.6	20726.4	21031.2
70	21336.0	21640.8	21945.6	22250.4	22555.2	22860.0	23164.8	23469.6	23774.4	24079.2
80	24384.0	24688.8	24993.6	25298.4	25603.2	25908.0	26212.8	26517.6	26822.4	27127.2
90	27432.0	27736.8	28041.6	28346.4	28651.2	28956.0	29260.8	29565.6	29870.4	30175.2
100	30480.0	30784.8	31089.6	31394.4	31699.2	32004.0	32308.8	32613.6	32918.4	33223.2
110	33528.0	33832.8	34137.6	34442.4	34747.2	35052.0	35356.8	35661.6	35966.4	36271.2
120	36576.0	36880.8	37185.6	37490.4	37785.2	38100.0	38404.8	38709.6	39014.4	39319.2
130	39624.0	39928.8	40233.6	40538.4	40843.2	41148.0	41452.8	41757.6	42062.4	42367.2
140	42672.0	42976.8	43281.6	43586.4	43891.2	44196.0	44500.8	44805.6	45110.4	45415.2
150	45720.0	46024.8	46329.6	46634.4	46939.2	47244.0	47548.8	47853.6	48158.4	48463.2
160	48768.0	49072.8	49377.6	49682.4	49987.2	50292.0	50596.8	50901.6	51206.4	51511.2
170	51816.0	52120.8	52425.6	52730.4	53035.2	53340.0	53644.8	53949.6	54254.4	54559.2
180	54864.0	55168.8	55473.6	55778.4	56083.2	56388.0	56692.8	56997.6	57302.4	57607.2
190	57912.0	58216.8	58521.6	58826.4	59131.2	59436.0	59740.8	60045.6	60350.4	60655.2
200	60960.0	–	–	–	–	–	–	–	–	–

Note: use Tables II and III together to obtain the metric equivalent of any dimension up to 200 ft. For example
56 ft 3¼ in: 56 ft = 17068.8
3¼ in = 95.3
TOTAL = 17164.1 mm = 17.164 m

Table IV Miles (up to 100 miles) to kilometres (to two places of decimals) may also be used to convert mph to kph

	0	1	2	3	4	5	6	7	8	9
Miles	**Kilometres**									
0	–	1.61	3.22	4.83	6.44	8.05	9.66	11.27	12.87	14.48
10	16.09	17.70	19.31	20.92	22.53	24.14	25.75	27.36	28.97	30.58
20	32.19	33.80	35.41	37.01	38.62	40.23	41.84	43.45	45.06	46.67
30	48.28	49.89	51.50	53.11	54.72	56.33	57.94	59.55	61.16	62.76
40	64.37	65.98	67.59	69.20	70.81	72.42	74.03	75.64	77.25	78.86
50	80.47	82.08	83.69	85.30	86.90	88.51	90.12	91.73	93.34	94.95
60	96.56	98.17	99.78	101.39	103.00	104.61	106.22	107.83	109.44	111.05
70	112.65	114.26	115.87	117.48	119.09	120.70	122.31	123.92	125.53	127.14
80	128.75	130.36	131.97	133.58	135.19	136.79	138.40	140.01	141.62	143.23
90	144.84	146.45	148.06	149.67	151.28	152.89	154.50	156.11	57.72	159.33
100	160.93	–	–	–	–	–	–	–	–	–

Table V Square inches (up to 100 sq in) to square millimetres (to one place of decimals)

	0	1	2	3	4	5	6	7	8	9
Square inches	**Square millimetres (mm^2)**									
0	–	645.2	1290.3	1935.5	2580.6	3225.8	3871.0	4516.1	5161.3	5806.4
10	6451.6	7096.8	7741.9	8387.1	9032.2	9677.4	10322.6	10967.7	11612.9	12258.0
20	12903.2	13548.4	14193.5	14838.7	15483.8	16129.0	16774.2	17419.3	18064.5	18709.6
30	19354.8	20000.0	20645.1	21290.3	21935.4	22580.6	23225.8	23870.9	24516.1	25161.2
40	25806.4	26451.6	27096.7	27741.9	28387.0	29032.2	29677.4	30322.5	30967.7	31612.8
50	32258.0	32903.2	33548.3	34193.5	34838.6	35483.8	36129.0	36774.1	37419.3	38064.4
60	38709.6	39354.8	39999.9	40645.1	41290.2	41935.4	42580.6	43225.7	43870.9	44516.0
70	45161.2	45806.4	46451.5	47096.7	47741.8	48387.0	49032.2	49677.3	50322.5	50967.6
80	51612.8	52258.0	52903.1	53548.3	54193.4	54838.6	55483.8	56128.9	56774.1	57419.2
90	58064.4	58709.6	59354.7	59999.9	60645.0	61290.2	61935.4	62580.5	63225.7	63870.8
100	64516.0	–	–	–	–	–	–	–	–	–

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table VI Square feet (up to 500 ft²) to square metres (to two places of decimals)

	0	1	2	3	4	5	6	7	8	9
Square feet	**Square metres (m²)**									
0	–	0.09	0.19	0.28	0.37	0.46	0.56	0.65	0.74	0.84
10	0.93	1.02	1.11	1.21	1.30	1.39	1.49	1.58	1.67	1.77
20	1.86	1.95	2.04	2.14	2.23	2.32	2.42	2.51	2.60	2.69
30	2.79	2.88	2.97	3.07	3.16	3.25	3.34	3.44	3.53	3.62
40	3.72	3.81	3.90	3.99	4.09	4.18	4.27	4.37	4.46	4.55
50	4.65	4.74	4.83	4.92	5.02	5.11	5.20	5.30	5.39	5.48
60	5.57	5.67	5.76	5.85	5.95	6.04	6.13	6.22	6.32	6.41
70	6.50	6.60	6.69	6.78	6.87	6.97	7.06	7.15	7.25	7.34
80	7.43	7.53	7.62	7.71	7.80	7.90	7.99	8.08	8.18	8.27
90	8.36	8.45	8.55	8.64	8.73	8.83	8.92	9.01	9.10	9.20
100	9.29	9.38	9.48	9.57	9.66	9.75	9.85	9.94	10.03	10.13
110	10.22	10.31	10.41	10.50	10.59	10.68	10.78	10.87	10.96	11.06
120	11.15	11.24	11.33	11.43	11.52	11.61	11.71	11.80	11.89	11.98
130	12.08	12.17	12.26	12.36	12.45	12.54	12.63	12.73	12.82	12.91
140	13.01	13.10	13.19	13.29	13.38	13.47	13.56	13.66	13.75	13.84
150	13.94	14.03	14.12	14.21	14.31	14.40	14.49	14.59	14.68	14.77
160	14.86	14.96	15.05	15.14	15.24	15.33	15.42	15.51	15.61	15.70
170	15.79	15.89	15.98	16.07	16.17	16.26	16.35	16.44	16.54	16.63
180	16.72	16.82	16.91	17.00	17.09	17.19	17.28	17.37	17.47	17.56
190	17.65	17.74	17.84	17.93	18.02	18.12	18.21	18.30	18.39	18.49
200	18.58	18.67	18.77	18.86	18.95	19.05	19.14	19.23	19.32	19.42
210	19.51	19.60	19.70	19.79	19.88	19.97	20.07	20.16	20.25	20.35
220	20.44	20.53	20.62	20.72	20.81	20.90	21.00	21.09	21.18	21.27
230	21.37	21.46	21.55	21.65	21.74	21.83	21.93	22.02	22.11	22.20
240	22.30	22.39	22.48	22.58	22.67	22.76	22.85	22.95	23.04	23.13
250	23.23	23.32	23.41	23.50	23.60	23.69	23.78	23.88	23.97	24.06
260	24.15	24.25	24.34	24.43	24.53	24.62	24.71	24.81	24.90	24.99
270	25.08	25.18	25.27	25.36	25.46	25.55	25.64	25.73	25.83	25.92
280	26.01	26.11	26.20	26.29	26.38	26.48	26.57	26.66	26.76	26.85
290	26.94	27.03	27.13	27.22	27.31	27.41	27.50	27.59	27.69	27.78
300	27.87	27.96	28.06	28.15	28.24	28.34	28.43	28.52	28.61	28.71
310	28.80	28.89	28.99	29.08	29.17	29.26	29.36	29.45	29.54	29.64
320	29.73	29.82	29.91	30.01	30.10	30.19	30.29	30.38	30.47	30.57
330	30.66	30.75	30.84	30.94	31.03	31.12	31.22	31.31	31.40	31.49
340	31.59	31.68	31.77	31.87	31.96	32.05	32.14	32.24	32.33	32.42
350	32.52	32.61	32.70	32.79	32.89	32.98	33.07	33.17	33.26	33.35
360	33.45	33.54	33.63	33.72	33.82	33.91	34.00	34.10	34.19	34.28
370	34.37	34.47	34.56	34.65	34.75	34.84	34.93	35.02	35.12	35.21
380	35.30	35.40	35.49	35.58	35.67	35.77	35.86	35.95	36.05	36.14
390	36.23	36.33	36.42	36.51	36.60	36.70	36.79	36.88	36.98	37.07
400	37.16	37.25	37.35	37.44	37.53	37.63	37.72	37.81	37.90	38.00
410	38.09	38.18	38.28	38.37	38.46	38.55	38.65	38.74	38.83	38.93
420	39.02	39.11	39.21	39.30	39.39	39.48	39.58	39.67	39.76	39.86
430	39.95	40.04	40.13	40.23	40.32	40.41	40.51	40.60	40.69	40.78
440	40.88	40.97	41.06	41.16	41.25	41.34	41.43	41.53	41.62	41.71
450	41.81	41.90	41.99	42.09	42.18	42.27	42.36	42.46	42.55	42.64
460	42.74	42.83	42.92	43.01	43.11	43.20	43.29	43.39	43.48	43.57
470	43.66	43.76	43.85	43.94	44.04	44.13	44.22	44.31	44.41	44.50
480	44.59	44.69	44.78	44.87	44.97	45.06	45.15	45.24	45.34	45.43
490	45.52	45.62	45.71	45.80	45.89	45.99	46.08	46.17	46.27	46.36
500	46.45	–	–	–	–	–	–	–	–	–

Table VII Cubic feet (up to 100 ft³) to cubic metres (to two places of decimals)

	0	1	2	3	4	5	6	7	8	9
Cubic feet	**Cubic metres (m³)**									
0	–	0.03	0.06	0.08	0.11	0.14	0.17	0.20	0.23	0.25
10	0.28	0.31	0.34	0.37	0.40	0.42	0.45	0.48	0.51	0.54
20	0.57	0.59	0.62	0.65	0.68	0.71	0.73	0.76	0.79	0.82
30	0.85	0.88	0.91	0.93	0.96	0.99	1.02	1.05	1.08	1.10
40	1.13	1.16	1.19	1.22	1.25	1.27	1.30	1.33	1.36	1.39
50	1.42	1.44	1.47	1.50	1.53	1.56	1.59	1.61	1.64	1.67
60	1.70	1.73	1.76	1.78	1.81	1.84	1.87	1.90	1.93	1.95
70	1.98	2.01	2.04	2.07	2.10	2.12	2.15	2.18	2.21	2.24
80	2.27	2.29	2.32	2.35	2.38	2.41	2.44	2.46	2.49	2.52
90	2.55	2.58	2.61	2.63	2.66	2.69	2.72	2.75	2.78	2.80
100	2.83	–	–	–	–	–	–	–	–	–

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table VIII Pounds (up to 500 lb) to kilograms (to two places of decimals)

Pounds	0	1	2	3	4	5	6	7	8	9
Pounds	Kilogrammes (kg)									
0	–	0.45	0.91	1.36	1.81	2.27	2.72	3.18	3.63	4.08
10	4.54	4.99	5.44	5.90	6.35	6.80	7.26	7.71	8.16	8.62
20	9.07	9.53	9.98	10.43	10.89	11.34	11.79	12.25	12.70	13.15
30	13.61	14.06	14.52	14.97	15.42	15.88	16.33	16.78	17.24	17.69
40	18.14	18.60	19.05	19.50	19.96	20.41	20.87	21.32	21.77	22.23
50	22.68	23.13	23.59	24.04	24.49	24.95	25.40	25.85	26.31	26.76
60	27.22	27.67	28.12	28.58	29.03	29.48	29.94	30.39	30.84	31.30
70	31.75	32.21	32.66	33.11	33.57	34.02	34.47	34.93	35.38	35.83
80	36.29	36.74	37.19	37.65	38.10	38.56	39.01	39.46	39.92	40.37
90	40.82	41.28	41.73	42.18	42.64	43.09	43.54	44.00	44.45	44.91
100	45.36	45.81	46.27	46.72	47.17	47.63	48.08	48.53	48.99	49.44
110	49.90	50.35	50.80	51.26	51.71	52.16	52.62	53.07	53.52	53.98
120	54.43	54.88	55.34	55.79	56.25	56.70	57.15	57.61	58.06	58.51
130	58.97	59.42	59.87	60.33	60.78	61.24	61.69	62.14	62.60	63.05
140	63.50	63.96	64.41	64.86	65.32	65.77	66.22	66.68	67.13	67.59
150	68.04	68.49	68.95	69.40	69.85	70.31	70.76	71.21	71.67	72.12
160	72.57	73.03	73.48	73.94	74.39	74.84	75.30	75.75	76.20	76.66
170	77.11	77.56	78.02	78.47	78.93	79.38	79.83	80.29	80.74	81.19
180	81.65	82.10	82.55	83.01	83.46	83.91	84.37	84.82	85.28	85.73
190	86.18	86.64	87.09	87.54	88.00	88.45	88.90	89.36	89.81	90.26
200	90.72	91.17	91.63	92.08	92.53	92.99	93.44	93.89	94.35	94.80
210	95.25	95.71	96.16	96.62	97.07	97.52	97.98	98.43	98.88	99.34
220	99.79	100.24	100.70	101.15	101.61	102.06	102.51	102.97	103.42	103.87
230	104.33	104.78	105.23	105.69	106.14	106.59	107.05	107.50	107.96	108.41
240	108.86	109.32	109.77	110.22	110.68	111.13	111.58	112.04	112.49	112.95
250	113.40	113.85	114.31	114.76	115.21	115.67	116.12	116.57	117.03	117.48
260	117.93	118.39	118.84	119.30	119.75	120.20	120.66	121.11	121.56	122.02
270	122.47	122.92	123.38	123.83	124.28	124.74	125.19	125.65	126.10	126.55
280	127.01	127.46	127.91	128.37	128.82	129.27	129.73	130.18	130.64	131.09
290	131.54	132.00	132.45	132.90	133.36	133.81	134.26	134.72	135.17	135.62
300	136.08	136.53	136.99	137.44	137.89	138.35	138.80	139.25	139.71	140.16
310	140.61	141.07	141.52	141.97	142.43	142.88	143.34	143.79	144.24	144.70
320	145.15	145.60	146.06	146.51	146.96	147.42	147.87	148.33	148.78	149.23
330	149.69	150.14	150.59	151.05	151.50	151.95	152.41	152.86	153.31	153.77
340	154.22	154.68	155.13	155.58	156.04	156.49	156.94	157.40	157.85	158.30
350	158.76	159.21	159.67	160.12	160.57	161.03	161.48	161.93	162.39	162.84
360	163.29	163.75	164.20	164.65	165.11	165.56	166.02	166.47	166.92	167.38
370	167.83	168.28	168.74	169.10	169.64	170.10	170.55	171.00	171.46	171.91
380	172.37	172.82	173.27	173.73	174.18	174.63	175.09	175.54	175.99	176.45
390	176.90	177.36	177.81	178.26	178.72	179.17	179.62	180.08	180.53	180.98
400	181.44	181.89	183.34	182.80	183.25	183.71	184.16	184.61	185.07	185.52
410	185.97	186.43	186.88	187.33	187.79	188.24	188.69	189.15	189.60	190.06
420	190.51	190.96	191.42	191.87	192.32	192.78	193.23	193.68	194.14	194.59
430	195.05	195.50	195.95	196.41	196.86	197.31	197.77	198.22	198.67	199.13
440	199.58	200.03	200.49	200.94	201.40	201.85	202.30	202.76	203.21	203.66
450	204.12	204.57	205.02	205.48	205.93	206.39	206.84	207.29	207.75	208.20
460	208.65	209.11	209.56	210.01	210.47	210.92	211.37	211.83	212.28	212.74
470	213.19	213.64	214.10	214.55	215.00	215.46	215.91	216.36	216.82	217.27
480	217.72	218.18	218.63	219.09	219.54	219.99	220.45	220.90	221.35	221.81
490	222.26	222.71	223.17	223.62	224.08	224.53	224.98	225.44	225.89	226.34
500	226.80	–	–	–	–	–	–	–	–	–

Table IX Pounds per cubic foot to kilogrammes per cubic metre (to one place of decimals)

	0	1	2	3	4	5	6	7	8	9
Pounds per cubic foot	Kilogrammes per cubic metre (kg/m^3)									
0	–	16.0	32.0	48.1	64.1	80.1	96.1	112.1	128.1	144.2
10	160.2	176.2	192.2	208.2	224.3	240.3	256.3	272.3	288.3	304.4
20	320.4	336.4	352.4	368.4	384.4	400.5	416.5	432.5	448.5	464.5
30	480.6	496.6	512.6	528.6	544.6	560.6	576.7	592.7	608.7	624.7
40	640.7	656.8	672.8	688.8	704.8	720.8	736.8	752.9	768.9	784.9
50	800.9	816.9	833.0	849.0	865.0	881.0	897.0	913.1	929.1	945.1
60	961.1	977.1	993.1	1009.2	1025.2	1041.2	1057.2	1073.2	1089.3	1105.3
70	1121.3	1137.3	1153.3	1169.4	1185.4	1201.4	1217.4	1233.4	1249.4	1265.5
80	1281.5	1297.5	1313.5	1329.5	1345.6	1361.6	1377.6	1393.6	1409.6	1425.6
90	1441.7	1457.7	1473.7	1489.7	1505.7	1521.8	1537.8	1553.8	1569.8	1585.8
100	1601.9	–	–	–	–	–	–	–	–	–

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table X UK gallons (up to 100 galls) to litres (to two places of decimals)

	0	1	2	3	4	5	6	7	8	9
UK gallons	**Litres**									
0	–	4.55	9.09	13.64	18.18	22.73	27.28	31.82	36.37	40.91
10	45.46	50.01	54.55	59.10	63.64	68.19	72.74	77.28	81.83	86.37
20	90.92	95.47	100.01	104.56	109.10	113.65	118.20	122.74	127.29	131.83
30	136.38	140.93	145.47	150.02	154.56	159.11	163.66	168.20	172.75	177.29
40	181.84	186.38	190.93	195.48	200.02	204.57	209.11	213.66	218.21	222.75
50	227.30	231.84	236.39	240.94	245.48	250.03	254.57	259.12	263.67	268.21
60	272.76	277.30	281.85	286.40	290.94	295.49	300.03	304.58	309.13	313.67
70	318.22	322.76	327.31	331.86	336.40	340.95	345.49	350.04	354.59	359.13
80	363.68	368.22	372.77	377.32	381.86	386.41	390.95	395.50	400.04	404.59
90	409.14	413.68	418.23	422.77	427.32	431.87	436.41	440.96	445.50	450.05
100	454.60	–	–	–	–	–	–	–	–	–

Table XI Acres (up to 1000 acres) to hectares (to two places of decimals)

