



DESIGN GUIDE

B a s e m e n t w a t e r p r o o f i n g

Foreword

This publication is one of a series related to basements for housing. It has been produced under the direction of the Basement Development Group, which was initiated and is co-sponsored by the British Cement Association.

Acknowledgments

The British Cement Association (BCA) is grateful to the British Structural Waterproofing Association (BSWA) for co-sponsoring this publication. It is also grateful for the assistance and comments provided by members of the Basement Development Group and for the considerable work of its Waterproofing Task Group in drafting and progressing this publication. Particular thanks go to Maria Hudlass and Steven Edwards of Servicised for the production of the figures. Thanks are also extended to all others who provided input to and comments on the preparatory drafts.

Basement Development Group

B Aspin (Chairman), House Builders Federation
A K Tovey (Secretary), Tecnicom
F Atkins, National Housebuilding Council
D Burke, Zurich Municipal
M A Clarke, British Cement Association
P Hart, Institute of Building Control
D James, Bovis Homes South West
A Jones, Stewart Milne Group Limited
B Keyworth, Architect
R S Reynolds, Institute of Clerks of Works
G R Sharpe, Association of Building Engineers
P Trotman, Building Research Establishment

Waterproofing Task Group

A K Tovey (Chairman), Tecnicom
S Brown, Sika Limited
V Connolly, Renlon Limited
M Falla, Booth Engineering Services Limited
Z Ginai, Marley Waterproofing Limited
P Hewitt, Vandex UK Limited
T Holloway, Renlon Limited
M Lenaghan, Servicised Limited
I J Moffat, Fosroc Expandite Limited
J A M Padley-Smith, Mastic Asphalt Council and
Employers Federation Limited
A J Parker, SCL Group Limited
M Radford, RIW Limited

Supporting Trade Groups

Autoclaved Aerated Concrete Products Association
British Structural Waterproofing Association
Concrete Block Association
Mortar Producers Association
Ready-mixed Concrete Bureau

48.058

First published 1994

ISBN 0 7210 1475 5

Price group D

© British Cement Association 1994

Published by

British Cement Association

Century House, Telford Avenue

Crowthorne, Berks RG11 6YS

Telephone (0344) 762676

Fax (0344) 761214

From April 1995 the code will be (01344)

All advice or information from the British Cement Association is intended for those who will evaluate the significance and limitations of its contents and take responsibility for its use and application. No liability (including that for negligence) for any loss resulting from such advice or information is accepted. Readers should not that all BCA publications are subject to revision from time to time and should therefore ensure that they are in possession of the latest version.

C o n t e n t s		
Introduction		2
Scope		
Design principles		2
Basement usage		2
Site information		2
Deciding on form of construction		3
Forms of construction		
Factors affecting choice of construction		
Characteristics of construction forms		
Suitability of construction forms		
Form and characteristics of waterproofing systems		5
Category 1: Bonded sheet membranes		
Category 2: Cavity drain membranes		
Category 3: Bentonite clay active membranes		
Category 4: Liquid-applied membranes		
Category 5: Mastic asphalt membranes		
Category 6: Cementitious crystallization active Systems		
Category 7: Proprietary cementitious multi-coat renders, toppings and coatings		
Ancillary materials		7
Waterstops		
Bandage joint systems		
Membrane protection products		
Other design considerations		7
Thermal insulation		
Condensation		
Vapour control		
Chemical barrier		
System restraint		
Substrate movement		
Expansion joints		
Defects and repair		
Site investigations		8
Groundwater		
Soil type and conditions		
Movement risks likely to affect basements		
Construction options		10
Basement site locations and forms		
Design factors affecting construction		
Waterproofing details		13
Details of waterproofing options and forms of construction		
Selection procedure		17
Guide to assessing basement designs		
Assessing risk		
Glossary		18
References		19
Other publications relating to basement structures		

Introduction

Basements provide an opportunity for the builder to achieve a good return on his outlay, and his customer to benefit by being offered houses with greater potential⁽¹⁾. Including a basement maximises available land space, provides more stable construction, is thermally efficient and offers ideal quiet areas and further space for storage or accommodation. Basements can be economically introduced onto most sites and, in particular, have clear advantages on sites with poor ground that may otherwise be regarded as difficult and possibly uneconomic to build on. This publication is intended to help the builder or designer arrive at the most appropriate form of construction and waterproofing solution.

A companion publication, *Basement waterproofing: Site guide*⁽²⁾ provides advice on the application or installation of the various waterproofing systems, and comments on other associated construction matters.

Scope

The details and comments given in this publication are limited to Grade 2 and 3 internal environments, as defined in BS 8102, which are appropriate for residential basements.

The Grade 2 environment is for use as workshops and plant rooms, and other areas where the performance level permits no water penetration, but higher levels of water vapour would be tolerable and surface condensation may occur.

The Grade 3 environment is for ventilated residential and working areas which require a drier environment.