	0	1	2	3	4	5	6	7	8	9
	Hectares									
Acres	–	0.40	0.81	1.21	1.62	2.02	2.43	2.83	3.24	3.64
	0	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
Acres	**Hectares**									
0	–	4.05	8.09	12.14	16.19	20.23	24.28	28.33	32.37	36.42
100	40.47	44.52	48.56	52.61	56.66	60.70	64.75	68.80	72.84	76.89
200	80.94	84.98	89.03	93.08	97.12	101.17	105.22	109.27	113.31	117.36
300	121.41	125.45	129.50	133.55	137.59	141.64	145.69	149.73	153.78	157.83
400	161.87	165.92	169.97	174.02	178.06	182.11	186.16	190.20	194.25	198.30
500	202.34	206.39	210.44	214.48	218.53	222.58	226.62	230.67	234.72	238.77
600	242.81	246.86	250.91	254.95	259.00	263.05	267.09	271.14	275.19	279.23
700	283.28	287.33	291.37	295.42	299.47	303.51	307.56	311.61	315.66	319.70
800	323.75	327.80	331.84	335.89	339.94	343.98	348.03	352.08	356.12	360.17
900	364.22	368.26	372.31	376.36	380.41	384.45	388.50	392.55	396.59	400.64
1000	404.69	–	–	–	–	–	–	–	–	–

Table XII Miles per hour (up to 100 mph) to metres per second (to two places of decimals)

	0	1	2	3	4	5	6	7	8	9
Miles per hour	**Metres per second**									
0	–	0.45	0.89	1.34	1.79	2.24	2.68	3.13	3.58	4.02
10	4.47	4.92	5.36	5.81	6.26	6.71	7.15	7.60	8.05	8.49
20	8.94	9.39	9.83	10.28	10.73	11.18	11.62	12.07	12.52	12.96
30	13.41	13.86	14.31	14.75	15.20	15.65	16.09	16.54	16.99	17.43
40	17.88	18.33	18.78	19.22	19.67	20.12	20.56	21.01	21.46	21.91
50	22.35	22.80	23.25	23.69	24.14	24.59	25.03	25.48	25.93	26.38
60	26.82	27.27	27.72	28.16	28.61	29.06	29.50	29.95	30.40	30.85
70	31.29	31.74	32.19	32.63	33.08	33.53	33.98	34.42	34.87	35.32
80	35.76	36.21	36.66	37.10	37.55	38.00	38.45	38.89	39.34	39.79
90	40.23	40.68	41.13	41.57	42.02	42.47	42.92	43.36	43.81	44.26
100	44.70	–	–	–	–	–	–	–	–	–

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table XIII Pressure and stress. Pounds–force per square inch to kilonewtons per square metre (to two places of decimals)

	0	1	2	3	4	5	6	7	8	9
lbf per sq In	**kN/m² or kPa**									
0	–	6.90	13.79	20.68	27.58	34.48	41.37	48.26	55.16	62.06
10	68.95	75.84	82.74	89.64	96.53	103.42	110.32	117.22	124.11	131.00
20	137.90	144.80	151.69	158.58	165.48	172.38	179.27	186.16	193.06	199.96
30	206.85	213.64	220.64	227.54	234.43	241.32	248.22	255.12	262.01	268.90
40	275.80	282.70	289.59	296.48	303.38	310.28	317.17	324.06	330.96	337.86
50	344.75	351.64	358.54	365.44	372.33	379.22	386.12	393.02	399.91	406.80
60	413.70	420.60	427.49	434.38	441.28	448.18	455.07	461.96	468.86	475.76
70	482.65	489.54	496.44	503.34	510.23	517.12	524.02	530.92	537.81	544.70
80	551.60	558.50	565.39	572.28	579.18	586.08	592.97	599.86	606.76	613.66
90	620.55	627.44	634.34	641.24	648.13	655.02	661.92	668.82	675.71	682.60
100	689.50	–	–	–	–	–	–	–	–	–

Note: the same table will convert kipf per.sq in to MN/m² or MPa

Table XIV British thermal units per hour to watts

	0	1	2	3	4	5	6	7	8	9
Btu per hr	**W**									
0	–	0.29	0.59	0.88	1.17	1.47	1.76	2.05	2.34	2.64
10	2.93	3.22	3.52	3.81	4.10	4.40	4.69	4.98	5.28	5.57
20	5.86	6.16	6.45	6.74	7.03	7.33	7.62	7.91	8.21	8.50
30	8.79	9.09	9.38	9.67	9.97	10.26	10.55	10.84	11.14	11.43
40	11.72	12.02	12.31	12.60	12.90	13.19	13.48	13.78	14.07	14.36
50	14.66	14.95	15.24	15.53	15.83	16.12	16.41	16.71	17.00	17.29
60	17.59	17.88	18.17	18.47	18.76	19.05	19.34	19.64	19.93	20.22
70	20.52	20.81	21.10	21.40	21.69	21.98	22.28	22.57	22.86	23.15
80	23.45	23.74	24.03	24.33	24.62	24.91	25.21	25.50	25.79	26.09
90	26.38	26.67	26.97	27.26	27.55	27.84	28.14	28.43	28.72	29.02
100	29.31	–	–	–	–	–	–	–	–	–

Table XV *U* value: British thermal units per square foot per hour per degree Fahrenheit to watts per square metre per Kelvin

	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
Btu per sq ft hr °F	**W/(m²K)**									
0	–	0.057	0.114	0.170	0.227	0.284	0.341	0.397	0.454	0.511
0.1	0.568	0.624	0.681	0.738	0.795	0.852	0.908	0.965	1.022	1.079
0.2	1.136	1.192	1.249	1.306	1.363	1.420	1.476	1.533	1.590	1.647
0.3	1.703	1.760	1.817	1.874	1.931	1.987	2.044	2.101	2.158	2.214
0.4	2.271	2.328	2.385	2.442	2.498	2.555	2.612	2.669	2.725	2.782
0.5	2.839	2.896	2.953	3.009	3.066	3.123	3.180	3.236	3.293	3.350
0.6	3.407	3.464	3.520	3.577	3.634	3.691	3.747	3.804	3.861	3.918
0.7	3.975	4.031	4.088	4.145	4.202	4.258	4.315	4.372	4.429	4.486
0.8	4.542	4.599	4.656	4.713	4.770	4.826	4.883	4.940	4.997	5.053
0.9	5.110	5.167	5.224	5.281	5.337	5.394	5.451	5.508	5.564	5.621
1.0	5.678	–	–	–	–	–	–	–	–	–

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Table XVI Feet and inches to metres and millimetres (to nearest millimetre)

	Inches											
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Feet	**Metres and millimetres**											
0	–	0.025	0.051	0.076	0.102	0.127	0.152	0.178	0.203	0.229	0.254	0.279
1	0.305	0.330	0.356	0.381	0.406	0.432	0.457	0.483	0.508	0.533	0.559	0.584
2	0.610	0.635	0.660	0.686	0.711	0.737	0.762	0.787	0.813	0.838	0.864	0.889
3	0.914	0.940	0.965	0.991	1.016	1.041	1.067	1.092	1.118	1.143	1.168	1.194
4	1.219	1.245	1.270	1.295	1.321	1.346	1.372	1.397	1.422	1.448	1.473	1.499
5	1.524	1.549	1.575	1.600	1.626	1.651	1.676	1.702	1.727	1.753	1.778	1.803
6	1.829	1.854	1.880	1.905	1.930	1.956	1.981	2.007	2.032	2.057	2.083	2.108
7	2.134	2.159	2.184	2.210	2.235	2.261	2.286	2.311	2.337	2.362	2.388	2.413
8	2.438	2.464	2.489	2.515	2.540	2.565	2.591	2.616	2.642	2.667	2.692	2.718
9	2.743	2.769	2.794	2.819	2.845	2.870	2.896	2.921	2.946	2.972	2.997	3.023
10	3.048	3.073	3.099	3.124	3.150	3.175	3.200	3.226	3.251	3.277	3.302	3.327
11	3.353	3.378	3.404	3.429	3.454	3.480	3.505	3.531	3.556	3.581	3.607	3.632
12	3.658	3.683	3.708	3.734	3.759	3.785	3.810	3.835	3.861	3.886	3.912	3.937
13	3.962	3.988	4.013	4.039	4.064	4.089	4.115	4.140	4.166	4.191	4.216	4.242
14	4.267	4.293	4.318	4.343	4.369	4.394	4.420	4.445	4.470	4.496	4.521	4.547
15	4.572	4.597	4.623	4.648	4.674	4.699	4.724	4.750	4.775	4.801	4.826	4.851
16	4.877	4.902	4.928	4.953	4.978	5.004	5.029	5.055	5.080	5.105	5.131	5.156
17	5.182	5.207	5.232	5.258	5.283	5.309	5.334	5.359	5.385	5.410	5.436	5.461
18	5.486	5.512	5.537	5.563	5.588	5.613	5.639	5.664	5.690	5.715	5.740	5.766
19	5.791	5.817	5.842	5.867	5.893	5.918	5.944	5.969	5.994	6.020	6.045	6.071
20	6.096	6.121	6.147	6.172	6.198	6.223	6.248	6.274	6.299	6.325	6.350	6.375
21	6.401	6.426	6.452	6.477	6.502	6.528	6.553	6.579	6.604	6.629	6.655	6.680
22	6.706	6.731	6.756	6.782	6.807	6.833	6.858	6.883	6.909	6.934	6.960	6.985
23	7.010	7.036	7.061	7.087	7.112	7.137	7.163	7.188	7.214	7.239	7.264	7.290
24	7.315	7.341	7.366	7.391	7.417	7.442	7.468	7.493	7.518	7.544	7.569	7.595
25	7.620	7.645	7.671	7.696	7.722	7.747	7.772	7.798	7.823	7.849	7.874	7.899
26	7.925	7.950	7.976	8.001	8.026	8.052	8.077	8.103	8.128	8.153	8.179	8.204
27	8.230	8.255	8.280	8.306	8.331	8.357	8.382	8.407	8.433	8.458	8.484	8.509
28	8.534	8.560	8.585	8.611	8.636	8.661	8.687	8.712	8.738	8.763	8.788	8.814
29	8.839	8.865	8.890	8.915	8.941	8.966	8.992	9.017	9.042	9.068	9.093	9.119
30	9.144	9.169	9.195	9.220	9.246	9.271	9.296	9.322	9.347	9.373	9.398	9.423
31	9.449	9.474	9.500	9.525	9.550	9.576	9.601	9.627	9.652	9.677	9.703	9.728
32	9.754	9.779	9.804	9.830	9.855	9.881	9.906	9.931	9.957	9.982	10.008	10.033
33	10.058	10.084	10.109	10.135	10.160	10.185	10.211	10.236	10.262	10.287	10.312	10.338
34	10.363	10.389	10.414	10.439	10.465	10.490	10.516	10.541	10.566	10.592	10.617	10.643
35	10.668	10.693	10.719	10.744	10.770	10.795	10.820	10.846	10.871	10.897	10.922	10.947
36	10.973	10.998	11.024	11.049	11.074	11.100	11.125	11.151	11.176	11.201	11.227	11.252
37	11.278	11.303	11.328	11.354	11.379	11.405	11.430	11.455	11.481	11.506	11.532	11.557
38	11.582	11.608	11.633	11.659	11.684	11.709	11.735	11.760	11.786	11.811	11.836	11.862
39	11.887	11.913	11.938	11.963	11.989	12.014	12.040	12.065	12.090	12.116	12.141	12.167
40	12.192	12.217	12.243	12.268	12.294	12.319	12.344	12.370	12.395	12.421	12.446	12.471
41	12.497	12.522	12.548	12.573	12.598	12.624	12.649	12.675	12.700	12.725	12.751	12.776
42	12.802	12.827	12.852	12.878	12.903	12.929	12.954	12.979	13.005	13.030	13.056	13.081
43	13.106	13.132	13.157	13.183	13.208	13.233	13.259	13.284	13.310	13.335	13.360	13.386
44	13.411	13.437	13.462	13.487	13.513	13.538	13.564	13.589	13.614	13.640	13.665	13.691
45	13.716	13.741	13.767	13.792	13.818	13.843	13.868	13.894	13.919	13.945	13.970	13.995
46	14.021	14.046	14.072	14.097	14.122	14.148	14.173	14.199	14.224	14.249	14.275	14.300
47	14.326	14.351	14.376	14.402	14.427	14.453	14.478	14.503	14.529	14.554	14.580	14.605
48	14.630	14.656	14.681	14.707	14.732	14.757	14.783	14.808	14.834	14.859	14.884	14.910
49	14.935	14.961	14.986	15.011	15.037	15.062	15.088	15.113	15.138	15.164	15.189	15.215
50	15.240	15.265	15.291	15.316	15.342	15.367	15.392	15.418	18.443	15.469	15.494	15.519
51	15.545	15.570	15.596	15.621	15.646	15.672	15.697	15.723	15.748	15.773	15.799	15.824
52	15.850	15.875	15.900	15.926	15.951	15.977	16.002	16.027	16.053	16.078	16.104	16.129
53	16.154	16.180	16.205	16.231	16.256	16.281	16.307	16.332	16.358	16.383	16.408	16.434
54	16.459	16.485	16.510	16.535	16.561	16.586	16.612	16.637	16.662	16.688	16.713	16.739
55	16.764	16.789	16.815	16.840	16.866	16.891	16.916	16.942	16.967	16.993	17.018	17.043
56	17.069	17.094	17.120	17.145	17.170	17.196	17.221	17.247	17.272	17.297	17.323	17.248
57	17.374	17.399	17.424	17.450	17.475	17.501	17.526	17.551	17.577	17.602	17.628	17.653
58	17.678	17.704	17.729	17.755	17.780	17.805	17.830	17.856	17.882	17.907	17.932	17.958
59	17.983	18.009	18.034	18.059	18.085	18.110	18.136	18.161	18.186	18.212	18.237	18.263
60	18.288	18.313	18.339	18.364	18.390	18.415	18.440	18.466	18.491	18.517	18.542	18.567
61	18.593	18.618	18.644	18.669	18.694	18.720	18.745	18.771	18.796	18.821	18.847	18.872
62	18.898	18.923	18.948	18.974	18.999	19.025	19.050	19.075	19.101	19.126	19.152	19.177
63	19.202	19.228	19.253	19.279	19.304	19.329	19.355	19.380	19.406	19.431	19.456	19.482
64	19.507	19.533	19.558	19.583	19.609	19.634	19.660	19.685	19.710	19.736	19.761	19.787
65	19.812	19.837	19.863	19.888	19.914	19.939	19.964	19.990	20.015	20.041	20.066	20.091
66	20.117	20.142	20.168	20.193	20.218	20.244	20.269	20.295	20.320	20.345	20.371	20.396
67	20.422	20.447	20.472	20.498	20.523	20.549	20.574	20.599	20.625	20.650	20.676	20.701
68	20.726	20.752	20.777	20.803	20.828	20.853	20.879	20.904	20.930	20.955	20.980	21.006
69	21.031	21.057	21.082	21.107	21.133	21.158	21.184	21.209	21.234	21.260	21.285	21.311

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Index

2D CAD systems **1**:1
3D parametric object-based modelling systems **1**:1, **1**:5
3D projection systems **15**:36
5 Churchill Place, London **1**:11–13

Aberdeen University Library **27**:8, **27**:9
absorption coefficients **10**:2, **10**:3
absorptivity **8**:5, **8**:6, **42**:34
academic laboratories **26**:1, **26**:9, **26**:11, **26**:16, **26**:23–6
academic libraries **27**:1, **27**:2, **27**:4, **27**:7, **27**:8–9, **27**:10–11, **27**:12, **43**:5–6, **43**:14
academies **36**:2
access: auditoria **15**:9, **15**:10, **15**:19, **15**:23; churches **32**:12–13; crime prevention design **13**:2; entrance doors **3**:3; for firefighters **11**:4–5, **11**:6, **20**:5, **23**:8; fire stations **18**:2; and flooding **12**:9; hotels **20**:2; housing **21**:5; libraries **27**:6; for maintenance **2**:6–7; masterplanning **28**:4–5; offices **30**:9; ramps **3**:1, **21**:5; shopping centres **35**:10; slope-dependent **28**:5; sports facilities **38**:27, **38**:29, **38**:38–9; steps **3**:2–3, **21**:5; *see also* wheelchair access
access control systems **20**:5, **23**:13, **37**:2
accessible facilities: ATMs and ATM lobbies **31**:5, **31**:7; auditoria **15**:3, **15**:8, **15**:9, **15**:35, **15**:40; dimensions **4**:1–6; doors **3**:3; hotel guestrooms **20**:11; housing **21**:3, **21**:5, **21**:8, **21**:12, **21**:13, **21**:22; laboratories **26**:16; libraries **27**:6; lifts **3**:9, **3**:10; lobbies **3**:4; older people's housing **22**:1, **22**:3–4; payment counters **31**:6, **31**:9; ramps **3**:1, **21**:5; sanitary facilities **2**:7, **2**:8, **2**:9–11, **4**:6, **18**:9, **21**:5; shopping centres **35**:10; sports facilities **38**:29, **38**:30, **38**:36, **38**:38, **38**:39, **38**:40; steps **3**:2–3, **21**:5; street design **39**:22; student housing **23**:8–9, **23**:11, **23**:12; tropics **42**:11
access roads **39**:6–7
Accident & Emergency (A&E) facilities **19**:7–8, **19**:10
acoustic barriers **10**:4
acoustic doors **40**:3, **40**:4
acoustic lining systems **10**:9–10
acoustics: absorption coefficients **10**:2, **10**:3; auditoria **10**:16, **10**:17, **15**:2, **15**:4, **15**:12, **15**:35; broadcasting studios **40**:3, **40**:4; community centres **17**:3; courtrooms **16**:10; fundamentals **10**:1–3; laboratories **26**:23; museums **29**:6; music teaching **43**:6; performance spaces **10**:16, **10**:17; reducing sound transmission **10**:3–6; reverberation times **10**:2–3, **10**:15, **10**:16–17, **40**:3; synagogues **32**:19; *see also* sound insulation
active frontages **28**:7
active shading **42**:15, **42**:19
adaptability: foodservice facilities **34**:7; industrial buildings **24**:2–5, **24**:7; libraries **27**:5; museums **29**:2, **29**:3; offices **30**:3; primary health care buildings **33**:11–12, **33**:16; school furniture layouts **36**:5–6
adhesives **7**:25–6
AEDET hospital design **19**:3
aerofoils **42**:23
affordable housing **21**:2, **21**:13, **21**:26, **21**:27
aggregates **7**:9
agricultural buildings **14**:1–20; legislation **14**:20; livestock housing **14**:2, **14**:4–11, **14**:12, **14**:13; stables **14**:12, **14**:15, **14**:16–20; storage **14**:1, **14**:13–15
AHUs *see* air handling units (AHUs)
air change rates **8**:10, **26**:23
air conditioning *see* mechanical ventilation systems
air displacement systems **8**:29
airflow models **8**:33–4
air handling units (AHUs) **8**:28
air infiltration **8**:10, **8**:22–3
air leakage measurements **8**:35
air moisture content **8**:20–1; *see also* relative humidity (RH)
air pollution **29**:4
airports **41**:1–16; air infiltration rates **8**:10; apron requirements **41**:12–13, **41**:14; arrivals areas **41**:9–11; case study **41**:14–16; departures areas **41**:4–9; foodservice facilities **34**:2, **34**:19, **34**:25; levels and volumes **41**:11; security **41**:4, **41**:5, **41**:7, **41**:8, **41**:9; *see also* cafeterias
air source heat pumps **8**:31
air speed **8**:7–8, **8**:9
air temperature **8**:7, **8**:11–12
airtightness **8**:35
aisles: auditoria **15**:4, **15**:7, **15**:32–3; churches **32**:14; laboratories **26**:11–13; warehouses **25**:6, **25**:7–9
alarms, fire **11**:22, **15**:12, **23**:8
albedo **42**:33–4
alcohol gel dispensers **19**:7
alloys **7**:2, **7**:5, **7**:10–11
altar rails **32**:10, **32**:11, **32**:12
altars **32**:2, **32**:6, **32**:8–9
alternating stairs **3**:5, **3**:6
alternative energy *see* renewable energy
aluminium **7**:10–11; alloys **7**:5, **7**:10–11; fire resistance **11**:19; properties **6**:13; roofing **7**:12; structural **7**:10–11; windows **7**:26
ambulances **39**:3
ambulance services **33**:2
ambulance stations **18**:7–9
amenity areas: ambulance stations **18**:9; fire stations **18**:4, **18**:5
American football **38**:2, **38**:33
amphibious structures **12**:9
angles: aluminium **7**:11; steel **7**:4
animals: assistance dogs **2**:7, **4**:4, **15**:35; farm **14**:2, **14**:3, **14**:4–11, **14**:12, **14**:13; horses **14**:12, **14**:15, **14**:16–20; tropics **42**:10
annealed float glass **6**:6, **6**:13
anthropometrics **2**:1–5, **4**:2, **42**:11
anti-shatter film **37**:7
ANUK/Unipol Code of Standards **23**:7
archaeological finds **42**:8
archery **38**:21
arching **6**:21–2
Architectural Liaison Officers (ALOs) **36**:6, **37**:10
ardhamandapa **32**:20
arid climates **42**:3, **42**:4, **42**:12, **42**:15
Arndale Centre, Luton **35**:9
art, in health **33**:12
art galleries **8**:10, **29**:1–8, **39**:15
artificial grass **38**:23
art teaching **36**:13, **43**:7–8
Arum Hotel, Side, Turkey **20**:14
asbestos **11**:19
ASPECT hospital design **19**:3
assembly buildings: access stairs **3**:5; escape routes **11**:12; gender ratios **2**:7; parking **39**:15; permissible noise levels **10**:8; sanitary facilities **2**:8

assistance dogs **2**:7, **4**:4, **15**:35
at-grade track (level) stations **41**:18
athletics **38**:8–9, **38**:23, **38**:27, **38**:34
ATMs and ATM lobbies **31**:1, **31**:2, **31**:3, **31**:5–6, **31**:7, **31**:8
atria **42**:21–2, **43**:2
audience participation studios **40**:1
audiovisual facilities **15**:29–31
auditoria: acoustics **10**:16, **10**:17, **15**:2, **15**:4, **15**:12, **15**:35; concert halls **10**:17, **15**:23–5, **15**:26; conference facilities **15**:3, **15**:25–31, **15**:37, **43**:9; design **15**:3–12; formats **15**:5–6, **15**:13, **15**:14, **15**:23, **15**:24, **15**:25–6, **15**:37; legislation **15**:40; multi-purpose **15**:36, **15**:37; seating **15**:1–3, **15**:4, **15**:5–6, **15**:7, **15**:11; sightlines **15**:1, **15**:4–8, **15**:15, **15**:24, **15**:32, **15**:34; studio theatres **15**:23; support facilities **15**:36–40; *see also* cinemas; theatres
aural impairments **15**:3, **15**:35, **15**:40, **23**:9
Australia **42**:5, **42**:6
Australian football **38**:3, **38**:33
automatic fire detectors **11**:21–2
awnings **42**:16
axial control **1**:9

Bab Al-Sadir **32**:19
baby changing facilities **2**:11, **4**:6, **17**:4
badminton **38**:10, **38**:23, **38**:25, **38**:35
baggage handling, airports **41**:4, **41**:7, **41**:8, **41**:9–10, **41**:12
balanced supply and extract systems **8**:28
balconies: auditoria **15**:4, **15**:6, **15**:9, **15**:10; flats **21**:18, **21**:20, **21**:21; hotels **20**:9; shading **42**:16
balcony access flats **21**:19
Balliol College, Oxford **23**:3
banisters **3**:7
banks **31**:1, **31**:2–3, **31**:5–6, **31**:7, **31**:8–9, **39**:14
banquet halls **20**:13
baptisms **32**:3, **32**:4, **32**:6
baptistries **32**:7
barns **14**:13, **14**:14; *see also* agricultural buildings
barriers, wind **8**:14–15
bars: aluminium **7**:10; steel **7**:1, **7**:2, **7**:3
baseball **38**:5
Baseline Designs, schools **36**:2, **36**:3, **36**:4, **36**:8, **36**:9, **36**:11, **36**:12
basketball **38**:12, **38**:25, **38**:35
bathrooms: accessible standards **21**:12; hotel guestrooms **20**:11; older people's housing **22**:3–4; single-family houses **21**:17; student housing **23**:3, **23**:4, **23**:8, **23**:10, **23**:12; *see also* sanitary facilities
baths **2**:10, **22**:3–4
battery houses **14**:11–12
beach volleyball **38**:10
beams **6**:6; increasing effective span **6**:23; laminated **6**:8, **6**:11; loading **6**:17–20; reinforced concrete **6**:12; steel **6**:14, **7**:3, **7**:4–5; timber **6**:8, **6**:12
Beaufort wind scale **42**:36
bedding planes **7**:17
bedrooms: accessible standards **21**:12; hospitals **19**:2–3; hotels **20**:2–3, **20**:4, **20**:6–11; older people's housing **22**:3; student housing **23**:3, **23**:4, **23**:9–11
beds, hospital **19**:9
bedsitting rooms **21**:21–2, **21**:23
behavioural, emotional and social difficulties (BESD) education **36**:17
benchmarking **43**:16
bench marks **1**:11
bending **6**:5–6, **6**:17
bending moments **6**:6
bespoke industrial buildings **24**:1, **24**:2, **24**:4
betting facilities **38**:39
bicycles **38**:34, **39**:2; *see also* cycling
BIM *see* Building Information Modelling (BIM)
Bima, synagogues **32**:16–17, **32**:18
biodiversity **7**:14, **28**:3, **28**:12
biofuels **42**:28
biogas **28**:17
biohazards **42**:9–10
biomass **36**:5, **42**:28
Birmingham library **27**:14–17
bitumen-based adhesives **7**:26
bitumen roofing membranes **7**:13–14
blast loading **37**:5–7
blast resistance **18**:12, **37**:7–8
blast testing **37**:8–9
Blaydon Leisure and Primary Care Centre, Tyne and Wear **33**:18–19
bleacher seating **15**:11
blinds **8**:19, **42**:17
block stacking **25**:5, **25**:6
blockwork **7**:9, **8**:4, **8**:16; low-density **8**:17
Bloomberg Suites **43**:7
blown insulation cavity fill **8**:17
Bluewater shopping centre, Dartford **35**:13, **42**:22
BMX tracks **38**:7
body-tinted glass **42**:35, **42**:36
boilers **8**:26
Bolton Market Place **35**:12
bomb attacks **37**:3–10
bomb shelter areas **37**:9–10
book stacks **27**:7, **27**:12
borehole cooling **36**:4
boundaries, property **13**:3, **21**:18
boundary conditions **1**:10
boundary layers **8**:13, **8**:14
bow-string truss **6**:23
boxing **38**:17
box offices **15**:37, **15**:38
bracing **6**:20–1
brand value **5**:1
BRE Environmental Assessment Method (BREEAM) **1**:12, **27**:19, **33**:17, **33**:19
Brent Civic Centre **16**:4–7
brickwork **7**:8–9, **8**:3, **8**:4, **8**:16, **11**:19
bridges, auditoria **15**:15, **15**:19
briefing process, university design **43**:11, **43**:15–17
brightness **9**:10
Brighton Public Library **27**:14
broadcasting, sports facilities **38**:40–2
broadcasting studios **10**:13, **15**:40, **40**:1–4
buckling **6**:5, **6**:22–3
buffer zones **37**:10
building energy models **8**:33, **8**:34
building envelopes: blast loading **37**:5–6; blast resistance **37**:7–8; blast testing **37**:8–9; climate modification **8**:1–2; fabric heat loss **8**:26, **8**:27; facade attenuation **10**:4, **10**:5; offices **30**:9; security **37**:3; thermal bridging **8**:17–18, **8**:20; thermal insulation **8**:17, **8**:18; tropics **42**:9; U-values **8**:15–17, **8**:18–19, **8**:20, **8**:32, **8**:35, **42**:34; *see also* facades
Building for Life **21**:13–14
Building Information Modelling (BIM) **1**:1, **1**:5, **1**:11–13
Building Regulations: accessible facilities **2**:8, **23**:9; agricultural buildings **14**:20; doors **7**:27; energy efficiency **7**:14–15; escape routes **11**:19, **26**:15; fire resistance **11**:2, **11**:3; fire safety **11**:22, **36**:6; house conversions **21**:21; houses in multiple occupation (HMOs) **23**:8; housing **21**:2–3, **21**:5; lighting **9**:8–9; refuse storage **21**:19–20; sound insulation **21**:18; structural robustness **37**:6
building services *see* services

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

building societies **31**:1, **31**:3, **31**:6, **31**:7
burial sites **42**:8
Burolandschaft (office landscaping) **30**:1–2
buses and coaches **39**:4, **41**:23
business schools **43**:6–7
bus stations **8**:10, **41**:22–8
Buttermarket, Ipswich **35**:13
butt joints **7**:24

CABE *see* Commission for Architecture and the Built Environment (CABE)
CAD systems **1**:1
cafes **2**:8, **8**:10, **10**:8, **34**:16, **39**:14, **43**:4
cafeterias: food production areas **34**:9; self-service **34**:2, **34**:16–17, **34**:19, **34**:20, **34**:21–2, **34**:24; space allowances **34**:5; sports facilities **38**:38; *see also* catering facilities
calcium silicate boards **7**:22
calf housing **14**:7
Cambridge University **43**:1
canteens **24**:9; *see also* cafeterias; catering facilities
cantilever beams **6**:6, **6**:12, **6**:19–20
canyon effects **8**:14, **8**:15
capital allowances **5**:6
capital asset replacement **5**:6
Carbon Calculator **36**:4
carbon dioxide: emissions **8**:27; fire protection systems **11**:21; metabolic **8**:23
Cardiff Millennium Stadium **38**:24, **38**:30
car parking **39**:12–18; crime prevention design **13**:3, **13**:4; domestic garages **39**:13, **39**:16, **39**:17; housing **21**:5–6, **39**:13, **39**:14; multi-storey **39**:13, **39**:18; police stations **18**:12; schools **36**:9, **39**:15; shopping centres **35**:10; sports facilities **38**:38, **39**:15; student housing **23**:12; synagogues **32**:19; universities **43**:11
carpentry workshops **15**:39, **15**:40
carriageway widths **39**:5–6, **39**:7
cars **39**:2–3
casino hotels **20**:13
cast stone **7**:17, **7**:19
catchment areas **28**:4
catering facilities: air infiltration rates **8**:10; auditoria **15**:37–8; hospitals **34**:23; hotels **20**:12–13; industrial buildings **24**:9; law courts **16**:14; police stations **18**:12; schools **36**:15; sports facilities **38**:38, **38**:39, **38**:43; universities **43**:7, **43**:9, **43**:11; *see also* cafeterias; foodservice facilities
cattle housing **14**:2, **14**:4–7
CCTV **13**:4, **20**:5, **23**:13, **37**:1, **37**:2, **37**:12
ceilings: auditoria **15**:12; housing **21**:14; police custody suites **18**:13; stables **14**:19; tropical design **42**:30
cells, police stations **18**:12, **18**:13–14
cellular glass **7**:23
cellulose insulation **7**:24, **8**:4
cement **7**:9, **7**:21, **8**:3
cement-bonded particleboard **7**:7, **7**:8
cemetery prayer halls **32**:18
central heating systems **8**:25
centralised online booking systems, universities **43**:4
Centre for Protection of National Infrastructure (CPNI) **37**:10
Centre for Tropical and Infectious Diseases, Liverpool **26**:24, **26**:25–6, **26**:29
Centre of Excellence in Teaching and Learning (CETL) **43**:8
ceramic materials **7**:15–16
CET *see* corrected effective temperature (CET)
CFD *see* computational fluid dynamics (CFD) models
chairs *see* seating
change of use **21**:21
changing rooms: accessible **2**:9–10, **4**:6; baptistries **32**:7; sports facilities **38**:32–3, **38**:36, **38**:37
channels **6**:27; aluminium **7**:11; steel **7**:4
chapels: crematoria **32**:22–3; Methodist **32**:6–7
check-in areas, airports **41**:7–8
checklists, masterplanning **28**:7–10
Chek Lap Kok airport, Hong Kong **41**:4
chemical, biological, radiological or nuclear (CBRN) attacks **37**:4–5
chicanes **39**:7, **39**:9
child care facilities **17**:3
children: anthropometrics **2**:4, **4**:2; disabled **4**:2; hospital services **19**:13–14, **19**:17–18; sanitary facilities **2**:8, **2**:11, **4**:6, **17**:4; *see also* schools
chilled surface cooling systems **8**:30–1, **30**:15
chipboard *see* wood particleboard
choirs, church **32**:15–16
churches **8**:10, **10**:17, **32**:1–16
Church of All Saints Flore **32**:3
Church of England **32**:1–3, **32**:8, **32**:12
Church of St Andrew, Farnham **32**:2–3
Church of St Paul, Bow Common **32**:2
cinemas **15**:32–6; acoustics **10**:17, **15**:35; parking **39**:14–15; permissible noise levels **10**:8; sanitary facilities **2**:8; sound insulation **10**:9, **10**:13, **10**:15
circular hollow sections (CHS) **6**:26, **7**:3
circulation areas: accessible standards **21**:5; auditoria **15**:9; churches **32**:14; crematoria **32**:22; hotels **20**:2, **20**:3–4, **20**:5; laboratories **26**:11–13; learning streets **43**:4; libraries **27**:5, **27**:12, **27**:15, **27**:19; masterplanning **28**:5; museums **29**:2; offices **30**:13; older people's housing **22**:2; shopping centres **35**:10; sports facilities **38**:38–9; student housing **23**:12; universities **43**:2, **43**:4
civic buildings: law courts **16**:7–16; and libraries **27**:5; permissible noise levels **10**:8; reverberation times **10**:16; sound insulation **10**:9, **10**:13, **10**:15; town halls **16**:1–7
civic centres **16**:1–7
Civic Theatre, Helsinki **15**:16
civic value **5**:1
cladding: fire safety **11**:7, **11**:8; gaskets **7**:25; materials **7**:11–15; stone **7**:17, **7**:18; tropical design **42**:31
classrooms **36**:10, **36**:13; interactive **43**:4
clay tennis courts **38**:24
cleaning: community centres **17**:2; student housing **23**:12
cleanrooms, laboratories **26**:2, **26**:23
clearance **2**:2
clerestory windows **42**:15, **42**:19
climate **8**:11–15, **42**:3–5, **42**:6, **42**:11–14
climate change **8**:15, **42**:5–6; and flooding **12**:2–3
climate-responsive design **42**:11–14; active design **42**:28–9; passive design **8**:2, **8**:33, **9**:1–5, **42**:14–28
clothing **8**:7
cloud cover **8**:11
clubs **34**:25, **34**:27, **39**:14
cluster flats **21**:22, **21**:23
coaches and buses **39**:4, **41**:23
coach stations **8**:10, **41**:22–8
coanda effect **8**:29
coastal flooding **12**:2
coated glasses **42**:36
coated steels **7**:5
COBie: Construction Operations Building information exchange **1**:1
Code for Sustainable Homes (CforSH) **10**:10–11, **21**:13, **21**:27
coffee bars **34**:16, **43**:9; *see also* cafes
collections *see* museums
colleges **8**:10, **39**:15, **43**:2; *see also* universities
collegiate universities **43**:1
colonial bungalows **42**:2, **42**:19, **42**:20
columns **6**:5; masonry **6**:7; steel **6**:15, **7**:3; timber **6**:11

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

combined heat and power (CHP) **36**:5
Commission for Architecture and the Built Environment (CABE) **27**:2, **27**:3, **28**:1, **28**:2, **28**:7–8, **33**:6, **36**:3, **36**:6
committee rooms **16**:3
communal areas: flats **21**:18; gardens **21**:20; older people's housing **22**:1, **22**:2; sanitary facilities **2**:13; student housing **23**:3, **23**:8, **23**:11–12; *see also* circulation areas; public areas
communications systems: courtrooms **16**:10; fire stations **18**:1; hotels **20**:5–6; offices **30**:9; police stations **18**:10, **18**:11; student housing **23**:10–11
communion tables **32**:2, **32**:4, **32**:6, **32**:8, **32**:11
community centres **17**:1–4, **39**:15
Community Churches **32**:1
community facilities, schools **36**:9, **36**:13
community hospitals **19**:2, **33**:2, **33**:4, **33**:6, **33**:10
composite climates **42**:3, **42**:4, **42**:12, **42**:13
composite plastics **7**:20
compression stresses **6**:5, **6**:11–12, **6**:20–1
computational fluid dynamics (CFD) models **8**:34
computerised tomography (CT) **19**:9
computer modelling **43**:6
computer simulations **28**:4–8
computer workstations **2**:5
concept design **1**:3
concert halls **10**:17, **15**:23–5, **15**:26
concrete: aggregates **7**:9; blast resistance **37**:8; cement **7**:9; components **7**:10; cover to reinforcement **6**:13; density **8**:4; earthquake zones **42**:32; embodied energy **8**:3; fire resistance **11**:19; foamed **7**:22; lightweight aggregate **7**:22, **7**:23; low-density blocks **8**:17; mixes **7**:9–10; precast concrete panels **7**:10, **37**:8; tropics **42**:29, **42**:30; waterstop seals **7**:25; *see also* reinforced concrete
condensation **8**:6, **8**:19–22
condensing boilers **8**:26
conduction **8**:3–4, **11**:1
conference facilities: auditoria **15**:3, **15**:25–31, **15**:37, **43**:9; hotels **20**:13; student housing **23**:13; universities **43**:7, **43**:9, **43**:10
confessionals **32**:15
constant air volume (CAV) **8**:30
constant illuminance controls **9**:9
construction management **5**:2
container vehicles **39**:4
continuous beams **6**:6
Control of Substances Hazardous to Health Regulations **26**:17
control panels **15**:28
control rooms **15**:20–1, **15**:29–30, **38**:42–3, **40**:2
convection **8**:4, **11**:2
conversion tables **6**:2
cooking equipment **34**:10–12, **34**:13–14
cool desks **30**:15
cooling systems **8**:29, **8**:30–1, **8**:32; police stations **18**:12; schools **36**:4; trading floors **30**:15
cooperative societies **35**:2
copper roofing **7**:12, **7**:13
cork **7**:23
corners, road **39**:9–10, **39**:11
corrected effective temperature (CET) **8**:9
corridors **3**:4–5; accessible standards **21**:5; fire safety **11**:16–17, **11**:18, **20**:4; flats **21**:18; hotels **20**:3–4, **20**:11; laboratories **26**:11–13; older people's housing **22**:2; police custody suites **18**:12; sports facilities **38**:36; student housing **23**:3, **23**:7; widths **3**:4–5
cost limits **5**:3
cost planning **5**:1, **5**:3; rates **5**:5; stages **5**:4–6
costs: checking **5**:6; estimating **5**:3–6; industrial buildings **24**:9; industrial storage buildings **25**:1; libraries **27**:14; primary health care **33**:2, **33**:3; whole life **5**:6–7
council chambers **16**:2, **16**:3
counselling spaces, payment offices **31**:6
counters, payment offices **31**:6, **31**:8–9
counter terrorism **37**:1, **37**:3–10
Counter Terrorist Security Advisors (CTSA) **37**:10
counterweight systems, theatres **15**:17
Countryside Agency **28**:2, **28**:3
court buildings **16**:7–16
court sports **38**:1, **38**:9–12, **38**:23, **38**:24, **38**:25–6, **38**:35
courtyards **42**:20–1
CPTED *see* Crime Prevention Through Environmental Design (CPTED)
Creativity Zones **43**:8
credence tables **32**:10
crematoria **32**:21–4
cricket **38**:5, **38**:23, **38**:25
crime generators **13**:3
crime prevention design **13**:1–5, **21**:13; *see also* security
Crime Prevention Design Advisors (CPDAs) **13**:1, **13**:2, **13**:5, **37**:10
Crime Prevention Through Environmental Design (CPTED) **13**:1–5
crop storage **14**:13–15
cross-gangways, auditoria **15**:7
cross-laminated timber **7**:7
cross ventilation **8**:14, **8**:24, **30**:9
cruise ships **34**:28
crutches **4**:4
CT *see* computerised tomography (CT)
CUBE civic centre, Corby **16**:4
cubicles, cattle housing **14**:2, **14**:4
cul-de-sacs **13**:2
cultural factors **42**:8
cupboards: laboratories **26**:16; older people's housing **22**:4; student housing **23**:12
curtains **42**:17
curtain walling **7**:28
curves, road **39**:9–10
custody suites: law courts **16**:12–13; police stations **18**:12–15
customer services **16**:3–4
customs areas, airports **41**:10
cyanoacrylate adhesives **7**:26
cycle lanes/paths **39**:6, **39**:10–12
cycle parking **27**:4, **39**:12, **39**:13, **39**:16
cycles **38**:34, **39**:2
cycling **28**:12, **39**:22, **43**:13
cycling tracks **38**:6–7, **38**:23

damp-proofing **7**:22
dance studios **15**:38, **15**:39
Darent Valley Hospital, Dartford **19**:5
Darzi Report (2008) **33**:3
data projection facilities **15**:31
Dawson Report (1920) **33**:2, **33**:6, **33**:8
Daylight Autonomy **36**:5
daylighting *see* natural lighting
daylight linking controls **9**:9
dead loads **6**:2, **6**:17
Deal Ground site, Norfolk **12**:10–14
decimal marker **1**:2
deck access flats **21**:19
decking **6**:12
defensible space **13**:3–4
deflection **6**:1, **6**:6, **6**:12, **6**:17–18
delivery areas **34**:7, **35**:3, **35**:10, **39**:18–19, **43**:11
demand and supply **30**:3
demonstration benches **15**:28
densities, materials **6**:2, **8**:4, **8**:6