Design principles

The specification of waterproofing systems is a specialised task. It is recommended that, once the design team has given the system some thought, the manufacturers of the systems under consideration are contacted immediately for early advice and help on the waterproofing design. The British Structural Waterproofing Association can provide details of manufacturers of the different generic waterproofing systems and of appropriate specialist waterproofing contractors.

Choosing a suitable basement construction may be divided into four main steps:

- ✿ Decide on basement usage
- ✿ Gather site information
- ✿ Decide on form of construction
- ✿ Decide on form of waterproofing

These and other factors needing consideration are shown in the flow chart in *Figure 1*.

Basement usage

Table 1 of BS 8102 relates environmental performance levels to basement usage, and defines them in Grades 1 to 4. Most basements will be for domestic accommodation, which is Grade 3. Some basements may be for permanent workshops or garages, and a Grade 2 environment would be acceptable. However, since usage may change, it is better to construct a basement to a

Grade 3 environment than to upgrade it later. Certain forms of construction and waterproofing may lend themselves to upgrading more readily than others (see *Construction options* on page 10).

It is unlikely that a Grade 4 environment would be required in a domestic situation. If it did become necessary, a Grade 1 environment may be upgraded to Grade 2 by introducing a drained cavity system or internal waterproofing. A basement performing to Grade 2 can be upgraded to Grade 3 or 4 by incorporating additional ventilation and/or dehumidification.

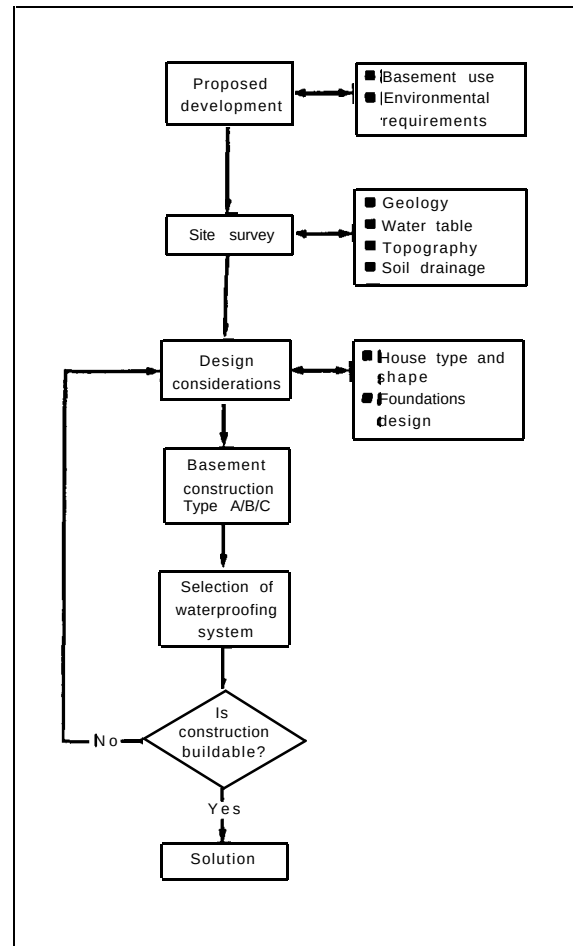


Figure 1: Principle selection criteria

Site information

The gathering of site information is dealt with in *Site investigations* on page 8. However, a few points need to be considered when selecting the form of construction and waterproofing system.

High water tables present the greatest risk of failure of the water-tightness of a basement. If there is a permanently high water table, it is important to identify it. A watercourse or water table that rises and falls with climatic changes must also be identified. How often and for how long the water table stays high are also important. If the water table rises briefly - say, after heavy rain - and then immediately falls again, the risk of water penetration through external waterproofing and then through the structure is less than if the water table stays high for a much longer period.

The likely presence of water and the position of the water table must also be established for construction purposes. The main contractor may need to lower the water table temporarily to enable the construction and waterproofing to go ahead. In addition, any lowering of the water table will need to be maintained until the loads acting on the basement, from either itself or in combination with the superstructure, are greater than the forces that would be generated by the water pressures as the water table returns to its original level.

The existence of any aggressive elements in the ground and/or the groundwater must be established to ensure

the most suitable combination of structure category and waterproofing system is selected.

Deciding on form of construction

Forms of construction

BS 8102 describes three forms of basement construction: Type A, B and C. These are shown diagrammatically in Figure 2, and discussed overleaf, together with the factors affecting their choice.

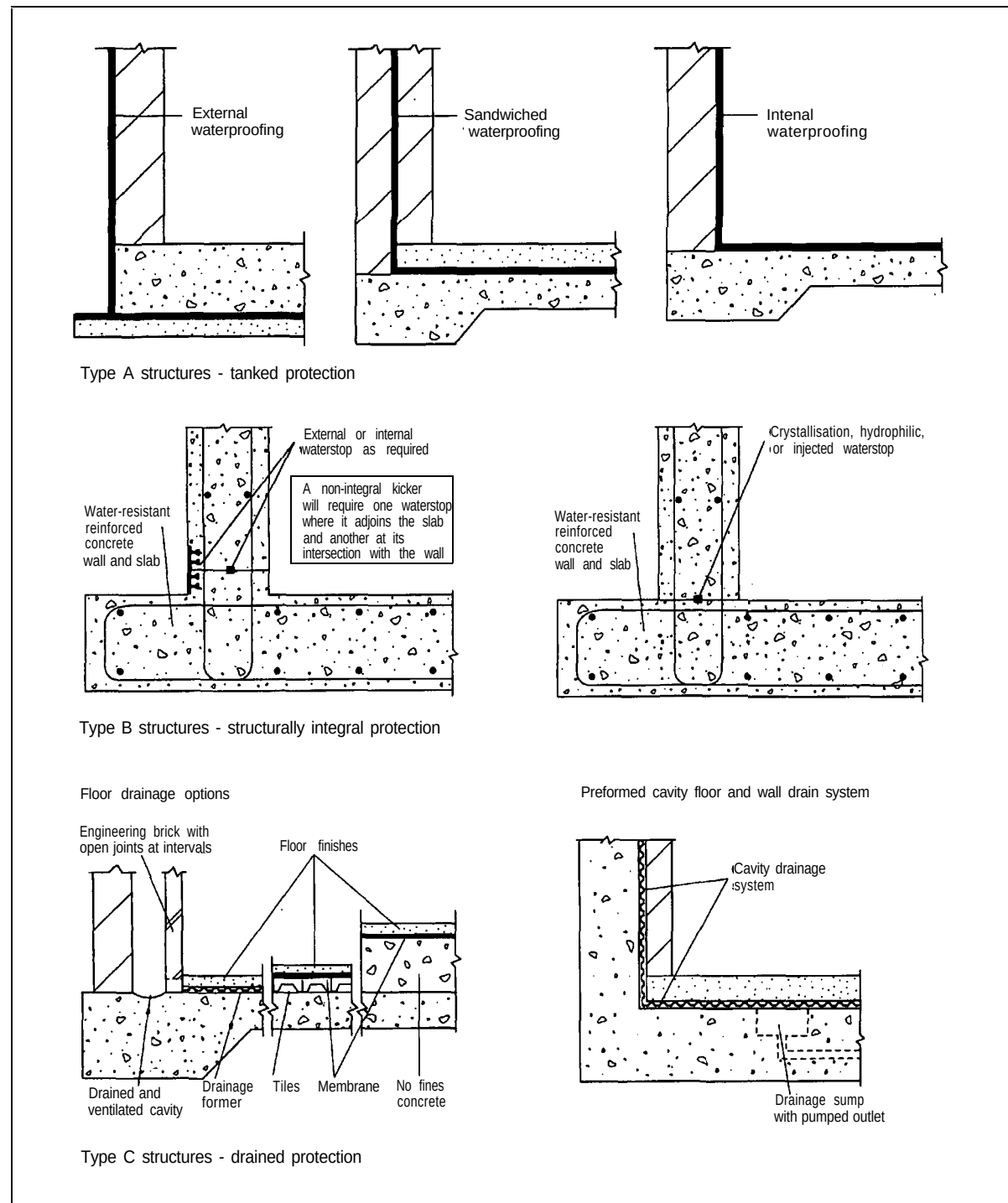


Figure 2: The three forms of basement construction

Type A (tanked protection) structures have no integral protection against water penetration and therefore rely totally and permanently on a waterproofing membrane to keep water out. The chosen structural waterproofing system must be able to withstand hydrostatic pressure from groundwater, together with any superimposed or service loading.

The structural wall may be prestressed, reinforced or plain concrete or masonry with the structural waterproofing system incorporated externally during construction. Or it may be applied internally to the finished basement. Masonry walls may require a cement rendering or flush pointing to produce a surface good enough to accept a waterproofing system.

This Form of construction can, depending on the waterproofing system used, also provide high resistance to water vapour movement.

Type B (structurally integral protection) structures requires the structure itself to be constructed as an integral water-resistant shell.

Invariably built of reinforced or prestressed concrete, the basement structure must be designed within certain strict parameters to ensure it is water-resistant. Most designs would be carried out according to the recommendations of BS 8007 or BS 8110, which give guidance on the grade of concrete and steel spacing.

Without the addition of a separate membrane, this form of construction may not be as resistant to water vapour movement as a Type A or C.

Type C (drained protection) structures incorporate a drained cavity within the basement structure. There is permanent reliance on this cavity to collect groundwater seepage through the structure and direct it to drains or a sump for removal by drainage or pumping.

Structural walls may be prestressed, reinforced or plain concrete or masonry. The external basement wall must provide enough resistance to water ingress to ensure the cavity accepts only a controlled amount of water or dampness. If this is not so, the cavity system may not cope with the deluge of water from a high water table or during storm/flood conditions.

This form of construction can, depending on the waterproofing system used, also provide high resistance to water vapour movement.