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

densities, planning **21**:4–5, **21**:6, **28**:12
density indication **28**:6
Department of Health **19**:1, **19**:3, **19**:6, **19**:19
department stores **35**:6
design and build contracts **5**:2
Design and Quality Standards (D&QS) **21**:2, **21**:6–7, **21**:17
design development **1**:3
design for change **24**:2–5
design for extension **24**:5
design heat loss **8**:26
design information standards **1**:1
Design Quality Indicators (DQI), schools **36**:2
Design Share website **36**:3
design stages **1**:3, **5**:3
desire lines **28**:5
desks **2**:5, **30**:14, **30**:15
detention suites **18**:12, **18**:15
deterrence **37**:1
dewpoint temperature **8**:20, **8**:22
diagnostic imaging facilities **19**:7, **19**:9–10, **19**:12, **19**:13, **19**:19
digital masterplanning **28**:4–8
digital media, libraries **27**:3–4, **27**:7, **27**:10–11
digital projection systems **15**:32
dimensional coordination (DC) **1**:7–10
dimensions: accessibility **4**:1–6; agricultural buildings **14**:4, **14**:6–11; anthropometrics **2**:1–5, **4**:2; auditorium seating **15**:1–2, **15**:4, **15**:7; baptistries **32**:7; car parking **39**:17; church seating **32**:14; corridors **3**:4–5; domestic garages **39**:16, **39**:17; doors **3**:3, **3**:4; equestrian design **14**:16–18, **14**:19; ergonomics **2**:5–7; fire appliances **11**:5, **11**:6, **18**:2–3; foodservice facilities **34**:4, **34**:5–11, **34**:13–14, **34**:17; hotel guestrooms **20**:7–9, **20**:11; industrial buildings **24**:7–8; industrial machines **24**:5, **24**:6–7; kitchens **34**:7, **34**:9–11, **34**:17; laboratories **26**:5–6; laboratory furniture **26**:15–16; mobility ranges **4**:5; offices **30**:8–9; older people's housing **22**:2, **22**:3; paper sizes **1**:10–11; primary health care buildings **33**:10–11; public houses **34**:26–7; pulpits **32**:11–12; pushchairs **4**:3; reach ranges **4**:4–5; shop fittings **35**:4, **35**:5; shopping centres **35**:8, **35**:11; shops **35**:3, **35**:5, **35**:6; sports equipment **38**:32, **38**:33, **38**:34–6; sports facilities **38**:2–21; steel **7**:1–5; vehicles **39**:1–5; warehouse handling equipment **25**:11; warehouses **25**:7–9; wheelchairs **4**:2–4, **4**:5
dining rooms **21**:17, **23**:11–12, **36**:15
Diocesan Advisory Committees (DACs) **32**:2, **32**:3
disabled people **4**:1, **4**:4; community centres **17**:3; escape routes **11**:18–19; street design **39**:22; *see also* accessible facilities; wheelchair access
discounting **5**:6, **5**:7
discount rates **5**:6, **5**:7
dishwashing, foodservice facilities **34**:10–11, **34**:17, **34**:18
displacement ventilation **43**:2–3
disproportionate collapse **37**:6
distance attenuation **10**:3–4
distance learning **43**:12
distributed learning **43**:12
district heating and cooling **28**:16
diving pools **38**:15, **38**:35
dogs, assistance **2**:7, **4**:4, **15**:35
domes, mosques **32**:19
domestic buildings *see* residential buildings
domestic space standards **2**:13
door entry systems **20**:5, **23**:13, **37**:2
doors: accessible **3**:3, **3**:4; acoustic **40**:3, **40**:4; entrance **3**:3; fire resistance **11**:20, **20**:4; laboratories **26**:13–14; lobbies **3**:4; materials **7**:27; police custody suites **18**:14; scenery **40**:3; security **37**:12; stables **14**:20
Door Set Energy Ratings (DSERs) **7**:27
doping control facilities **38**:38
drainage: baptistries **32**:7; cycle lanes/paths **39**:12; site analysis **28**:3; stables **14**:20; Sustainable Drainage Systems (SuDS) **7**:14, **12**:9–10, **12**:13, **12**:14
drama teaching **36**:15
drawings **1**:2–7; dimensional coordination **1**:9; graded components **1**:7; RIBA work stages **1**:3; scales **1**:2, **1**:3, **1**:6–7; symbols **1**:5–6; traditional types **1**:2, **1**:3–5
dressage arenas **14**:19
dressing rooms **15**:21–3, **40**:2
drive-in racking **25**:5, **25**:6
driving rain index **8**:12
drying-out **8**:21
dry laboratories **26**:1, **26**:9
dry powder installations **11**:21
dry proofing **12**:7, **12**:8
dual carriageways **39**:5–6
Dutch barns **14**:14
dwellings *see* residential buildings
DWP Jobcentre Plus offices **31**:4–5, **31**:6
dynamic loads **6**:2
dynamic wind pressure **8**:13–14

Early Years Foundation Stage (EYFS) education **36**:6–7
earthquakes **42**:8, **42**:31–2
earth tubes **36**:4
East Riding Crematorium **32**:23, **32**:24
Ecohomes **10**:10–11, **21**:13
Eco School standard **36**:9
education *see* schools; universities
Education Funding Agency (EFA) *see* Baseline Designs, schools
effluent production **14**:11, **14**:14
egg crates **42**:17, **42**:18
elastic sealants **7**:24–5
elastic zone **6**:5
elastomers **7**:20, **7**:21
elastoplastic sealants **7**:24
e-learning **43**:5–6, **43**:12
electrical installations **11**:2
electrical supply: accessible standards **21**:5; broadcasting studios **40**:3; laboratories **26**:21–2; police stations **18**:12; student housing **23**:11, **23**:12; tropics **42**:32
electric lighting *see* lighting
elemental cost planning **5**:3
embedded e-learning **43**:12
embedded service risers **26**:6, **26**:7, **26**:8
embodied energy **8**:2–3, **8**:33
emergency electrical supply **18**:12, **20**:4, **26**:21
emergency eyewash facilities **26**:20–1
emergency lighting **11**:17, **15**:35, **20**:4, **26**:23
emergency services: ambulance stations **18**:7–9; fire stations **8**:10, **18**:1–7; police stations **18**:9–15; *see also* Accident & Emergency (A&E) facilities
emissivity **8**:5, **8**:6, **42**:34
Ena De Silva house, Colombo **42**:3
encastré beams **6**:6
end-bearing piles **6**:16, **6**:17
energy **8**:2–3; building energy models **8**:33, **8**:34; embodied **8**:2–3, **8**:33; masterplanning **28**:16, **28**:19; reducing demand **8**:33; renewable **8**:33, **28**:16, **36**:5, **42**:28–9, **43**:13; schools **36**:5; seasonal energy use **8**:26, **8**:27; shops **35**:5; universities **43**:2–3
energy efficiency **7**:14–15; boilers **8**:26; design **8**:1–2; doors **7**:27; electric lighting **9**:8–9; heat-recovery systems **8**:25, **8**:28–9; hotels **20**:4; housing **21**:27; mechanical ventilation systems **8**:28; student housing **23**:13; windows **7**:26–7
Energy Star standards **36**:5
English Heritage **32**:2, **32**:3
English Nature **28**:2, **28**:3

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

entrances **3**:3; auditoria **15**:9, **15**:10, **15**:36–7; churches **32**:12–13; community centres **17**:3–4; hotels **20**:5, **20**:11; student housing **23**:12; town halls **16**:3; *see also* lobbies
entry control systems **20**:5, **23**:13, **37**:2
Environment Agency **12**:3, **12**:10
Environmental Building, BRE **42**:23
environmental conditions: climate **8**:1–2, **8**:11–15; condensation **8**:6, **8**:19–22; courtrooms **16**:10; industrial buildings **24**:8–9; laboratories **26**:1, **26**:23; libraries **27**:12–14, **27**:15, **27**:19; museums **29**:4–6; music teaching **43**:6; offices **30**:10; schools **36**:2; shops **35**:4–5; stables **14**:18, **14**:19; thermal comfort **8**:1, **8**:7–10, **42**:3–4; universities **43**:6, **43**:7, **43**:8, **43**:11
environmental design **42**:9; active design **42**:28–9; Crime Prevention Through Environmental Design (CPTED) **13**:1–5; masterplanning **28**:14–19; passive design **8**:2, **8**:33, **9**:1–5, **42**:14–28; schools **36**:3–5
Environmental Impact Assessments **28**:2, **42**:7
environmental site analysis **8**:15
environmental temperature **8**:27
epoxy resin adhesives **7**:26
Equality Act (2010) **23**:8–9
equestrian design **14**:12, **14**:15, **14**:16–20
equipment: foodservice kitchens **34**:10–12, **34**:13–14, **34**:16, **34**:17; industrial machines **24**:5, **24**:6–7, **24**:8; laboratories **26**:17–21, **26**:23; sports **38**:31–2, **38**:33, **38**:34–6, **38**:43; warehouses **25**:5–6, **25**:7–9, **25**:10, **25**:11
ergonomics **2**:5–7, **30**:14, **36**:5–6, **42**:11
escalators **3**:7–8
escape routes **11**:8–19; alternative routes **11**:13–14; auditoria **15**:8–9; community centres **17**:3; corridors and lobbies **11**:16–17, **11**:18, **20**:4; disabled people **11**:18–19; evacuation procedures **11**:14–15, **11**:16; flats **11**:9–12, **21**:18; hospitals **19**:7; hotels **20**:4; housing **21**:14; laboratories **26**:15; lighting **11**:17; maisonettes **11**:9, **11**:11–12; numbers required **11**:12–13; offices **11**:16; shopping centres **11**:13, **35**:10; shops **11**:16, **35**:6; statutory requirements **11**:22; student housing **23**:4, **23**:8; travel distances **11**:13–14, **11**:16, **11**:18, **15**:8, **19**:7, **21**:18, **26**:15; widths **11**:14
estate regeneration **21**:23–7
esteem value **5**:1
ethnic restaurants **34**:15
e-University **43**:12
evacuation procedures **11**:14–15, **11**:16, **19**:7
evaporation **8**:6
evidence based design (EBD) **33**:6
Executive Training Suites **43**:7
exercise yards, police stations **18**:13
exfoliated vermiculite **7**:23
Exhibition Road, South Kensington **39**:20
exhibition spaces *see* museums
expanded perlite **7**:23
expanded polystyrene (EPS) **7**:23, **8**:4
expanded PVC **7**:23
expansion: industrial buildings **24**:5; museums **29**:2, **29**:3
explosion hazards **24**:9; *see also* bomb attacks
extension, design for **24**:5
extensions, churches **32**:2–3
external areas, housing **21**:17, **21**:18, **21**:20, **21**:21
external shading **42**:16
external sheltered areas **8**:14–15
extinguishers, fire **11**:21, **15**:12, **23**:8
extruded polystyrene **7**:23

fabrics: structural **6**:6, **6**:15; tensile roof structures **7**:14
facades: attenuation **10**:4, **10**:5; blast loading **37**:5–6; blast resistance **37**:7–8; blast testing **37**:8–9; double-skin **43**:3; libraries **27**:12, **27**:19; and sustainability **43**:3, **43**:13; universities **43**:3, **43**:13; *see also* building envelopes
facial control **1**:9
facilities management (FM) **30**:2
factories *see* industrial buildings
Fanger's comfort equation **8**:9
fans **42**:29
farm animals **14**:2, **14**:3, **14**:4–11, **14**:12, **14**:13; *see also* horses
farm machinery **14**:3
farm shops **14**:20
farrowing houses **14**:10
fastenings, fire exits **11**:17–18
fast-food outlets **34**:1, **34**:2, **34**:5, **34**:19–20, **34**:24
fattening houses **14**:8, **14**:9
fencing **13**:3, **21**:18, **37**:12, **38**:20
FFR *see* flux fraction ratio (FFR)
fibreboards **7**:8, **8**:4, **11**:20
fillet joints **7**:24
film projection facilities **15**:31, **15**:32, **15**:33, **15**:36
filter strips **12**:9, **12**:10, **12**:13
finishes: community centres **17**:1–2; laboratories **26**:20; laboratory furniture **26**:16; paints **7**:26, **42**:34; plaster and boards **7**:21–2, **8**:4; tooled stone **7**:18
fire **11**:1–2
fire alarms **11**:22, **15**:12, **23**:8
fire appliances **11**:5, **11**:6, **18**:2–3
fire compartments **11**:2, **11**:4, **11**:9, **19**:7
fire detectors **11**:21–2
fire doors **11**:17–18, **11**:20, **20**:4
fire-engineering solutions **11**:8
firefighting shafts **11**:5, **11**:6
fire resistance **11**:2, **11**:3, **11**:19–21
fire safety **11**:1–23; appliances and installations **11**:21–2, **15**:12, **23**:8; auditoria **15**:12; broadcasting studios **40**:3–4; cladding **11**:7, **11**:8; department stores **35**:6; evacuation procedures **11**:14–15, **11**:16; exfoliated vermiculite **7**:23; fire doors **7**:27; flats **21**:18; glass **7**:15, **7**:16; hospitals **19**:6–7; hotels **20**:4, **20**:5; industrial buildings **24**:8; management **11**:19; plasterboard **7**:22; plastics **7**:20, **11**:20; precautions **11**:2; principles **11**:2–8; roof coverings **11**:8; schools **36**:6; shopping centres **35**:10; stables **14**:19; statutory requirements **11**:22–3; student housing **23**:8; unprotected areas **11**:6–7; warehouses **25**:12; *see also* escape routes
fire stations **8**:10, **18**:1–7
first aid rooms **38**:38
fitness centres **38**:38
fittings: hotel guestrooms **20**:11; laboratories **26**:20–1, **26**:24, **26**:26; older people's housing **22**:3–4; payment offices **31**:6; shops **35**:3–4, **35**:5; stables **14**:20; student housing **23**:10
five-a-side football **38**:3, **38**:34
fixed end beams **6**:6
Fixed Furniture and Equipment (FFE) **36**:5–6
fixings, stone cladding **7**:18
flanking sound transmission **10**:6
flats: air infiltration rates **8**:10; escape routes **11**:9–12, **21**:18; purpose-built **21**:18–20; student housing **23**:3, **23**:4, **23**:5, **23**:6
flexibility *see* adaptability
flipcharts **15**:29
floating structures **12**:9
flood-aware design **12**:1–14; case study **12**:10–14; planning for flood risk **12**:3–4, **12**:11; reducing flood risk **12**:4–10, **12**:11–12; Sustainable Drainage Systems (SuDS) **7**:14, **12**:9–10, **12**:13, **12**:14; understanding flood risk **12**:1–3, **12**:10–11
flooding **12**:1–3, **42**:7–8
floodlights **38**:24–5
Flood Risk Assessments (FRAs) **12**:3
flood voids **12**:13
flood zones **12**:3, **12**:10
floor areas: community centres **17**:3; hotels **20**:3; retail **35**:1; schools **36**:2, **36**:7, **36**:11, **36**:15; universities **43**:13–15