Factors affecting choice of construction

To consider the performance and likely reliability of these three types of structure, many factors need to be known (*Figure 1*). These include natural groundwater levels or perched water tables, groundwater contaminants, natural drainage and soil type. Of these, by far the most significant is water table level, which depends upon many factors and no two sites can, therefore, be said to be the same. However, they can be generally classified as follows:

- A high or perched water table where, by definition, the groundwater level is consistently above the level of the basement floor.
- A permanently low water table, or free-drained site, where the water table is consistently below the level of the basement floor.
- A variable water table, where the levels may vary between the two extremes described above.

Characteristics of construction forms

Any structural waterproofing membrane designed to resist a hydrostatic head should not let any free water pass through it. However, in practice, consideration must always be given to what would happen as a result of any defect. The effects of water table conditions on the three basement types are discussed below.

Type A

The watertightness of the Type A basement relies totally on the effectiveness of the waterproofing system. With a high water table, any defects will allow water to penetrate the structure, finally entering the basement as free water. If this water is not removed, the basement will fill to the level of the water table.

Since total reliance is placed on the waterproofing system in Type A structures, account must be taken of the need to gain access if a defect occurs. Externally applied systems will require subsequent excavation. Locating the source of a defect in a system not continuously bonded to the substrate wall can add further complications.

Where access is, or is liable to be, severely restricted by, for example, a permanent external in-situ pavement or patio, then an internally applied membrane may be easier to maintain. Defects can then be more readily found and repaired. An internal system could be used with an integral construction or external system to reduce the risk (see *Assessing risk* on page 18). The performance of internal waterproofing systems can be affected by the attachment of skirtings etc. or by fittings applied subsequently.

Where the site is permanently free-drained, any defects in the system will allow moisture to move under capillary action. Where the defect is small, this will usually result in some dampness in the structure, but will not necessarily show itself on the internal surface. However, any decoration or surface coating that acts as a vapour check will increase the risk of interstitial condensation and hence possible damage.

With a varying water table, significant water ingress through defects will occur only during storm or water-logged conditions. If the water table is high only briefly, the ingress might not be enough to show itself. The longer it stays high, the greater the risk of significant dampness or even partial flooding.

Type B

The watertightness of the Type B construction is totally reliant upon the design and construction of the basement as an integral shell, using a concrete of low permeability, and appropriate joint details.

The most common defects are permeable concrete through lack of compaction, honeycombed concrete, contamination of construction joints, cracking due to thermal contraction and shrinkage. These can all be reduced by correct specification and design and by careful construction.

Type B structures need to be carefully constructed to avoid defects that let water through. Although they are designed to be water-resistant, additional waterproofing systems may be applied either internally or externally to the faces of the walls and floors to control water vapour movement, where appropriate, or to provide further protection.

Construction joints need particular attention as these are the areas most commonly associated with leaks. While attention needs to be paid to jointing and positioning water stops, great care is required in the placing and compaction of the concrete. An alternative method of controlling water ingress at construction joints is to use a crystallization or hydrophilic system that reacts in the presence of water to seal the joint.

The construction of a 'kicker' either during or after pouring the floor slab should not be encouraged as it is difficult to construct without defects. Modern types of formwork and kickerless construction techniques mean that kickers no longer need be part of the construction process (see *Figure 2* on page 3).

With a high water table, minor defects in the concrete usually result in only small amounts of water penetrating, and stopping these is usually fairly straightforward. Remedial action can usually be carried out from the inside, so avoiding the need for external excavation.

Variable water tables present less of a problem, unless the water table stays high for a long time.

In a free-draining site, it is rare for a defect to be so serious that water comes through by capillary action.

Type C

The Type C construction relies totally on water collected in the cavity being taken away. The amount of free water entering will depend on the volume of external water and its hydrostatic pressure, and on the initial resistance of the structure to water ingress.

With a permanently high or variable water table, defects can arise in several ways:

- Failure of drains or mechanical pumps could result in flooding.
- Blockage of the cavity by silt or other contaminants could result in flooding. (The design of the structure should allow for clearing of silt and rodding of drains should blockages occur.)

An increase in the ingress of water could exceed the drainage capacity and result in dampness or flooding.

On a free-drained or sloping site, the cavities may be led to a soakaway to handle any ingress from, say, percolating surface water. If the soakaway silts up or the drain becomes blocked, dampness on the internal surface becomes a possibility.

Suitability of construction forms

Generally, Type A structures are not recommended in areas with an undrainable high water table.

A well-built Type B construction carries a low risk of serious failure in a high water table. This is because these structures can themselves be designed to be resistant to the ingress of water under a hydrostatic head. Care in the placement of concrete and waterstops (*Figure 2*) at construction joints is essential. Additional waterproofing protection may be used, but defects in Type B structures are less likely to result in water ingress owing to the integral protection of the structure.

A Type C construction could provide a suitable form of structure, where any water can be easily drained to a convenient point, for example on sloping sites where the back is completely retaining but the front is not.