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

floor depths, offices **30**:8
floor loads **6**:4
floor plenum **30**:15
floors **8**:4; auditoria **15**:10; raised **30**:11, **30**:14; timber **6**:9, **6**:10, **6**:11; tropical design **42**:30; *see also* surfaces
floor tiles **7**:15, **7**:17
floor to floor heights: laboratories **26**:5–6; offices **30**:8
flux fraction ratio (FFR) **9**:8
fly screens **42**:19–20, **42**:31, **42**:33
flytowers **15**:15, **15**:16–17
foam installations **11**:21
follow spots **15**:20
fonts **32**:4, **32**:6, **32**:12, **32**:13
food cabinets, shops **35**:4
food courts **34**:19, **34**:25, **35**:10, **43**:9
foodservice facilities **34**:1–28; cafes **2**:8, **8**:10, **10**:8, **34**:16, **39**:14, **43**:4; fast-food outlets **34**:1, **34**:2, **34**:5, **34**:19–20, **34**:24; food courts **34**:19, **34**:25, **35**:10, **43**:9; food production areas **34**:3, **34**:7–15, **34**:16, **34**:17; hotels **20**:12–13, **34**:1, **34**:2, **34**:5, **34**:7, **34**:18, **34**:27–8; public areas **34**:3, **34**:4–7, **34**:8, **34**:9; *see also* cafeterias; catering facilities; restaurants
football **38**:2–3, **38**:23; competitors and officials areas **38**:37; equipment **38**:32, **38**:34; media areas **38**:41; spectator facilities **38**:39; viewing distances **38**:27
footfall measurement **28**:5
footpaths **39**:6
footways **39**:6
force **6**:2
foreign currency outlets **31**:1, **31**:4, **31**:5, **31**:7
fork-lift truck operations **25**:6–9, **25**:11
Formula 1 cars **38**:35
Fort Halstead Masterplan, Sevenoaks **28**:4–7
foundations **6**:15–17
found property stores **18**:9
foyers: auditoria **15**:37, **15**:38; single person accommodation **21**:23; synagogues **32**:19; *see also* entrances; lobbies
franchises **35**:2
free schools **36**:2
frequency distribution curve **2**:1–2
friction piles **6**:16–17
Friendship House, London **23**:5
frontage widths **21**:14
front gardens **13**:3, **21**:14, **21**:18
Fruin Levels of Service **41**:21
fume cupboards (FCs) **26**:17–18, **26**:19
function rooms **20**:13
furnace rooms **32**:23
furniture: churches **32**:8–11; foodservice facilities **34**:5–7; hotel guestrooms **20**:10, **20**:11; laboratories **26**:15–16, **26**:24, **26**:26; libraries **27**:7–10; older people's housing **22**:4; police custody suites **18**:14; schools **36**:5–6; space standards **21**:7; street **39**:22; student housing **23**:10; *see also* seating
further education (FE) colleges **43**:2

gabions **7**:19
Gaelic football **38**:3, **38**:33
galvanized steel **7**:5
gangways, auditoria **15**:4, **15**:7, **15**:32–3
gap-filling adhesives **7**:26
garages, domestic **39**:13, **39**:16, **39**:17
garbagriha **32**:20
gardens **13**:3, **21**:14, **21**:18, **21**:20, **21**:21
Gardens of Remembrance **32**:21, **32**:23
gas cylinder storage **26**:17
gaseous installations **11**:21
gaskets **7**:25
gates **13**:3, **21**:18
Gatwick Airport **34**:25, **41**:2
GEA *see* gross external area (GEA)
gender ratios **2**:7, **38**:39
General Practitioners **33**:2, **33**:3, **33**:4, **33**:5, **33**:6, **33**:13
geotechnics **42**:7
geothermal energy **42**:28
GIA *see* gross internal area (GIA)
GLA *see* gross leasable area (GLA)
glass and glazing **6**:13, **6**:15, **7**:14–15; blast resistance **37**:7–8; blast testing **37**:8–9; cellular **7**:23; curtain walling **7**:28; density **8**:4; design requirements **7**:15; embodied energy **8**:3; fire resistance **11**:20; gaskets **7**:25; G-values **8**:19; libraries **27**:12, **27**:19; properties **6**:6; radiation transmission **8**:5; solar control **42**:17, **42**:18, **42**:35–6; sound insulation **7**:15, **7**:16, **10**:4, **10**:5; systems **7**:16; thermal conductivity **8**:4; thermal design **8**:18–19, **8**:20; types **7**:15–16; U-values **8**:18–19
glass blocks **42**:18, **42**:36
glass-fibre reinforced cement **7**:21
glass-fibre reinforced gypsum **7**:21, **7**:22
glass-fibre reinforced plastics **6**:6, **7**:20–1
glass wool **7**:22–3, **8**:4, **8**:16
glazing *see* glass and glazing
Glebe House, Southbourne **22**:2
global warming **8**:15
globe temperature **8**:9
goods handling equipment **25**:5–6, **25**:7–9, **25**:10, **25**:11
government services outlets **31**:2, **31**:4–5, **31**:6, **31**:7–8
gradients: cycle lanes/paths **39**:10–11; ramps **3**:1; roads **39**:10
grain stores **14**:13, **14**:15
granite **7**:17–18
grants **5**:6
graphic techniques **1**:2
grass, sports facilities **38**:23
Greater London Authority **21**:8, **21**:9–10
greenhouse gas emissions **8**:5, **8**:27
green roofs **7**:14, **12**:9, **12**:13, **28**:17
green spaces **28**:12
Green Travel Plans **36**:9
grids **1**:7–8, **1**:9–10, **30**:9
gross external area (GEA) **30**:6, **43**:14, **43**:15
gross internal area (GIA) **26**:9, **30**:6, **43**:14, **43**:15
gross leasable area (GLA) **35**:1, **35**:8
ground cooling systems **8**:31, **36**:4
groundskeeping **38**:43
ground source heat pumps (GSHP) **8**:31, **8**:32, **36**:5
groundwater **12**:2, **36**:4, **42**:7
guarding, staircases **3**:7
guide dogs *see* assistance dogs
G-values, glazing **8**:19
gymnasium equipment **38**:31, **38**:32, **38**:36
gymnasiums **38**:38
gymnastics **38**:18–19, **38**:23, **38**:36
gypsum: glass-fibre reinforced **7**:21; plaster **7**:21, **7**:22

Habinteg Housing Association **21**:8, **21**:11
halls: community centres **17**:4; Salvation Army **32**:5–6; schools **36**:10, **36**:15; Society of Friends **32**:7–8
halls of residence **43**:10; *see also* student housing
Hammarby Sjöstad, Stockholm **28**:14–19
Hammersmith Town Hall **16**:2
handball **38**:9, **38**:25
hand drying facilities **2**:13
handrails: auditoria **15**:9–10, **15**:11; escalators **3**:8; ramps **3**:1; staircases and steps **3**:2–3, **3**:6, **3**:7, **4**:6
hand washing facilities **2**:8, **2**:12, **2**:13, **19**:7, **26**:20; *see also* washbasins
hazardous waste management **28**:18
hazards: laboratories **26**:2, **26**:17–20; trips **3**:3, **4**:5–6; *see also* fire safety

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

hazard warning surfaces **3**:3
headroom: escalators **3**:8; staircases **3**:6
health: masterplanning **28**:10–12; offices **8**:10, **30**:3; sick building syndrome **8**:10; universities **43**:3; *see also* hospitals; primary health care buildings
Health Building Notes (HBNs) **19**:19, **33**:9–10
health care buildings *see* hospitals; primary health care buildings
Health Technical Memoranda (HTMs) **19**:19
Healthy Living Centres **33**:6, **33**:7, **33**:8
hearing impairments **15**:3, **15**:35, **15**:40, **23**:9
heat detectors **11**:21, **15**:12
heat gains **8**:26–7, **8**:29, **26**:23; *see also* solar gain
heating **8**:25–7; auditoria **15**:2, **15**:12; baptistries **32**:7; boilers **8**:26; and condensation **8**:21; distribution systems **8**:25, **8**:26; Passive Haus **8**:32, **8**:33; police custody suites **18**:14; seasonal energy use **8**:26, **8**:27; solar water heating **28**:16, **36**:5, **42**:32, **43**:3; student housing **23**:11; synagogues **32**:18
heat loss **8**:23–4, **8**:26, **8**:27
heat-recovery systems **8**:25, **8**:28–9
heat transfer mechanisms **8**:3–7, **11**:1–2
heavy industries **24**:2, **24**:4
hedges **13**:3
heliodons **9**:4, **9**:5
HEPA (high efficient particulate air) filtration **26**:18, **26**:19
Hindu temples **32**:20, **32**:22
Hive public library, Worcester **27**:2, **27**:3
hockey **38**:4, **38**:23, **38**:33
Holbeck Village, Leeds **28**:8, **28**:9
holiday centres and villages **34**:28
holistic care **33**:1, **33**:13
hollow joins **7**:13
Holy Ark **32**:16, **32**:17, **32**:18, **32**:19
Holy Trinity school, Halifax **28**:10
'home base' model for schools **36**:12
Homes and Communities Agency (HCA) **21**:2, **21**:6–7, **28**:1
Hooke's Law **6**:5
horse boxes **14**:19
horses **14**:12, **14**:15, **14**:16–20
hose reels **11**:21
hospices **33**:2
hospitality suites, sports facilities **38**:39–40
hospitals **19**:1–19; Accident & Emergency (A&E) facilities **19**:7–8, **19**:10; air infiltration rates **8**:10; catering facilities **34**:23; children's services **19**:13–14, **19**:17–18; community **19**:2, **33**:2, **33**:4, **33**:6, **33**:10; department relationships **19**:5–6; design **19**:2–7; diagnostic imaging facilities **19**:7, **19**:9–10, **19**:12, **19**:13, **19**:19; hi-tech specialties **19**:19; infection control **7**:12, **19**:7, **19**:8–9, **19**:11; maternity services **19**:18–19; mental health services **19**:19; older people's services **19**:14, **19**:18; operating theatres **19**:8–9, **19**:11, **19**:15; outpatient facilities **19**:8, **19**:14–15, **19**:16, **19**:17, **19**:18, **19**:19; parking **39**:15; rehabilitation services **19**:16–17; sound insulation **10**:9, **10**:11, **10**:13, **10**:14, **10**:17; wards **19**:2–3, **19**:4, **19**:10–11, **19**:13–14, **19**:18–19; *see also* primary health care buildings
Hospital Streets **19**:7
hostile vehicle mitigation **37**:1, **37**:4, **37**:6
hot-desking offices **43**:11
hot dry climates **42**:3, **42**:4, **42**:12, **42**:15
hotels **20**:1–17; air infiltration rates **8**:10; case studies **20**:14–18; classification **20**:1; design considerations **20**:1–6; foodservice facilities **20**:12–13, **34**:1, **34**:2, **34**:5, **34**:7, **34**:18, **34**:27–8; guestrooms **20**:2–3, **20**:4, **20**:6–11; parking **39**:14; permissible noise levels **10**:8; public areas **20**:2, **20**:4–5, **20**:11–13; sanitary facilities **2**:8; sound insulation **10**:9, **20**:4
hot-melt adhesives **7**:26
hot springs **42**:8
hot water heating, solar **28**:16, **36**:5, **42**:32, **43**:3
hot wet climates **42**:3, **42**:4, **42**:12, **42**:13
Houghton le Spring Primary Care Centre, Tyne & Wear **33**:17–18
Hounslow Health Centre, London **33**:13–15
house conversions **21**:20–1
houses in multiple occupation (HMOs) **23**:7–8; *see also* student housing
housing: air infiltration rates **8**:10; estate regeneration **21**:23–7; house conversions **21**:20–1; for older people **21**:22, **22**:1–4, **39**:14; parking **21**:5–6, **39**:13, **39**:14; purpose-built flats **21**:18; single-family houses **21**:14–18; single person accommodation **21**:21–3; standards **21**:1–14; students and young people **23**:1–13, **43**:10; *see also* residential buildings
Housing Act (2004) **23**:7
Housing Quality Indicators (HQI) **21**:2, **21**:7
humid climates **42**:3, **42**:4, **42**:12, **42**:13
hybrid ventilation systems **8**:31–2
hydrant systems **11**:21
hydraulic systems: auditoria **15**:11, **15**:17; lifts **3**:9, **3**:10
hygiene: foodservice facilities **34**:9; hotels **20**:5; infection control **7**:12, **19**:7, **19**:8–9, **19**:11
Hylands Primary School, Hornchurch, Essex **36**:8
hypermarkets **35**:7–8

ice hockey **38**:16, **38**:34
ice rinks **38**:16–17
ICT *see* information technology
identity parade suites **18**:11–12
IFC *see* Industry Foundation Class (IFC)
illuminance **9**:10
immigration desks, airports **41**:9
imposed loads **6**:2
improvised explosives devices (IED) **37**:3–4, **37**:5, **37**:6–7, **37**:8, **37**:10
inclusive design **4**:1
incubators, university **43**:8
induction loop systems **15**:3, **15**:35, **15**:40, **32**:14, **32**:18–19
industrial buildings **24**:1–9; air infiltration rates **8**:10; parking **39**:14; permissible noise levels **10**:8; reverberation times **10**:16; storage buildings **8**:10, **25**:1–12, **39**:14
Industry Foundation Class (IFC) **1**:1
infection control **7**:12, **19**:7, **19**:8–9, **19**:11
information technology: hospitals **19**:1; libraries **27**:7, **27**:8, **27**:10–11; offices **30**:3; primary health care buildings **33**:12; schools **36**:5, **36**:8, **36**:13; sports facilities **38**:43; trading floors **30**:14–15; universities **43**:12
insects **42**:9–10, **42**:11, **42**:19–20, **42**:33
institutional foodservices *see* cafeterias; catering facilities
insulation: densities **8**:4; fire safety **11**:8; installation of **8**:18; thermal conductivity **7**:23, **8**:4, **8**:17; transparent insulation material (TIM) **8**:19, **8**:20; types **7**:22–4, **8**:17; U-values **8**:16
Integrated Project Delivery (IPD) **1**:1
Intensive Therapy Units (ITUs) **19**:7, **19**:9
interactive classrooms **43**:4
InterContinental Hotel, Westminster **20**:16–18
Intergovernmental Panel on Climate Change (IPCC) **42**:5
interior design: mental health services **19**:19; purpose-built flats **21**:18–19; reducing sound transmission **10**:5; single-family houses **21**:15–16, **21**:17–18
international aid **42**:8
internet access **23**:10–11
interstitial condensation **8**:22
interstitial floor service zones **26**:6–7, **26**:8
interview spaces, payment offices **31**:6, **31**:10
Intruder Detection Systems (IDS) **37**:13
intumescent coatings **11**:21
intumescent strips **11**:20
IPD *see* Integrated Project Delivery (IPD)
irrigation, sports pitches **38**:23, **38**:24
IT-mediated learning **43**:12

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Jobcentre Plus offices **31**:4–5
joints **7**:24
joists: floor **6**:9, **6**:10, **6**:11; steel **6**:14, **7**:3
Joseph Rowntree Foundation (JRF) **21**:8
Judaism **32**:16–19
judo **38**:18
junctions, road **39**:9, **39**:11, **39**:21

karate **38**:20, **38**:25
kayaking **38**:16, **38**:35
kennels, cattle housing **14**:2, **14**:4
keratin **7**:21
kerbs **3**:1
key reference planes **1**:10
King Edward Memorial Hospital, Ealing **19**:12
kitchens: accessible standards **21**:12; community centres **17**:4; equipment **34**:10–12, **34**:13–14, **34**:16, **34**:17; foodservice facilities **34**:7, **34**:9–12, **34**:13–14, **34**:15, **34**:16, **34**:17; schools **36**:15; single-family houses **21**:17; space standards **2**:5–6; student housing **23**:3, **23**:8, **23**:10, **23**:11–12; work surface heights **2**:5–6, **21**:14, **22**:4, **34**:9

laboratories **26**:1–29; case studies **26**:23–6; environmental conditions **26**:1, **26**:23; equipment **26**:17–21, **26**:23; furniture **26**:15–16, **26**:24, **26**:26; planning modules **26**:2–5, **43**:5; schools **26**:1, **26**:9, **26**:10–11, **26**:15, **26**:16, **36**:13; services **26**:5, **26**:6–7, **26**:8, **26**:21–3; space organisation **26**:7, **26**:9–17; types and sectors **26**:1; universities **26**:1, **26**:9, **26**:11, **26**:16, **26**:23–6, **43**:5–6, **43**:14; vibration **26**:6, **26**:7, **26**:15
lacrosse **38**:4, **38**:33
Ladbroke Hotel **34**:28
Lady Mitchell Hall, Cambridge **15**:27
laminated beams **6**:8, **6**:11
laminated glass **6**:15, **7**:16, **37**:7
laminated timber **7**:7
laminated veneer lumber **7**:7
lamp efficacy **9**:8
landings **3**:1, **3**:2, **3**:6
landlord efficiency **30**:8
land remediation allowances **5**:6
landscape design **28**:8–9; tropics **42**:11, **42**:23–4, **42**:26–7
Landscape Institute **28**:1
land-use and mix simulation **28**:6
lap joints **7**:24
La Puente, California **35**:9
laser beam detectors **11**:22
laundries **18**:9, **23**:12
law courts **16**:7–16
layered glazing systems **8**:19
lead **7**:5, **7**:12–13
Leadenhall Building, London **30**:4
learning cafes **43**:4
learning centres **43**:4–5, **43**:14
Learning Resource Centre, Thames Valley University **27**:8
Learning Resource Centres (LRCs) **36**:13
learning streets **43**:4
lecterns **15**:27–8, **32**:4, **32**:8, **32**:10, **32**:11
lecture theatres **15**:25, **15**:27, **43**:3, **43**:4, **43**:6, **43**:7
legislation: agricultural buildings **14**:20; auditoria **15**:40; community centres **17**:3; foodservice facilities **34**:3–4; laboratories **26**:2, **26**:27–9; schools **36**:2; student housing **23**:7–9; *see also* Building Regulations
leisure facilities: hotels **20**:13; *see also* sports facilities
letter bombs **37**:4
level, changes in **4**:5–6
Levels of Service, airports **41**:4
libraries **16**:4, **27**:1–19; air infiltration rates **8**:10; case study **27**:14–17; community roles **27**:2–4; design **27**:4–6; environmental conditions **27**:12–14, **27**:15, **27**:19; layouts **27**:7–11; parking **39**:15; space standards **27**:11–12, **43**:14; university **27**:1, **27**:2, **27**:4, **27**:7, **27**:8–9, **27**:10–11, **27**:12, **43**:4–5, **43**:14
library desks **27**:5
licensing **17**:3
LifE *see* Long-term Initiatives for Flood-risk Environments (LifE)
life cycle analysis (LCA) **5**:6
life cycle costs **5**:6, **8**:32, **33**:3
Lifetime Homes **21**:8, **21**:11
Lifetime Homes standard **2**:13
LIFT (Local Improvement Finance Trust) **33**:6, **33**:7
lifting platforms **3**:9
lifts **3**:9–12; firefighting **11**:5, **20**:5; flats **21**:5, **21**:19; laboratories **26**:15; lobbies **3**:11; service **20**:4; specifications **3**:12; student housing **23**:3, **23**:4
light baffles **42**:18
lighting: auditoria **15**:12, **15**:19–20, **15**:23, **15**:35; broadcasting studios **40**:2–3; controls **9**:9; courtrooms **16**:10; crime prevention design **13**:3, **13**:5; display **9**:10; emergency **11**:17, **15**:35, **20**:4, **26**:23; energy efficiency **9**:8–9; escape routes **11**:17; glazing **7**:15, **7**:16; glossary **9**:10–12; hotels **20**:4; industrial buildings **24**:8; laboratories **26**:23; libraries **27**:12–14, **27**:15; museums **29**:4, **29**:5–6; older people's housing **22**:2; police custody suites **18**:14; schools **36**:4–5; shops **35**:4; sizing installations **9**:9; sports floodlighting **38**:24–5; student housing **23**:10, **23**:12; synagogues **32**:18; universities **43**:3, **43**:8, **43**:13; and visual display terminals **9**:10; *see also* natural lighting
lighting control rooms **15**:20, **15**:30
light pipes **42**:15, **42**:17, **42**:19
light pollution **13**:5
light rail **41**:26, **41**:28
light scoops **42**:15, **42**:17, **42**:19
lightweight aggregate concrete **7**:22, **7**:23
lime **7**:21
limestones **7**:17, **7**:19
limit states **6**:1
linear assembly methods **24**:5
lintels **6**:6
liquid nitrogen storage **26**:17
Listed Building Consent **21**:20
listed buildings **32**:2, **32**:3
litter **42**:28
Liverpool School of Tropical Medicine (LSTM) **26**:24, **26**:25–6, **26**:29
livestock **14**:2, **14**:3, **14**:4–11, **14**:12, **14**:13; *see also* horses
loadbearing capacity **11**:19
loading bays **25**:6, **25**:9, **25**:10, **39**:18–19
loading bridges, airports **41**:12–13
load mounting **25**:5
loads **6**:1–3, **6**:4; on beams **6**:17–20; industrial buildings **24**:8; laboratories **26**:6; masonry elements **6**:7, **6**:8; offices **30**:8–9
lobbies **3**:4; ATM **31**:2, **31**:5–6, **31**:7, **31**:8; auditoria **15**:36–7, **15**:38; fire safety **11**:16–17, **11**:18; hotels **20**:11–12; lifts **3**:11; *see also* entrances; foyers
Local Ecumenical Projects (LEPs) **32**:1
local exhaust ventilation (LEV) **26**:17
lockers **18**:5, **18**:6, **18**:7, **18**:9
loft conversions **21**:21
London Housing Design Guide (LHDG) **21**:8, **21**:27
London Plan **21**:8, **21**:9–10
Long-term Initiatives for Flood-risk Environments (LifE) **12**:5
Lord's cricket ground **38**:40, **38**:41
lorries **39**:3–4, **39**:18–19
louvres **42**:17
low carbon design **8**:32–3, **36**:3–5
low-density concrete blocks **8**:17
low-emissivity glass **8**:19