With a very high water table, a Type B construction with a preformed plastic drained cavity former applied internally (effectively turning the construction into Type C) could be considered to carry the smallest risk of failure.

Where the site drains well enough to prevent the build-up of hydrostatic water pressure, all three forms of construction carry little risk of damp penetration.

Form and characteristics of waterproofing systems

Since reliance has often to be placed on the waterproofing system, the designer must ensure the materials are properly selected and adequate for the proposed location and conditions. It is imperative that all continuous horizontal, sloping or vertical waterproofing be specified, and executed, in one proprietary waterproofing system. Hybrid systems - using one system with another - must be avoided because of the danger of incompatibility. Do not mix hot and cold systems.

Most proprietary systems and materials are covered by British Standards, Agrément certificates or manufacturers' warranties.

There are several categories of structural waterproofing:

- Category 1: Bonded sheet membranes
- Category 2: Cavity drain membranes
- Category 3: Bentonite clay active membranes
- Category 4: Liquid-applied membranes
- Category 5: Mastic asphalt membranes
- Category 6: Cementitious crystallization active systems
- Category 7: Proprietary cementitious multi-coat renders, toppings and coatings

Category 1: Bonded sheet membranes

Bonded sheet membranes are generally cold-applied or heat-bonded to the finished structural walls. Both are modified bitumen on a range of carrier films. They are applied externally, or internally with a loading coat strong enough to resist hydrostatic pressure. Composite polymeric sheet membranes are also available. They are attached to the enabling works (reverse tanking), but subsequently fully bonded by means of a specifically formulated pressure-sensitive adhesive, to the pouted concrete.

Design considerations

- Flexible and able to adapt to minor movement and shrinkage within the substrate
- They are of consistent thickness and quality
- May provide protection against aggressive soils and groundwater when applied externally
- When applied internally, they need to be restrained by a loading coat
- Substrate must be free from surface water for bonding to occur
- Generally, suitable only for uncomplicated foundation systems such as plain rafts

Category 2: Cavity drain membranes

Cavity drain membranes are high-density dimpled polyethylene sheets, placed against the structure. The dimples form permanent cavities between the structure

and the internal shell. They are used internally to drain and control water ingress.

Design considerations

- Installed after the construction of the basement
- Defects may be rectified before completion
- Minimum preparation of substrate needed
- There is no hydrostatic pressure on the system: water entering the cavity is collected and drained or pumped away
- They are of consistent thickness and quality
- Flexible and able to adapt to minor settlement and shrinkage within the substrate
- Simple internal applications can overcome complicated designs, e.g. piles and ground beams
- With high or variable water tables, blockages or failure of drains/pumps may lead to flooding

Category 3: Bentonite clay active membranes

Bentonite clay active membranes are sheets of sodium bentonite clay sandwiched between two layers of biodegradable cardboard. When the clay meets water, it can swell to many times its original volume, sealing any gaps or voids in the membrane. This category of membrane is used externally.

Design considerations

- Minor defects in placing should self-seal
- They are simple to apply
- The substrate does not need to be dry before application
- Minimum preparation of substrate is required
- Must not be used in acidic or excessively alkaline soils

Category 4: Liquid-applied membranes

Liquid-applied membranes are one- or two-part systems. They are applied cold, generally in two coats as a bitumen solution, elastomeric urethane or modified epoxy. They can be applied both externally and internally. In the latter case, the loading coat must be strong enough to resist hydrostatic pressure, unless used as a vapour barrier in Type B construction.

Design considerations

- Being jointless, they maintain continuity of membrane
- Easily applied to difficult substrate profiles
- Elastic and flexible, thus accommodating minor movement and shrinkage within the structure
- Can protect the structure against aggressive soils and groundwater when applied externally
- Have high substrate adhesion and chemical resistance
- Must be applied to a dry surface
- When applied internally, must be restrained by a loading coat if subjected to a hydrostatic water pressure, as in Type A construction
- Require good surface preparation
- Careful application needed to achieve correct thickness of dried film

Category 5: Mastic asphalt membranes

Mastic asphalt membranes are applied in three coats as a hot, mastic liquid. They cool to a hard, waterproof coating, but retain a degree of flexibility. Application can be external or internal. If internal, the loading coat must be strong enough to resist hydrostatic pressure.

Design considerations

- Because of the multiple coats, there is little risk of defects in one coat being carried right through the total membrane
- May provide protection against aggressive soils and groundwater when applied externally
- Substrate must be dry before application
- Requires protective screed on horizontal membrane before loading coat is installed
- Externally applied membranes are generally unsuitable for complicated foundations such as piles

Category 6: Cementitious crystallization active systems

Cementitious crystallization active systems are coatings applied as internal or external slurries. By reacting with free lime in concrete, renders or mortars, they block cracks and capillaries.