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Loxford Polyclinic, Essex **33**:15–16
LRCs *see* Learning Resource Centres (LRCs)
luminaires **9**:8–9, **35**:4
lump sum contracts **5**:2
Lyttleton Theatre, London **15**:16

magnetic resonance imaging (MRI) **19**:9, **19**:19
Maidment Court, Dorset **22**:2
mail scanning **37**:4
maintenance: access for **2**:6–7; and crime prevention design **13**:4; foodservice facilities **34**:7; universities **43**:11; warehouse equipment **25**:10
maisonettes, escape routes **11**:9, **11**:11–12
management, crime prevention design **13**:4
Manchester Metrolink **41**:28
mandapa **32**:20
manned security provision **37**:3
Manoel theatre, Malta **42**:19
manufacturing *see* industrial buildings
manure **14**:11, **14**:14
marble **7**:18
markets **35**:2–3
masonry **6**:7, **6**:8; blast resistance **37**:8; fire resistance **11**:19; properties **6**:6; structural robustness **37**:6; tropics **42**:30; U-values **8**:16
mass **6**:2–3; *see also* thermal mass
masterplanning **28**:1–12; case study **28**:14–19; checklists **28**:7–10; digital **28**:4–8; and health **28**:10–12; key documents **28**:13–14
mastic asphalt roofing **7**:14
matchbox sundials **9**:4–5
materials: bending **6**:5–6; densities **6**:2, **8**:4, **8**:6; emissivities/absorptivities **8**:5, **8**:6, **42**:34; fire resistance **11**:19–21; for fire stopping and cavity barriers **11**:21; masses **6**:3; moisture content **8**:21; older people's housing **22**:2; sound absorption **10**:2, **10**:3, **10**:6; storage and handling **25**:2; structural **6**:6–15; thermal capacity **8**:6–7; thermal conductivity **7**:23, **8**:3–4; time lag **42**:37; vapour resistance **8**:22; *see also individual materials*
maternity services **19**:18–19
matrix glazing systems **8**:19, **8**:20
MDF *see* medium density fibreboard (MDF)
Meadowhall Centre, Sheffield **35**:14
means of escape *see* escape routes
measurement **5**:3–6, **30**:3, **30**:6–7
mechanical smoke extraction systems **11**:4
mechanical ventilation systems **8**:23, **8**:27–30; air speed **8**:8; auditoria **15**:12; broadcasting studios **40**:3; CBRN attacks **37**:5; design **8**:2; fire safety **11**:18; heat-recovery systems **8**:25, **8**:28–9; museums **29**:4; police stations **18**:12; shops **35**:5; tropics **42**:29; universities **43**:13
mechanised passenger conveyor system **3**:8–9
media: broadcasting studios **10**:13, **15**:40, **40**:1–4; sports facilities **38**:40–2
median strips **39**:21, **39**:23
medical facilities: sports buildings **38**:38; *see also* hospitals; primary health care buildings
medium density fibreboard (MDF) **7**:8
medium industrials **24**:1–2, **24**:3
meeting halls, Society of Friends **32**:7–8
meeting rooms **15**:38, **16**:3, **17**:4; churches **32**:5; libraries **27**:11; offices **30**:11, **30**:12; payment offices **31**:6, **31**:10
mental health services **19**:19
mesh reinforcement **6**:11
metabolic carbon dioxide **8**:23
metabolic heat **8**:7
metals: alloys **7**:2, **7**:5, **7**:10–11; fencing **13**:3; roofing **7**:11–13; *see also* aluminium; steel
metalwork shops **15**:39
Methodist Church **32**:6–7
metric annotation **1**:1–2
microbiological safety cabinets (MSCs) **26**:18–20, **26**:21
middens **14**:20
Mihrab **32**:19
milking parlour systems **14**:2, **14**:5, **14**:6
minarets **32**:19
mineral wool **7**:22, **8**:4, **8**:16, **8**:17
mixed mode cooling **36**:4
mixed use environments **28**:12
mobile and wireless learning **43**:12
mobility ranges **4**:5
Modern Methods of Construction (MMC) **23**:4
modified wood **7**:8
modules, laboratories **26**:2–5, **43**:5
moisture: condensation **8**:6, **8**:19–22; evaporation **8**:6; *see also* relative humidity (RH)
Mold Community Hospital **19**:2
moment joints **6**:25
money transfer outlets **31**:1, **31**:4, **31**:5, **31**:7
monsoon climates **42**:3, **42**:4, **42**:12, **42**:13
mosques **32**:19–20, **32**:21
mosquitoes **42**:9–10, **42**:11, **42**:33
motorcycles **39**:2
mould growth **8**:20
movement **3**:1–12; access to buildings **3**:1–3; crime prevention design **13**:2; escalators **3**:7–8; moving walkways **3**:8–9; *see also* lifts; passenger movement
moving walkways **3**:8–9
MRI *see* magnetic resonance imaging (MRI)
multi-layer thermo-reflective materials **7**:24
multi-sports halls **38**:22
multi-storey car parks **39**:13, **39**:18
Munsell numbers **42**:34
Museum of London Docklands **29**:5
museums **8**:10, **29**:1–8, **38**:40, **39**:15
musicians **15**:17–18, **15**:22, **15**:24–5, **15**:26
music teaching **36**:15, **43**:6
Muslims **32**:19–20

National Affordable Housing Programme **21**:2
National Counter Terrorism Security Office (NaCTSO) **37**:10
National Curriculum **36**:1, **36**:8, **36**:10
National House Building Council (NHBC) **21**:7–8
national libraries **27**:1, **27**:6, **27**:13
National Planning Policy Framework (NPPF) **21**:4–6, **21**:13
natural lighting: daylight factors **9**:5–6; glazing **7**:15, **7**:16; industrial buildings **24**:8; libraries **27**:12, **27**:13, **27**:15; maintenance factors **9**:7, **9**:11; schools **36**:2, **36**:4–5; tropics **42**:35; uniformity in **36**:5; universities **43**:2, **43**:3, **43**:7, **43**:8, **43**:13; window design **9**:6–8
natural turf **38**:23
natural ventilation **8**:23; design **8**:24–5; fire safety **11**:4; hybrid systems **8**:31–2; libraries **27**:12, **27**:13, **27**:14, **27**:15; offices **30**:9–10; schools **36**:4; universities **43**:2–3
natural wood finishes **7**:26
NEAT hospital design **19**:3–4
neoprene **7**:20
netball **38**:11, **38**:23, **38**:25, **38**:35
net internal area (NIA) **30**:6, **43**:14, **43**:15
net office area (NOA) **30**:6
net sales area (NSA) **35**:1
net useable area (NUA) **26**:9, **43**:14, **43**:15
network models **8**:33–4
neutral axis **6**:5
Newport Law Court **16**:8
New Rules of Measurement (NRM) **5**:3–6
New Zealand House, London **30**:6
NHS *see* primary health care buildings
NHS Estates **33**:2

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

NHS LIFT (Local Improvement Finance Trust) **33**:6, **33**:7
NIA *see* net internal area (NIA)
night time cooling **36**:4
NOA *see* net office area (NOA)
noise: broadcasting studios **40**:3, **40**:4; community centres **17**:3; external sources **10**:3–5; hotels **20**:4–5; industrial buildings **24**:8; laboratories **26**:6, **26**:23; libraries **27**:6, **27**:10, **27**:11; museums **29**:6; permissible levels **10**:6–8; reducing transmission **10**:3–6; stables **14**:19; student housing **23**:8; universities **43**:6, **43**:8; *see also* sound insulation
Noise Rating (NR) standards **10**:6–7, **15**:12, **20**:4
non-condensing boilers **8**:26
normal distribution curve **2**:1–2
Northern Ireland, housing standards **21**:8
North Somerset Courthouse **16**:14–16
nosing **3**:2, **4**:6, **11**:15
no-sky line **9**:1, **9**:6, **42**:21–2
notation **1**:2
NSA *see* net sales area (NSA)
NUA *see* net useable area (NUA)
nursery classes **36**:6–7

O2 Arena, London **38**:22, **38**:23
Oasis Academy, Enfield **36**:2
obesity **4**:2
occupancy-linked lighting controls **9**:9
office as city concept **30**:2
offices **30**:1–16; air infiltration rates **8**:10; auditoria **15**:38; conversion to residential **21**:21; design **30**:1–2, **30**:3; dimensions **30**:8–9; ergonomics **2**:5; escape routes **11**:16; in industrial buildings **24**:7, **25**:9–10; layouts **30**:10–14; life spans **30**:7; parking **39**:14; payment **31**:1–10; permissible noise levels **10**:8; reverberation times **10**:16; services **30**:7, **30**:9–10, **30**:11, **30**:14; sick building syndrome **8**:10; sound insulation **10**:9, **10**:13, **10**:15; space requirements **30**:6–7; town halls **16**:3; trading floors **30**:14–16; types **30**:3; universities **43**:10–11, **43**:14
Ofsted **36**:1, **36**:6
older people **4**:1–2; hospital services **19**:14, **19**:18; housing **21**:22, **22**:1–4, **39**:14
Olympic Games **38**:9
one-bedroom flats **21**:22
onion stores **14**:15
on-line exams and assessments **43**:12
online learning **43**:5–6
open plan offices **43**:11
open-stage auditoria **15**:5, **15**:13, **15**:14, **15**:18–19
Opera House, Essen **15**:16
operating theatres **19**:8–9, **19**:11, **19**:15
operational costs **5**:6
operational value **5**:1
option studies **5**:6
orchestras **15**:17–18, **15**:22, **15**:24–5, **15**:26
order assembly, warehouses **25**:6, **25**:8, **25**:9
order of cost estimate **5**:3–4
Ordnance Survey maps **1**:11
organs, church **32**:15–16
orientation: housing **21**:14, **42**:23; and noise **10**:4, **10**:5, **17**:3; sports facilities **38**:24; universities **43**:2
oriented strand board (OSB) **7**:7, **7**:8
outpatient facilities **19**:8, **19**:14–15, **19**:16, **19**:17, **19**:18, **19**:19
outside broadcasts **38**:42
ovens **34**:10, **34**:11, **34**:13, **34**:14
overhangs **42**:16
overhead projectors **15**:29, **15**:30
oxygen level detection systems **26**:17

pad foundations **6**:15
paints **7**:26, **42**:34
paint shops **15**:39
pallet racking **25**:5, **25**:6, **25**:7
pallets **25**:11
pallet trucks **25**:11
panic bolts **11**:18
paper insulation **7**:24, **8**:4, **8**:17
paper sizes **1**:10–11
parallel flange channels (PFC) **6**:27, **7**:4
parcel bombs **37**:4
pareto rule **5**:5
Parker Morris standards **21**:1, **21**:2, **21**:4, **21**:17, **21**:18, **21**:27
parking *see* car parking; cycle parking
particleboards **7**:7–8
passenger movement: airports **41**:4, **41**:5, **41**:6, **41**:7, **41**:8, **41**:9, **41**:10, **41**:11; railway stations **41**:21–2
passive design **8**:2, **8**:33, **9**:1–5, **42**:14–28
Passive Haus **8**:32, **8**:33
passive shading **42**:14–15, **42**:16–18
passive solar design **9**:1–5
passive stack ventilation (PSV) **8**:25
pastoral centres **32**:8
Patients Charter **19**:2
patios **42**:20–1
pavements **39**:6
paving flags **7**:10
payment offices **31**:1–10
Peckham Public Library **27**:6, **27**:10
pedestrian permeability **28**:12
pedestrians **27**:4, **28**:12, **39**:22
percentage people dissatisfied (PPD) **8**:9
percentiles **2**:2
pergolas **42**:16, **42**:20
perimeter ducting **26**:22, **30**:11, **30**:14
Perimeter Intrusion Detection Systems (PIDSs) **37**:1, **37**:2
permeable paving **12**:9
permissible stress design **6**:1
personal space requirements **2**:2
personal symptom index (PSI) **8**:10
petanque **38**:21
PFI programme **33**:6, **33**:7
pharmacy services **19**:1, **19**:8, **19**:14–15
phased evacuation **11**:14–15, **11**:16
phenolic foam **7**:23, **8**:4
photographers, sports facilities **38**:40
photovoltaics **28**:16, **36**:5, **42**:29, **43**:13
physiotherapy **19**:16
piano stores **15**:21
Picture Archiving and Communication Systems (PACS) **19**:10
piers **6**:5, **6**:7
pig housing **14**:8–10
pile foundations **6**:15, **6**:16–17
pin-jointed frames **6**:5
pin joints **6**:25
piston and cylinder principle **1**:8
pitch sports: competitors and officials areas **38**:36–8; equipment **38**:32, **38**:33, **38**:34; media areas **38**:41; pitch layouts **38**:1, **38**:2–5; playing surfaces **38**:23; spectator facilities **38**:39
pitch technology **38**:24
place-making **39**:22
places of worship **32**:1–24; air infiltration rates **8**:10; Christian churches and meeting halls **32**:1–16; crematoria **32**:21–4; Hindu temples **32**:20, **32**:22; mosques **32**:19–20, **32**:21; parking **39**:15; Sikh gurdwara **32**:20–1, **32**:22; synagogues **32**:16–19
planning grids **1**:9–10, **30**:9
planning modules, laboratories **26**:2–5, **43**:5
planning permission **21**:20
planning policy: crime prevention design **13**:2; flood risk **12**:3–4; house conversions **21**:20

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Planning Policy Guidance Notes (PPGs) **28**:1–2, **28**:13–14
Planning Policy Statements (PPSs) **28**:1–2, **28**:13–14
Planning Portal **28**:1
planting: crime prevention design **13**:3, **13**:4–5; tropics **42**:16, **42**:18, **42**:24, **42**:26–7
plaster **7**:21–2, **8**:4, **8**:16
plasterboard **7**:21–2, **8**:4, **11**:20
plastic films **7**:16, **42**:17
plastic pipe adhesives **7**:26
plastics **7**:19–20, **7**:21; fire safety **7**:20, **11**:20; glass-fibre reinforced **6**:6, **7**:20–1; rooflights **11**:8, **11**:9; sealants **7**:24
platforms: cinemas **15**:36; concert halls **15**:24, **15**:25; conference halls **15**:27–8, **15**:31; railway stations **41**:22
playing fields **36**:11, **38**:43–4, **39**:15
pluvial flooding **12**:2
plywood **7**:7
PMV *see* predicted mean vote (PMV)
point loads **6**:17
pole barns **14**:13
pole houses **18**:3, **18**:6
Police Counter Terrorist Security Advisors (CTSA) **37**:10
police stations **18**:9–15
political factors **42**:8
pollution **13**:5, **29**:4, **42**:7
pollution control **12**:9
polo fields **14**:19
polyethylene **7**:19, **7**:20, **7**:21
polyisocyanurate foam **7**:23
Polytechnics and Colleges Funding Council (PCFC) **43**:13–14
polyurethane foam **7**:23, **8**:16
polyvinyl chloride (PVC) **7**:19, **7**:20, **7**:21; expanded **7**:23
pool-based sports **38**:1, **38**:12–15, **38**:35
Portcullis House, London **42**:2
Portobello Square, Kensington **21**:24–7
Post House Hotel, Sevenoaks **34**:15
post offices **31**:1, **31**:3–4, **31**:6, **31**:7
potato storage **14**:14
poultry housing **14**:11, **14**:12, **14**:13
power supply *see* electrical supply
Poynton, Cheshire **39**:22–5
PPD *see* percentage people dissatisfied (PPD)
precast concrete panels **7**:10, **37**:8
predicted mean vote (PMV) **8**:9
pre-fabrication **23**:4, **23**:7
pregnant women **4**:2
Presbyterian Church of Scotland (PCS) **32**:4
presence detectors **9**:9
press rooms **15**:31, **38**:40–2
pressure: vapour **8**:22; wind **8**:13–14
pressure coefficients **8**:14
Prestwick Airport **34**:2
primary health care buildings **33**:1–13, **39**:15; case studies **33**:13–19
primary schools **36**:1, **36**:7–10, **39**:15
prisoners' vehicle docks **18**:11
private laboratories **26**:1, **26**:11
private schools **36**:2
problem analysis triangle **13**:1
procedural security **37**:3
procurement **5**:2–3; payment offices **31**:7–8; primary health care **33**:6–7
production information **1**:3
Project Faraday **36**:13, **36**:14
projection facilities **15**:29–31, **15**:32, **15**:33, **15**:36
proscenium stages **15**:5, **15**:6, **15**:13–15, **15**:37
PSI *see* personal symptom index (PSI)
PSV *see* passive stack ventilation (PSV)
public areas: bus and coach stations **41**:25–6; foodservice facilities **34**:3, **34**:4–7, **34**:8, **34**:9; hotels **20**:2, **20**:4–5, **20**:11–13; law courts **16**:13; museums **29**:2, **29**:3; police stations **18**:9; primary health care buildings **33**:12; town halls **16**:3–4; universities **43**:9
public houses **34**:1, **34**:5, **34**:20, **34**:23–7, **39**:14
public laboratories **26**:1, **26**:11
public libraries *see* libraries
public outdoor spaces **27**:4, **27**:5; green spaces **28**:12; *see also* streets/roads
public realm appropriation **28**:7
public transport: bus and coach stations **8**:10, **41**:22–8; and libraries **27**:4; masterplanning **28**:15; railway stations **8**:10, **41**:16–22; and universities **43**:13
Pulkovo Airport, St Petersburg, Russia **41**:14–16
pulpits **32**:4, **32**:6, **32**:11–12, **32**:17
pushchairs **3**:4, **4**:3
PVA adhesives **7**:25, **7**:26
PVB laminated glass **37**:7
PVC *see* polyvinyl chloride (PVC)

Quakers **32**:7–8
quartzite **7**:19
Queen Mary University of London **23**:5

racecourses **38**:37, **38**:39
racking **6**:20–1, **25**:5, **25**:6, **25**:7, **34**:8–9
radiant temperature **8**:7
radiation **8**:5, **11**:1
radiation detectors **11**:21
radiation protection **7**:16
rafters **6**:9, **6**:12
raft foundations **6**:15, **6**:16
railings **13**:3, **21**:18
railway stations **8**:10, **41**:16–22
rainfall **8**:12, **12**:2
rainwater collection **42**:32, **43**:3, **43**:13
raised buildings **42**:10
raised floors **30**:11, **30**:14
raised track (viaduct) stations **41**:17–18
ramps **3**:1, **4**:5–6, **15**:9, **21**:5
Randhurst, Illinois **35**:9
Rapid Diagnostic and Treatment Centres (RDTC) **19**:14
Ravenscraig Regional Sports Facility **38**:45–50
reach ranges **4**:4–5, **22**:4
reading rooms, libraries **27**:3, **27**:5, **27**:7, **27**:14
reception areas: schools **36**:9–10, **36**:13; town halls **16**:3
recording studios **10**:13, **15**:40, **40**:1–4
rectangular hollow sections (RHS) **6**:26, **7**:4
recycled paper insulation **8**:17
recycling facilities **23**:11, **23**:12, **23**:13, **28**:17–18, **43**:11
reference systems **1**:9
reflectance **9**:10, **9**:11
reflected radiation **8**:11, **8**:12
refrigeration **8**:31, **8**:32, **35**:5
refuse storage **21**:18, **21**:19–20, **23**:12, **23**:13, **34**:7–8
regeneration, housing estates **21**:23–7
Register of Security Engineers and Specialists (RSES) **37**:10
rehabilitation services **19**:16–17
rehearsal rooms **15**:38, **15**:39, **40**:2
reinforced bitumen roofing membranes **7**:13–14
reinforced concrete **6**:6, **6**:9–13; blast resistance **37**:8; concrete cover **6**:13; reinforcement **6**:11–12, **7**:5
relative humidity (RH) **8**:7, **8**:8, **8**:9; and condensation **8**:20, **8**:21; external **8**:12, **8**:13; laboratories **26**:23; museums **29**:4, **29**:5, **29**:6
religious buildings *see* places of worship
religious factors **42**:8
renewable energy **8**:33, **28**:16, **36**:5, **42**:28–9, **43**:13
rents **23**:1, **35**:2
reservation of the sacrament **32**:12, **32**:13, **32**:14