Design considerations

- Provide in-depth waterproofing of concrete and construction joints
- The chemicals remain active and will self-seal leaks
- In construction joints, they assist repair of local defects
- Applied externally, may protect against aggressive soils and groundwater
- Will not self-seal cracks greater than hairline (0.3 mm)
- Cannot be used on building materials containing no free lime
- Will not waterproof defective concrete, such as honeycombing

Category 7: Proprietary cementitious multi-coat renders, toppings and coatings

Proprietary cementitious multi-coat renders, toppings and coating are applied as a layer(s) to form a dense, waterproof membrane. Waterproof renders or toppings consist of a layer or layers of dense cementitious material incorporating a waterproofing component. Cementitious coatings are premixed slurries applied as a thin layer. All are designed to be used inside the structure but can be external.

Design considerations

- Can be applied internally with no loading coat requirement
- Effective against severe groundwater infiltration
- Easily applied to difficult substrate profiles
- When applied internally, defects are easy to find and repair
- Provide a durable surface suitable for direct finish
- When applied externally, can protect against aggressive soils and groundwater

- Being rigid, they may reflect any cracking of the substrate
- Fittings fixed mechanically through the system can cause problems and should be avoided

Ancillary materials

Waterstops

Waterstops for basement construction may be of one of the following types, according to the location and function:

- Rubber or flexible PVC extruded profiles
- Strips or profiles of hydrophilic materials which swell in water, either alone or as part of a composite with a rubber or PVC extrusion
- Cementitious crystallization products
- Post injected systems

Rubber or flexible PVC waterstops

These are extruded profiles fabricated with junction pieces to provide a linked continuous system through all the joints or discontinuities within a concrete structure.

Plain web profiles are available for non-moving or low-movement construction and contraction joints. Profiles incorporating a centre bulk or box are used where there is movement, as in expansion joints.

Alternatively, waterstops may be cast totally within the site-placed concrete. These are known as internal or centrally placed waterstops. Internal waterstops will resist the passage of water through a joint from either face. However, as they are more difficult to install and can cause problems when the concrete is being placed and compacted, they are best avoided.

External waterstop profiles are also available and are positioned on one face of the concrete. These rear-fixed or surface waterstops simplify the shuttering and installation but will resist the passage of water only from the face in which they are installed.

Water-swellaable waterstops

Such waterstops depend upon a sealing pressure being developed by the water absorption of a hydrophilic material or filler. They are available as strips for bonding or nailing to the first-placed concrete immediately before the second pour. The strips may be wholly of hydrophilic material, or compounded with a rubber, or part of a composite profile. They can be applied against existing concrete since they avoid the problems of breaking out to install a conventional rubber or PVC waterstop. The use of water-swellaable strips is limited to low-movement construction and contraction joints.

Hydrophilic material may be applied to a conventional PVC waterstop profile to provide a combined system that may also cater for expansion joints.

Cementitious crystallization waterstops

These differ from the previous two categories in that the product consists of cements, fillers and chemicals to be mixed on site as a slurry. The slurry is applied to the face of the first-poured concrete before the second pour. The waterstopping action results from salt crystallization, in the presence of water, within the pores and capillaries of the concrete. These products are not suitable for use in expansion joints.

Post injected waterstops

These consist of a perforated or permeable tube fixed to the first pour of concrete in the construction joint with either end attached to fittings connected to the formwork, or protruding from underneath it. The tube is then cast into the construction joint.

After the concrete has hardened a polyurethane resin or other propriety fluid is injected under low pressure to flow through the tube and, when the exit of the tube is sealed, it flows freely out of the perforations into any cracks, fissures or holes in the construction joint. The injected material then sets to seal all water paths through the joint.

Bandage joint systems

Where large or unusual movement is expected in joints or cracks - in both new and remedial work - bandage joint systems may be used. These consist of strips of synthetic polymer membrane, bonded across the joint with a suitable adhesive. As systems vary, the manufacturer's advice on application method and adhesive should always be followed.

Membrane protection products

If construction operations may damage applied membranes, adequate protection must be provided. This can consist of vertical blockwork and a 50 mm screed to horizontal surfaces. Alternatively, protection boards supplied by most membrane manufacturers may be used. They are more convenient since they provide immediate protection. They also eliminate a 'wet trade' operation and allow the following works to continue immediately after laying.

Protection boards should be rot-proof and robust enough to withstand site operations. They should therefore be chosen in consultation with the supplier of the waterproofing system.

A protection board may be used in vertical applications. Alternatively, if vertical protection and drainage are required, a geocomposite drainage sheet could be used: its greater cost may be offset by the reduction or elimination of hydrostatic pressure on the membrane as a result of the better drainage.

Other design considerations

As well as the general characteristics of the categories of waterproofing already given, certain aspects are common to several systems. The final selection will depend on the form of structure and on other design and construction aspects such as the need to control water vapour.

Thermal insulation

Including a basement can improve the thermal insulation of the structure since the lower basement slab is more efficient than a slab at ground level. The surrounding earth will also improve the thermal transmittance of the basement walls and there may be no need to provide further insulation to comply with the Building Regulations. However, where insulation is required, it may - depending on whether it is placed inside or outside the basement walls - dictate the form of construction and waterproofing system. Any external insulation must have low water absorption and be frost resistant to prevent loss of its thermal insulation properties.

Condensation

Because window areas are often reduced, there tends to be less natural ventilation in basements than in other areas of a house. They are therefore generally more prone to condensation, so heating and air circulation need to be carefully designed to ensure condensation is controlled.

Condensation in basements is too complex to be covered in detail here. Reference 3 explains how to estimate its risk and effects.

Water vapour tends to move from areas of high vapour pressure to low vapour pressure. The vapour pressure in a specific area relates directly to the humidity of the air at that point, which in turn depends on the temperature and the amount of free water available to be released into the air.

Although it is commonly thought that water vapour will always pass from the ground into a basement, this is not so. In most domestic situations, water vapour will move, if the water table is low, from within the structure towards the ground. If the water table is high, water vapour will penetrate the basement but usually at such a low rate as to be of little consequence.

A vapour-permeable waterproofing system can thus be advantageous if the vapour tends to move from the inside to the ground, but will allow relative humidity within the basement to rise if the reverse conditions apply.

A system that acts as a vapour check can be advantageous if the vapour tends to move from the ground into the basement but similarly will allow the relative humidity to rise if the reverse is true. However, a vapour check applied externally can cause interstitial condensation⁽³⁾. This should not be a problem as long as it is allowed for in the design.

In general, careful consideration must be given to the effect that the waterproofing system has on the resistance to water vapour. In practice, where internal conditions in a basement are controlled by properly designed heating and permanent ventilation, the condensation risk can be reduced to be no worse than in the rest of the dwelling. The advantages/disadvantages of vapour permeable/impermeable systems are then usually negligible.

If the environment is controlled solely by natural air movement, the condensation risk increases and more care is needed in the choice of waterproofing and insulation systems.

Vapour control

As well as controlling water ingress, categories 1 to 5 can also act as an effective vapour check. Although this is often seen as an advantage, some structures need to allow for water vapour movement, in which case a category 6 or 7 system will be needed. The vapour resistance of category 7 systems can vary significantly with the product. It is important, therefore, to decide whether water vapour needs to be controlled or not - see *Condensation* above.

Chemical barrier

An external membrane can protect the main structure. However, if the ground or groundwater is contaminated with aggressive chemicals, methane and other gases, their precise nature and concentration must be

determined and the membrane manufacturer must be consulted.

System restraint

Categories 1, 3, 4 and 5 need to be restrained so that they can resist the forces involved. When applied externally, the structure provides the restraint. When categories 1, 4 and 5 are employed internally, they need to be restrained by a loading coat. This will take up space within the structure. Categories 2, 6 and 7 can be used internally without a loading coat.

Substrate movement

Categories 1 to 5 have reasonable strain capacity and will usually accommodate some flexing or design cracking of the structure. Categories 6 and 7 are more brittle with low strain capacity and so are less tolerant of structural flexing. They will crack if the substrate cracks but may still control moisture ingress if the cracks are fine.

Expansion joints

Care is needed when considering systems used with expansion joints: always consult the manufacturer. However, although joints can be detailed to cater for movement, it is far better to design the structure in a way that avoids expansion joints.

Defects and repair

Categories 1, 3, 4, 5 and 7 rely on their impermeability to control water ingress. Defects in the materials or in their jointing may require remedial treatment. With externally applied systems, this may mean excavation. It is often difficult, therefore, to reach defects in externally applied systems, and there can be problems in locating defects in systems that are not continuously bonded. Particular difficulties will arise where the water table is high permanently or for long periods, since ground dewatering would be required. Access following construction may not be desirable or possible, in which case an internal waterproofing system may be preferable. However, the performance of internal waterproofing systems can be affected, as indicated in *Characteristics of construction forms* on page 4, by the attachment of skirtings etc., or by the application of subsequent fittings. Categories 3 and 6 are active systems and can 'self-heal', even years later.

Site investigations

As stated in BS 5930⁽⁴⁾, "Investigation of the site is an essential preliminary to the construction of all civil engineering and building works". This is particularly important for basements, since the materials used and the performance of the finished structure will be greatly influenced by the ground conditions. Several factors need to be assessed and reference should be made to BS 5930 for detailed information on site investigations. Brief details of some of these aspects are given below.

Groundwater

Water table

The existence of a watercourse or water table and its seasonal position below ground will need to be established. The site history and name clues such as "Pond Lane" can help. Evidence of a flooding site could suggest an impermeable soil or a high or perched water table.