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

residential buildings: permissible noise levels **10**:8; reverberation times **10**:16; sound insulation **10**:9, **10**:10–11, **10**:13, **10**:17; *see also* flats; housing
resort hotels **20**:1, **20**:13, **20**:14, **34**:27–8
restaurants **34**:1, **34**:2, **34**:15–16; air infiltration rates **8**:10; food production areas **34**:9; parking **39**:14; permissible noise levels **10**:8; sanitary facilities **2**:8; seating plans **34**:4, **34**:5, **34**:6; *see also* cafeterias; foodservice facilities
resultant temperature **8**:9, **8**:27
retail **35**:1–14; air infiltration rates **8**:10; markets **35**:2–3; retail parks **35**:3, **35**:14; shopping centres **11**:13, **34**:2, **34**:19, **35**:4, **35**:8–14; sports facilities **38**:40; supermarkets **25**:9, **35**:4, **35**:5, **35**:6–8; universities **43**:9–10; *see also* shops
reverberation times **10**:2–3, **10**:15, **10**:16–17, **40**:3
revolving doors **3**:3
revolving stages **15**:15
RIBA work stages **1**:3
rigid board insulation **8**:17
Rio Earth Summit **28**:2
risk **37**:1; fire **11**:1; flooding **12**:1, **12**:3–4
risk management **5**:2, **29**:7
risk matrix **5**:2
risk register **37**:11
river flooding **12**:1
Rivers Agency, Northern Ireland **12**:3
roads *see* streets/roads
roll-through racking **25**:5, **25**:6
Roman Catholic Church **32**:3–4, **32**:8, **32**:12
roofing materials **7**:11–15, **8**:4
roofing slates **7**:18
roofing tiles **7**:10, **7**:15, **7**:17, **8**:4
rooflights, plastic **11**:8, **11**:9
roofs: coverings **11**:8; fire safety **11**:8; forces acting on **6**:24–5; green **7**:14, **12**:9, **12**:13, **28**:17; sports facilities **38**:30–1; structural timbers **6**:8–9, **6**:12; tropical design **42**:31
roof trusses **6**:8–9, **6**:12, **6**:25, **8**:16
room pressurisation **26**:23
room sizes: hotel guestrooms **20**:7–9, **20**:11; housing **21**:2, **21**:3–4; older people's housing **22**:2, **22**:3; primary health care buildings **33**:10–11; student housing **23**:8, **23**:9–10; *see also* space standards
rostra **15**:11
rubber **7**:20
rugby **38**:2, **38**:23, **38**:32
running dimensions **1**:9

Sabine formula **10**:2
sacristies **32**:15
safety: community centres **17**:2; glass **7**:15, **7**:16; hotels **20**:5; laboratories **26**:2, **26**:17–20; lifts **3**:9; steps **3**:3; student housing **23**:13; windows **7**:26
safety curtains **15**:15, **15**:16
safety shower facilities **26**:20–1
sailing **38**:15, **38**:35
St Francis Church, Westborough **17**:2
St Hugh's College, Oxford **23**:9
St James's Church, Finchampstead **17**:2
St John's College, Oxford **23**:10
St Johns School, Blackpool **36**:9, **36**:10
Salvation Army **32**:5–6
sandstones **7**:17, **7**:19
sandstorms **42**:37
sanitary facilities: accessible facilities **2**:7, **2**:8, **2**:9–11, **4**:6, **18**:9, **21**:5; ambulance stations **18**:9; for children **2**:8, **2**:11, **4**:6, **17**:4; community centres **17**:4; crematoria **32**:23; hospitals **19**:2, **19**:4; hotel guestrooms **20**:11; industrial buildings **24**:9; mosques **32**:20; numbers required **2**:7, **2**:8; older people's housing **22**:3–4; police stations **18**:9, **18**:12; schools **2**:7, **2**:8, **36**:7, **36**:10, **36**:15; shopping centres **35**:10; single-family houses **21**:17; space standards **2**:7–13; sports facilities **38**:36, **38**:37, **38**:39; student housing **23**:8, **23**:12; tropics **42**:33; warehouses **25**:9, **25**:10
sanitary ware, materials **7**:15, **7**:17
SAS headquarters, Stockholm **30**:2, **30**:3
SBS *see* sick building syndrome (SBS)
scaffolding-type auditorium seating **15**:11
scales **1**:6–7; drawings **1**:2, **1**:3
scenery doors **40**:3
scenery workshops **15**:38–40
Scheme Development Standards (SDS) **21**:2
schools **36**:1–17; air infiltration rates **8**:10; design standards **36**:2–3; Early Years Foundation Stage **36**:6–7; environmental design **36**:3–5; fire safety **36**:6; foodservice facilities **34**:5; furniture **36**:5–6; laboratories **26**:1, **26**:9, **26**:10–11, **26**:15, **26**:16, **36**:13; National Curriculum **36**:1, **36**:8, **36**:10; outside areas **36**:10, **36**:12–13; parking **36**:9, **39**:15; permissible noise levels **10**:7; primary schools **36**:1, **36**:7–10, **39**:15; reverberation times **10**:16; sanitary facilities **2**:7, **2**:8, **36**:7, **36**:10, **36**:15; secondary schools **36**:10–15, **39**:15; security **36**:6; sound insulation **10**:9, **10**:11, **10**:12, **10**:13, **10**:17; Special Educational Needs **36**:15–17; sports facilities **38**:22; types **36**:1–2
'schools within schools' model **36**:11–12
science teaching **36**:13, **36**:14, **43**:5–6
scoreboards **38**:31, **38**:32, **38**:42–3
Scotland, housing standards **21**:8
Scottish Centre for Regenerative Medicine, University of Edinburgh **26**:23–5
Scottish Environment Protection Agency (SEPA) **12**:3
Scottish Housing Quality Standard (SHQS) **21**:8
screens: cinemas **15**:35–6; conference facilities **15**:30; sports facilities **38**:31, **38**:32, **38**:40, **38**:42–3; trading floors **30**:14–15
screen walling **42**:17, **42**:18
sealants **7**:24–5
search and scanning equipment **37**:13
seasonal energy use **8**:26, **8**:27
Seasons pizzeria, London **34**:19
seating: auditoria **15**:1–3, **15**:4, **15**:5–6, **15**:7, **15**:11; churches and meeting halls **32**:2, **32**:5–6, **32**:8, **32**:11, **32**:14; cinemas **15**:32; council chambers **16**:2, **16**:3; foodservice facilities **34**:4, **34**:5–7, **34**:8, **34**:9; older people's housing **22**:4; sports facilities **38**:27, **38**:28–9, **38**:30; synagogues **32**:17–18; *see also* chairs
secondary schools **36**:10–15, **39**:15
sections **6**:26–7
Secured by Design (SBD) **13**:1, **13**:2, **13**:5, **21**:13
security **37**:1–10; active frontages **28**:7; airports **41**:4, **41**:5, **41**:7, **41**:8, **41**:9; community centres **17**:3; counter terrorism **37**:1, **37**:3–10; crime prevention design **13**:1–5, **21**:13; gardens **21**:18; glass **7**:15, **7**:16; hardware **13**:5; hotels **20**:5; laboratories **26**:2; museums **29**:6; payment offices **31**:2, **31**:3, **31**:6; risk register **37**:11; schools **36**:6; sports facilities **38**:39, **38**:43; standards **37**:3, **37**:12–13; student housing **23**:13; surveillance **13**:2–3, **21**:18, **28**:7, **37**:2–3; tropics **42**:11; universities **43**:11; warehouses **25**:10
self-cleaning glass **7**:16
self-service foodservices: cafeterias **34**:2, **34**:16–17, **34**:19, **34**:20, **34**:21–2, **34**:24; serveries **34**:12, **34**:20, **34**:21; space allowances **34**:5
SEN *see* Special Educational Needs (SEN)
serveries **34**:11, **34**:12, **34**:15, **34**:20, **34**:21
serviceability limit states **6**:1
service lifts **20**:4
services: access **2**:6–7; broadcasting studios **40**:2–3; distribution systems **8**:25, **8**:26, **26**:22–3, **30**:11, **30**:14; fire safety **11**:18; fire stations **18**:4; flats **21**:20; hotels **20**:3, **20**:6, **20**:9, **20**:13–14; industrial buildings **24**:8; laboratories **26**:5, **26**:6–7, **26**:8, **26**:21–3; masterplanning **28**:6; museums **29**:6–7; offices **30**:7,

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

30:9–10, **30**:11, **30**:14; primary health care buildings **33**:11, **33**:12; shopping centres **35**:10, **35**:11; site analysis **28**:3; stables **14**:20; student housing **23**:10–11; synagogues **32**:18–19; tropics **42**:8–9, **42**:32–3; universities **43**:3, **43**:8
sewage management **28**:16–17, **28**:19, **42**:33
sewer flooding **12**:2
shade houses **42**:24
shading **8**:19, **27**:12, **27**:19, **42**:14–20, **43**:2
shading coefficients **42**:34
shared space **39**:6, **39**:19–21, **39**:22, **39**:24
Sharing of Churches Act **32**:1
shear forces **6**:6, **6**:12
sheaves **3**:9
sheep housing **14**:7–8
sheep's wool **7**:24
sheet metal roofing **7**:11–13
sheltered areas, external **8**:14–15
sheltered housing **21**:22, **22**:1–4, **39**:14
shelving: foodservice facilities **34**:8–9, **34**:10; shops **35**:3, **35**:4
Sheraton Muscat Hotel **34**:18
Sherway gardens, Toronto **35**:10
shock tubes **37**:8
shopping centres **11**:13, **34**:2, **34**:19, **35**:4, **35**:8–14
shops **35**:3–8; air infiltration rates **8**:10; auditoria **15**:38; department stores **35**:6; escape routes **11**:16, **35**:6; farm **14**:20; parking **39**:14; small **35**:5–6; sports facilities **38**:40; supermarkets **25**:9, **35**:4, **35**:5, **35**:6–8; universities **43**:9–10; *see also* retail
short-bored piles **6**:16, **6**:17
showers **2**:10, **17**:4, **22**:3–4, **23**:12
shutters **11**:20, **42**:17, **42**:31
sick building syndrome (SBS) **8**:10
sidestitial service zones **26**:6, **26**:7, **26**:8
sightlines: auditoria **15**:1, **15**:4–8, **15**:15, **15**:24, **15**:32, **15**:34; sports facilities **38**:26–7, **38**:28, **38**:30
signage: auditoria **15**:38; escape routes **11**:17; hotels **20**:3; masterplanning **28**:5
Sikh gurdwara **32**:20–1, **32**:22
silencers, laboratories **26**:23
silicones, structural **37**:7–8
silos **14**:13
single-family houses **21**:14–18
single person accommodation **21**:21–3
single-ply roofing systems **7**:14
site analysis **28**:3, **42**:7–8
site loading scenarios **28**:7
site planning **28**:8–9; and climate **8**:11–15; hotels **20**:1–2, **20**:6; skylight and sunlight **9**:1–3; tropics **42**:6–8, **42**:23
sitting dimensions **2**:2–5
sitting work spaces **2**:5
skating **38**:16–17
skin-friction piles **6**:16–17
skylight **9**:1–3, **42**:35
skylight indicators **9**:2, **9**:11
sky lobbies **3**:11
slate **7**:18
slatted yards **14**:6
slide projectors **15**:30–1
sliding doors **3**:3
slope-dependent access **28**:5
slurry storage **14**:14
smoke **11**:1, **11**:2; control **11**:8, **11**:18, **21**:18, **35**:10, **35**:11
smoke detectors **11**:21, **15**:12
smoke reservoirs **11**:4, **35**:6, **35**:10, **35**:11
snack bars **34**:16
snooker **38**:20
soakaways **12**:9
soccer **38**:2, **38**:3
social housing **21**:1–2
social value **5**:1
Society of Friends **32**:7–8
soil **6**:15, **42**:7
soil decontamination **28**:14
sol-air temperature **8**:12, **8**:27, **42**:34
solar control glass **42**:17, **42**:18, **42**:35–6
solar dazzle **42**:7
solar declinations **9**:4
solar flues **42**:23
solar gain **8**:19, **8**:26, **8**:27, **8**:29, **9**:7, **36**:4; housing **21**:14; solar heat factors **42**:34; through glass **42**:36; universities **43**:2, **43**:3, **43**:13
solar geometry **9**:3
solar heat factors **42**:34
solar power **28**:16, **36**:5, **42**:28, **42**:29, **43**:13
solar radiation **8**:5, **8**:11, **9**:1–5, **42**:34–5
solar screening **8**:19, **27**:12, **27**:19, **42**:14–20, **43**:2
solar-shading analysis **28**:7
solar water heating **28**:16, **36**:5, **42**:32, **43**:3
sound *see* acoustics; noise
sound control rooms **15**:20, **15**:30
sound insulation **10**:8–15; auditoria **15**:12; broadcasting studios **40**:3, **40**:4; community centres **17**:3; flats **21**:18–19; glazing **7**:15, **7**:16, **10**:4, **10**:5; hotels **10**:9, **20**:4; plasterboard **7**:22
sound studios **10**:13, **15**:40, **40**:1–4
sound systems: induction loop systems **15**:3, **15**:35, **15**:40, **32**:14, **32**:18–19; places of worship **32**:14–15, **32**:18–19
sound transmission **10**:1–2; absorption coefficients **10**:2, **10**:3; external sources **10**:3–5; and interior design **10**:5; reducing **10**:3–6; reverberation times **10**:2–3, **10**:15, **10**:16–17, **40**:3; through structure **10**:5–6
space budget, offices **30**:6–7
Space Management Group (SMG) **43**:13, **43**:14
space standards: domestic **2**:13; ergonomics **2**:5–7; furniture **21**:7; housing **21**:2, **21**:3–4; kitchens **2**:5–6; libraries **27**:11–12, **43**:14; older people's housing **22**:2, **22**:3; personal **2**:2; sanitary facilities **2**:7–13; schools **36**:2, **36**:7, **36**:11, **36**:15; student housing **23**:8; universities **43**:13–15; *see also* dimensions; room sizes
spandrel construction **7**:28
Special Educational Needs (SEN) **36**:15–17
special schools **36**:15, **39**:15
speech therapy **19**:16
speed humps **39**:7, **39**:8
speed restriction design **39**:6–7, **39**:8, **39**:9, **39**:19–21
speed skating **38**:16–17
split ridges **42**:15, **42**:19
sports facilities **38**:1–50; air infiltration rates **8**:10; case study **38**:45–50; community centres **17**:1, **17**:4; competitors and officials areas **38**:32–3, **38**:36–8; equipment **38**:31–2, **38**:33, **38**:34–6, **38**:43; fields of play **38**:1–25; floodlights **38**:24–5; management areas **38**:42–3; masterplanning **28**:15; media areas **38**:40–2; orientation **38**:24; parking **38**:38, **39**:15; pitch technology **38**:24; playing surfaces **38**:23–4; scales of **38**:43–4; schools **36**:11, **36**:12–13; sightlines **38**:26–7, **38**:28, **38**:30; spectator facilities **38**:38–40; universities **43**:10; vertical clearances **38**:25–6; viewing structures **38**:26–31, **38**:32
sprinkler systems **11**:3–4, **11**:21; auditoria **15**:12; department stores **35**:6; flats **21**:18; hospitals **19**:7; hotels **20**:4, **20**:5; industrial buildings **24**:8; warehouses **25**:12
square hollow sections (SHS) **6**:26, **7**:3
squash courts **38**:11, **38**:23, **38**:25
stables **14**:12, **14**:15, **14**:16–20
stack effect **8**:24
staff facilities: bus and coach stations **41**:26; schools **36**:10, **36**:15; universities **43**:9
stages, auditoria **15**:5, **15**:6, **15**:13–17, **15**:18–19, **15**:36
stainless steel **7**:5, **7**:12

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

staircases **3**:2–3, **3**:5–7, **4**:6; accessible standards **21**:5; auditoria **15**:9; design **11**:15–16; escape routes **11**:15–16; external **11**:16; flats **21**:18; guarding **3**:7; handrails **3**:2–3, **3**:6, **3**:7, **4**:6; hotels **20**:3–4, **20**:5; housing **21**:14; pitch **3**:2, **3**:5; single-family houses **21**:17–18; student housing **23**:3; widths **3**:5, **3**:7; *see also* steps
stairlifts **3**:9, **3**:10
stanchions **6**:5
standard busy rate (SBR) **41**:1
standard deviation (SD) **2**:2
Standard Method of Measurement (SMM) **5**:3, **30**:3, **30**:6–7
Standard Overcast Sky **9**:5
standards: housing **21**:1–14; laboratories **26**:27–9; security **37**:3, **37**:12–13; student housing **23**:7–9
standby power, laboratories **26**:21
standing dimensions **2**:2–5
standing work spaces **2**:5–6
state maintained schools **36**:1
static wind pressure **8**:13
steel **7**:1–5; bars **7**:1, **7**:2, **7**:3; coated **7**:5; dimensions **7**:1–5; earthquake zones **42**:32; embodied energy **8**:3; fire resistance **11**:19; hot-dip galvanized **7**:5; properties **6**:6, **6**:13; reinforcement **6**:11–12, **7**:5; roofing **7**:12; sheet **7**:1; stainless **7**:5, **7**:12; structural **6**:13, **6**:14–15, **7**:1–2, **7**:3–4; tropics **42**:29, **42**:30; U-values **8**:16; weather-resistant **7**:2, **7**:5; windows **7**:26
Steel Corporation Offices, Sri Lanka **42**:2
steering groups **43**:16, **43**:17
Stefan-Boltzmann law **8**:5
steps **3**:2–3, **4**:5, **4**:6, **21**:5; *see also* staircases
stick construction **7**:28
stiffness **10**:6
stone **7**:17–19
stopping distances **39**:9
storage **21**:12; agricultural **14**:1, **14**:13–15; ambulance stations **18**:9; auditoria **15**:21, **15**:39; community centres **17**:4; foodservice facilities **34**:8–9, **34**:10; laboratories **26**:16–17; museums **29**:2, **29**:3; older people's housing **22**:4; public houses **34**:23–4, **34**:26; Salvation Army halls **32**:5–6; single-family houses **21**:17; single person accommodation **21**:23; space standards **2**:6; sports facilities **38**:43; universities **43**:11; warehouses **8**:10, **25**:1–12, **39**:14
stores *see* shops
stormwater management **28**:17; Sustainable Drainage Systems (SuDS) **7**:14, **12**:9–10, **12**:13, **12**:14; tropics **42**:11, **42**:33
strain **6**:3, **6**:5
straw-covered yards **14**:6, **14**:7
street furniture **39**:22
streets/roads **28**:12, **39**:1–25; case study **39**:22–5; cycle lanes/paths **39**:6, **39**:10–12; design details **39**:9–10, **39**:11; place-making **39**:22; residential **39**:6–7; shared space **39**:6, **39**:19–21, **39**:22, **39**:24; speed restriction design **39**:6–7, **39**:8, **39**:9, **39**:19–21; tropics **42**:24, **42**:28; vehicles **39**:1–5; widths **39**:5–6, **39**:7; *see also* car parking
stress **6**:3, **6**:5, **6**:6
strip foundations **6**:15, **6**:16
structural grids **1**:9–10, **26**:5, **30**:9
structural sections **6**:26; aluminium **7**:10–11; steel **7**:1–2, **7**:3–4
structural silicones **37**:7–8
structure **6**:1–27; blast loading **37**:5–7; earthquake zones **42**:31–2; foundations **6**:15–17; laboratories **26**:5–6; materials **6**:6–15; offices **30**:7; robustness **37**:6–7; sound transmission **10**:5–6; theory **6**:1–6; thumb-nails **6**:17–27; tropical design **42**:29–32
struts **6**:5, **6**:21
student housing **23**:1–13, **43**:10
student support facilities **43**:8–9
student union buildings **43**:8–9
studio rooms, student housing **23**:10, **23**:11
studios: recording **10**:13, **15**:40, **40**:1–4; rehearsal **15**:38, **15**:39
studio theatres **15**:23
study bedrooms **23**:3, **23**:4, **23**:9–11
sunken track (cutting) stations **41**:18
sunlight **9**:1–5, **42**:35
sunlight availability indicators **9**:2, **9**:3, **9**:12
sun-on-ground indicators **9**:4, **9**:12
sunpath indicators **9**:4, **9**:12, **42**:33
sunpipes **42**:15, **42**:17, **42**:19
supermarkets **25**:9, **35**:4, **35**:5, **35**:6–8
superstores **35**:7–8
Supplementary Planning Documents (SPDs) **21**:4, **21**:26
supply chain **30**:3
Sure Start Children's Centres **36**:6, **36**:7
surface condensation **8**:20–2
surface-modified glasses **42**:36
surfaces: corridors **3**:4; lobbies **3**:4; ramps **3**:1; steps **3**:3
surface temperatures **8**:20
surgical facilities **19**:8–9, **19**:11, **19**:15
surveillance **13**:2–3, **21**:18, **28**:7, **37**:2–3, **37**:12
sustainability **12**:5, **28**:2; Code for Sustainable Homes (CforSH) **10**:10–11, **21**:13, **21**:27; and health **28**:10–12; housing **21**:27; laboratories **26**:2, **26**:24–5, **26**:29; libraries **27**:19; low carbon design **8**:32–3, **36**:3–5; masterplanning **28**:14–19; Passive Haus **8**:32, **8**:33; primary health care buildings **33**:1, **33**:16, **33**:17, **33**:19; renewable energy **8**:33, **28**:16, **36**:5, **42**:28–9, **43**:13; schools **36**:3–5; student housing **23**:2; tropics **42**:9; universities **43**:2–3, **43**:12–13; zero carbon buildings **8**:33
Sustainable Development Commission **36**:3–4
Sustainable Drainage Systems (SuDS) **7**:14, **12**:9–10, **12**:13, **12**:14
swales **12**:9, **12**:13
swimming pools **8**:10, **38**:12–14, **39**:15, **42**:33
switches, light **9**:9
synagogues **32**:16–19

tabernacles **32**:12, **32**:13, **32**:14
tables: auditoria **15**:3; communion **32**:2, **32**:4, **32**:6, **32**:8, **32**:11; credence **32**:10; foodservice facilities **34**:4, **34**:5–7, **34**:8, **34**:9; older people's housing **22**:4; panel **15**:28
table tennis **38**:19, **38**:33
tableware **34**:18
tack rooms **14**:18
take-aways **34**:1, **34**:2, **34**:5, **34**:19–20, **34**:24
tapered flange channels **7**:4
taps **22**:3
teaching laboratories **26**:1, **26**:9, **26**:10–11
team sports *see* pitch sports
team technology methods **24**:5
technical design **1**:3
technology: pitch **38**:24; tropics **42**:9; *see also* information technology
technology teaching **36**:13
television viewing facilities **15**:10, **15**:31
temperature: air **8**:7, **8**:11–12; corrected effective (CET) **8**:9; dewpoint **8**:20, **8**:22; environmental **8**:27; industrial buildings **24**:8; laboratories **26**:23; libraries **27**:12; museums **29**:4, **29**:5, **29**:6; radiant **8**:7; resultant **8**:9, **8**:27; shops **35**:4; sol-air **8**:12, **8**:27, **42**:34; stables **14**:18; surface **8**:20; thermal comfort **8**:1, **8**:7–10, **42**:3–4; urban centres **42**:24
temporary bench marks (TBMs) **1**:11
temporary exhibition spaces **29**:2, **29**:5
tenant efficiency **30**:8, **30**:9
tennis **38**:11, **38**:23, **38**:24, **38**:26, **38**:27, **38**:35
tensile fabric roof structures **7**:14
tensile stresses **6**:5, **6**:11–12, **6**:20–1
termites **42**:10
terraced houses **21**:15–16
terraces, hotels **20**:9, **20**:10
terracotta **7**:17

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

terrorism *see* counter terrorism
theatre-in the-round auditoria **15**:5, **15**:9, **15**:14, **15**:19, **15**:20
Theatre Royal, Plymouth **15**:17
theatres **15**:12–23; acoustics **10**:17; control rooms **15**:20–1; dressing rooms **15**:21–3; lighting **15**:19–20; parking **39**:15; permissible noise levels **10**:8; sanitary facilities **2**:8; stages **15**:13–17, **15**:18–19; studio **15**:23
thermal bridging **8**:17–18, **8**:20
thermal capacity **8**:6–7
thermal comfort **8**:1, **8**:7–10, **42**:3–4; *see also* temperature
thermal conductivity **7**:23, **8**:3–4, **8**:15, **8**:17
thermal design **8**:1–2; climate **8**:11–15; condensation **8**:19–22; glass and glazing **7**:15, **7**:16, **8**:18–19, **8**:20; low carbon design **8**:32–3, **36**:3–5; Passive Haus **8**:32, **8**:33; prediction and measurement techniques **8**:33–5; thermal bridging **8**:17–18, **8**:20; thermal insulation **8**:17, **8**:18; U-values **8**:15–17, **8**:18–19, **8**:20, **8**:32, **8**:35, **42**:34; ventilation **8**:22–5; zero carbon buildings **8**:33; *see also* heating; mechanical ventilation systems
thermal mass **8**:6–7; libraries **27**:12; schools **36**:4; trombe walls **42**:23; universities **43**:2
thermal resistance **8**:3, **8**:4, **8**:15
thermal response **8**:6–7
thermal transmittance **8**:17–18
thermographic surveys **8**:34–5
thermoplastics **7**:19, **7**:20, **7**:21, **11**:20
thermo-reflective insulation **7**:24
thermosetting plastics **7**:19–20, **7**:21, **11**:20
thousand marker **1**:2
ticket desks **31**:2, **31**:4
ticketing, sports facilities **38**:39
ties **6**:5, **6**:9, **6**:21, **6**:24–5
tile adhesives **7**:25
tiles **7**:10, **7**:15, **7**:17, **8**:4
TIM *see* transparent insulation material (TIM)
timber **7**:5–8; density **8**:4; earthquake zones **42**:32; embodied energy **8**:3; fire resistance **11**:19; hardwoods **7**:6; products **7**:6–8; properties **6**:6; softwoods **7**:6; strength classes **7**:5, **7**:6; structural **6**:7–9, **6**:10, **6**:11, **6**:12, **7**:5; thermal conductivity **8**:4; tropics **42**:29, **42**:30; use classes **7**:6, **7**:7; U-values **8**:16; windows **7**:26, **7**:27
timber frame **6**:8, **6**:11, **6**:12, **8**:16, **42**:30, **42**:32
time lag **42**:37
time switching **9**:9
tin **7**:5
titanium **7**:13
toilet facilities *see* sanitary facilities; WCs
tooled stone finishes **7**:18
Torah scrolls **32**:16, **32**:17
Total Cost Indicators (TCIs) **21**:2
total evacuation **11**:14, **11**:15
toughened glass **6**:13, **7**:16
tourist accommodation **20**:1; *see also* hotels
Town and Country Planning Act (1990) **14**:20, **23**:7
town halls **16**:1–7
track sports **38**:1, **38**:6–9, **38**:23, **38**:34–5
traction lifts **3**:9–11
trading floors **30**:14–16
training facilities, fire stations **18**:3–4, **18**:6–7
trampolines **38**:18
trams **41**:26, **41**:28
translators' booths **15**:28–9
transparent insulation material (TIM) **8**:19, **8**:20
transport *see* bicycles; public transport; vehicles
transport terminals and interchanges: bus and coach stations **8**:10, **41**:22–8; railway stations **8**:10, **41**:16–22; *see also* airports
Travelodge, Southwark **20**:14–16
treadmills **38**:32
trees **28**:3, **42**:16
trellises **42**:16
triangulation **6**:20–1
trip hazards **3**:3, **4**:5–6
trolleys, hospital **19**:9
trombe walls **42**:23
tropical design **42**:1–38; active design **42**:28–9; building science data **42**:33–7; climate types **42**:11–14; factors affecting **42**:1–11; passive design **42**:14–28; services **42**:32–3; structural **42**:29–32
tropical diseases **42**:9, **42**:11
turbines, wind **42**:29
turnbuckle locks **11**:18
turning circles **11**:5, **11**:6, **18**:2, **18**:11, **25**:11, **39**:4–5, **41**:23–4
turn-round areas **39**:10, **39**:11
turnstiles **38**:39
TV broadcasting, sports facilities **38**:40–2
TV production studios **40**:1–4; *see also* broadcasting studios
Tyrone Guthrie Theatre, Minneapolis **15**:18

ultraviolet detectors **11**:21
under-reamed piles **6**:17
uninterrupted power supply (UPS) **18**:12
Uninterruptible Power Supply (UPS) **26**:21
United Reformed Church (URC) **32**:4–5
unitised construction **7**:28
units **1**:1–2
universal beams **6**:26, **7**:3
universal bearing piles **7**:3
universal columns **6**:26, **7**:3
universal design **2**:1
universities **43**:1–17; briefing process **43**:11, **43**:15–17; circulation areas **43**:2, **43**:4; incubators **43**:8; laboratories **26**:1, **26**:9, **26**:11, **26**:16, **26**:23–6, **43**:5–6, **43**:14; libraries **27**:1, **27**:2, **27**:4, **27**:7, **27**:8–9, **27**:10–11, **27**:12, **43**:4–5, **43**:14; offices **43**:10–11, **43**:14; space standards **43**:13–15; sports facilities **43**:10; student housing **23**:1–13, **43**:10; support facilities **43**:8–10; sustainability **43**:2–3, **43**:12–13; teaching spaces **43**:3–8, **43**:14, **43**:15; types **43**:1–2; virtual campus **43**:11–12
University Grants Committee (UGC) **43**:13
University of Birmingham **43**:2
University of Bournemouth **23**:5
University of East Anglia **23**:4
University of Edinburgh **26**:23–5
University of Warwick **23**:6
upholstery **15**:2, **15**:3
UPS *see* Uninterruptible Power Supply (UPS)
urban design: libraries **27**:4, **27**:14; tropics **42**:24, **42**:28
Urban Task Force **28**:1, **28**:3
urban universities **43**:1–2
urinals **2**:8, **2**:13, **38**:39
U-values **8**:15–17, **8**:18–19, **8**:20, **8**:32, **8**:35, **42**:34

value **5**:1–2
value management **5**:2
vaporising liquid installations **11**:21
vapour pressure **8**:22
vapour resistance **8**:22
variable air volume (VAV) **8**:30
variety stores **35**:6
varnishes **7**:26
vehicle-borne improvised explosive devices (VBIEDs) **37**:4, **37**:5, **37**:6–7, **37**:8, **37**:10
vehicles **39**:1–5, **41**:23; *see also* fire appliances
vehicle workshops: ambulance stations **18**:8; bus and coach stations **41**:26; police stations **18**:11
velodromes **38**:6, **38**:23
vending machines **38**:39

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

vented ridges **42**:20
ventilation **8**:22–5; air change rates **8**:10, **26**:23; air infiltration **8**:10, **8**:22–3; auditoria **15**:2, **15**:12; and condensation **8**:21; courtrooms **16**:10; effectiveness and efficiency **8**:23; fire safety **11**:4, **20**:4; flats **21**:18; heat loss **8**:23–4, **8**:26, **8**:27; hybrid systems **8**:31–2; industrial buildings **24**:8; laboratories **26**:9, **26**:17, **26**:23; libraries **27**:12, **27**:13, **27**:14, **27**:15; models **8**:33–4; offices **30**:9–10; police custody suites **18**:14; schools **36**:4; shops **35**:4; student housing **23**:8, **23**:11, **23**:12; synagogues **32**:18; tropics **42**:29; universities **43**:2–3, **43**:8; wind effect **8**:14, **8**:24, **30**:9
verandas **42**:19, **42**:20
verges, road **39**:10
vertical sky component **9**:1, **9**:2
vertical support elements: masonry **6**:7, **6**:8; timber **6**:11
very sheltered housing (VSH) **22**:1–4
vestries **32**:15, **32**:19
veterinary boxes **14**:18
vibration: broadcasting studios **40**:3; laboratories **26**:6, **26**:7, **26**:15
victim examination suites, police stations **18**:9, **18**:10
Victoria and Albert Museum, London **29**:7–8
video projection facilities **15**:31
video screens, sports facilities **38**:31, **38**:32, **38**:40, **38**:42–3
viewing distances, sports facilities **38**:27
visibility, roads **39**:9
vision statements **43**:16, **43**:17
visual display terminals (VDTs) **9**:10, **30**:14–15
visual impairments **4**:4, **15**:35, **15**:40, **23**:9
visual massing envelopes **28**:6
visual narrowing **39**:20–1
volleyball **38**:10, **38**:25, **38**:35
vomitories, auditoria **15**:9, **15**:10
Vosper site, Southampton **28**:8
voting panels **15**:31
vulnerability to flooding **12**:4

wagon stages **15**:15
Wales, housing standards **21**:8
walking **4**:5, **27**:4, **28**:4, **28**:12, **36**:8–9, **39**:22
walkways, moving **3**:8–9
walls: crime prevention design **13**:3, **21**:18; fire safety **11**:7, **11**:8; masonry **6**:7; security **37**:12; stables **14**:19; stone **7**:19; thermal resistance **8**:4, **8**:15; timber panels **6**:11; U-values **8**:15–17
wall tiles **7**:15
wall to floor ratio **5**:3, **43**:2
wardrobe departments **15**:40
wards, hospital **19**:2–3, **19**:4, **19**:10–11, **19**:13–14, **19**:18–19
warehouses **8**:10, **25**:1–12, **39**:14
washbasins **2**:8, **2**:12, **2**:13; hospitals **19**:7; hotels **20**:11; older people's housing **22**:3; police custody suites **18**:12; sports facilities **38**:39; student housing **23**:3, **23**:8, **23**:10; *see also* hand washing facilities
washing facilities, mosques **32**:20
waste management **28**:17–18, **28**:19, **38**:43, **43**:11; *see also* refuse storage
wastewater treatment **28**:17
water drenchers **11**:21
water energy **42**:28
water management: masterplanning **28**:16–17, **28**:19; Sustainable Drainage Systems (SuDS) **7**:14, **12**:9–10, **12**:13, **12**:14; tropics **42**:11, **42**:33; universities **43**:3, **43**:13; *see also* flood-aware design
water polo **38**:14
Water Sensitive Urban Design (WSUD) **12**:10
water sports **38**:15–16, **38**:35
water spray projector systems **11**:21
waterstop seals **7**:25
water supply, tropics **42**:7, **42**:32
water vapour **8**:20
WCs **2**:8; accessible facilities **2**:8, **2**:9–11, **4**:6, **21**:5; for children **2**:8, **2**:11, **4**:6, **17**:4; compartments and cubicles **2**:11–12; police stations **18**:12; schools **36**:10, **36**:15; single-family houses **21**:17; sports facilities **38**:39; student housing **23**:8, **23**:12
weight **6**:2–3
welt joins **7**:13
West Yorkshire Playhouse, Leeds **15**:18, **15**:39
wet laboratories **26**:1, **26**:9, **43**:5
wet proofing **12**:7–9
wheelchair access **4**:1; ATMs and ATM lobbies **31**:5, **31**:7; auditoria **15**:8, **15**:9, **15**:35, **15**:40; dimensions **4**:2–4, **4**:5; doors **3**:3; housing **21**:3, **21**:8, **21**:12; libraries **27**:6; lifts **3**:9, **3**:10; lobbies **3**:4; older people's housing **22**:1; payment counters **31**:6, **31**:9; sanitary facilities **2**:7, **2**:9–11, **18**:9; sports facilities **38**:29, **38**:30, **38**:39; student housing **23**:9, **23**:11, **23**:12
Wheelchair Housing Design Guide **21**:8, **21**:12
wheelie-bins **21**:18
White Collar Factory, London **30**:5
whole life costs **5**:6–7
Wi-Fi **16**:4, **23**:11, **23**:12
wildlife **7**:14
Willowbrook Mall, New Jersey **35**:9
wind **8**:12–15, **42**:36–7
wind catchers **42**:22
wind effect ventilation **8**:14, **8**:24, **30**:9
wind energy **36**:5, **42**:28, **42**:29
Window Energy Ratings (WERs) **7**:26–7
windows: crime prevention design **13**:2–3; materials **7**:26–7; natural lighting **9**:6–8; police custody suites **18**:13; sound insulation **10**:4, **10**:5; stables **14**:20; U-values **8**:18–19; *see also* glass and glazing
wind roses **8**:13
wind towers **42**:22–3
wind tunnel modelling **8**:34
wired services, auditoria **15**:3
wood *see* timber
wood adhesives **7**:26
wood-boring insects **42**:10
wood-cored joins **7**:13
wood fibre insulation **7**:23
wood particleboard **7**:7, **7**:8
wood stains **7**:26
wood wool slabs **7**:22, **8**:4
working spaces **2**:5–7
workplace-based learning **43**:12
workshops: ambulance stations **18**:8; auditoria **15**:38–40; bus and coach stations **41**:26; police stations **18**:11
work surface heights **2**:5–6, **21**:14, **22**:4, **34**:9
writing boards **15**:29
writing surfaces, auditoria **15**:3

X-ray facilities **19**:7, **19**:9–10, **19**:12, **19**:13
X-ray plaster **7**:22

young people: housing **23**:1–13, **43**:10; *see also* children
Young's Modulus **6**:5

zero carbon buildings **8**:33
zinc **7**:5, **7**:13
zoning: banks **31**:2–3; government services outlets **31**:5, **31**:6; learning centres **43**:4–5; libraries **27**:5–6; museums **29**:2, **29**:6; primary health care buildings **33**:12

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Licensed copy from CIS: smu, University of Wales Trinity Saint David, 27/11/2020, Uncontrolled Copy.

Taylor & Francis eBooks

eBooks
from Taylor & Francis
Helping you to choose the right eBooks for your Library

Add to your library's digital collection today with Taylor & Francis eBooks. We have over 50,000 eBooks in the Humanities, Social Sciences, Behavioural Sciences, Built Environment and Law, from leading imprints, including Routledge, Focal Press and Psychology Press.

Choose from a range of subject packages or create your own!

Benefits for you

- Free MARC records
- COUNTER-compliant usage statistics
- Flexible purchase and pricing options
- 70% approx of our eBooks are now DRM-free.

Benefits for your user

- Off-site, anytime access via Athens or referring URL
- Print or copy pages or chapters
- Full content search
- Bookmark, highlight and annotate text
- Access to thousands of pages of quality research at the click of a button.

ORDER YOUR FREE INSTITUTIONAL TRIAL TODAY

Free Trials Available

We offer free trials to qualifying academic, corporate and government customers.

eCollections

Choose from 20 different subject eCollections, including:

- Asian Studies
- Economics
- Health Studies
- Law
- Middle East Studies

eFocus

We have 16 cutting-edge interdisciplinary collections, including:

- Development Studies
- The Environment
- Islam
- Korea
- Urban Studies

For more information, pricing enquiries or to order a free trial, please contact your local sales team:

UK/Rest of World: **online.sales@tandf.co.uk**
USA/Canada/Latin America: **e-reference@taylorandfrancis.com**
East/Southeast Asia: **martin.jack@tandf.com.sg**
India: **journalsales@tandfindia.com**

www.tandfebooks.com