Table 1: Characteristics of soils which effect basement construction

Material	Major divisions	Sub-groups	Drainage characteristics	Shrinkage or swelling properties
Coarse soils and other materials	Boulder and cobbles	Boulder gravels	Good	Almost none
	Other materials	Hard: hard broken rock, hardcore, etc.	Excellent	Almost none
		Soft: chalk, soft rocks, rubble	Fair to practically impervious	Almost none to slight
	Gravels and gravelly soils	Well graded gravel and gravel-sand mixtures, little or no fines	Excellent	Almost none
		Well graded gravel-sand mixtures with excellent clay binder	Practically impervious	Very slight
		Uniform gravel with little or no fines	Excellent	Almost none
		Poorly graded gravel and gravel-sand mixtures, little or no fines	Excellent	Almost none
		Gravel with fines, silty gravel, clayey gravel, poorly graded gravel-sand-clay mixtures	Fair to practically impervious	Almost none to slight
	Sands and sandy soils	Well graded sands and gravelly sands, little or no fines	Excellent	Almost none
		Well graded sand with excellent clay binder	Practically impervious	Very slight
		Uniform sands with little or no fines	Excellent	Almost none
		Poorly graded sands, little or no fines	Excellent	Almost none
Sands with fines, silty sands, clayey sands, poorly graded sand-clay mixtures		Fair to practically impervious	Almost none to medium	
Fine soils	Soils having low compressibility	Silts (inorganic) and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Fair to poor	Slight to medium
		Clayey silts (inorganic)	Practically impervious	Medium
		Organic silts of low plasticity	Poor	Medium to high
	Soils having medium compressibility	Silt and sandy clays (inorganic) of medium plasticity	Fair to poor	Medium to high
		Clays (inorganic) of medium plasticity	Fair to practically impervious	High
		Organic clays of medium plasticity	Fair to practically impervious	High
	Soils having high compressibility	Micaceous or diatomaceous fine sandy and silty soils, elastic silts	Poor	High
		Clays (inorganic) of high plasticity, fat clays	Practically impervious	High
		Organic clays of high plasticity	Practically impervious	High
Fibrous organic soils with very high compresibility		Peat and other highly organic swamp soils	Fair to poor	Very high

Ground drainage

The topography of the land and the direction and movement of any groundwater should be determined as they will have a bearing on any proposals to provide drainage to reduce local groundwater pressures.

If there are any drains or land drains, their positions should be established. Any new construction proposals should not interrupt drains that still function unless measures are taken to redirect them or to intercept the water by a new drainage system.

Soil type and conditions

The type of soil can greatly influence the quantity of water reaching the basement wall. Free-draining soils present fewer problems than clays, which tend to be impermeable. It is important, therefore, to determine the soil type and, in particular, its drainage characteristics. Table 1, adapted from reference 5, gives the characteristics of the main soil types.

Some soils contain chemicals that may harm both the structure and the waterproofing system. Check the ground for materials that are detrimental, such as peat and sulfates.

The presence of, or potential for, natural gases such as radon and methane should be ascertained. The likelihood of radon can be established from the underlying geological structure, and guidance for its control may be found in reference 6.

Methane and other gases are likely to be linked to infill and made-up ground, particularly where large amounts of organic matter have been buried. Such sites can also present risks from acid wastes, mineral oil shales, and other fill materials.

Some slags and other residues often contain toxic materials and some furnace ashes may be reactive. Reference 7 gives information on site preparation and resistance to moisture, and includes guidance on ground contaminants.

Movement risks likely to affect basements

A change in ground moisture content - caused, for example, by the removal of trees - can result in ground movement and affect the loadbearing capacity of soil. Clay and peaty soils are particularly prone to volumetric changes leading to varying foundation pressures and movement.

The remains of former buildings or structures on the site need to be assessed. They are best removed to avoid differential movement due to bearing over strong points. Steeply sloping sites may have high land-slip risks, which should be assessed before proceeding further.

Particular care is needed where there are changes in the soil strata that may cause differential foundation movement. Although such matters can be catered for structurally, they do present problems. For example, although expansion joints are a common solution, they may not be appropriate because of the difficulties of maintaining watertightness, particularly in a waterlogged site.

If the risk of movement is high, movement joints should be considered. Where possible, designers should not attempt to create waterproofed expansion joints, but instead should design discrete boxes that can be separately waterproofed.

Construction options

Basement site locations and forms

There are many potential basement locations. Design forms and waterproofing methods will therefore depend on, for example, the prevailing terrain, soil conditions, water tables, proximity of adjacent buildings and the requirement of the end user. Typical locations and forms of basement construction are illustrated and summarized for three types of site: sloping, flat and infill.

Sloping sites

Sloping or elevated sites allow both full and semi-basements or split-level dwellings to be built, with cut-and-fill options (*Figure 3*). Since these sites can normally be effectively drained, properties would be at little risk from percolating groundwater. Economical Type A tanked basements or Type C structures can therefore be built, simply designed in concrete or masonry, with drainage provisions.

Flat sites

Flat sites provide the opportunity for basements wholly or partially below ground (*Figure 4*). Excavated material may be re-used to landscape around basements partially below ground, giving the dwelling an elevated aspect.

Type A or C construction may be used if the site is free-draining or is in an elevated position with drainage provisions.

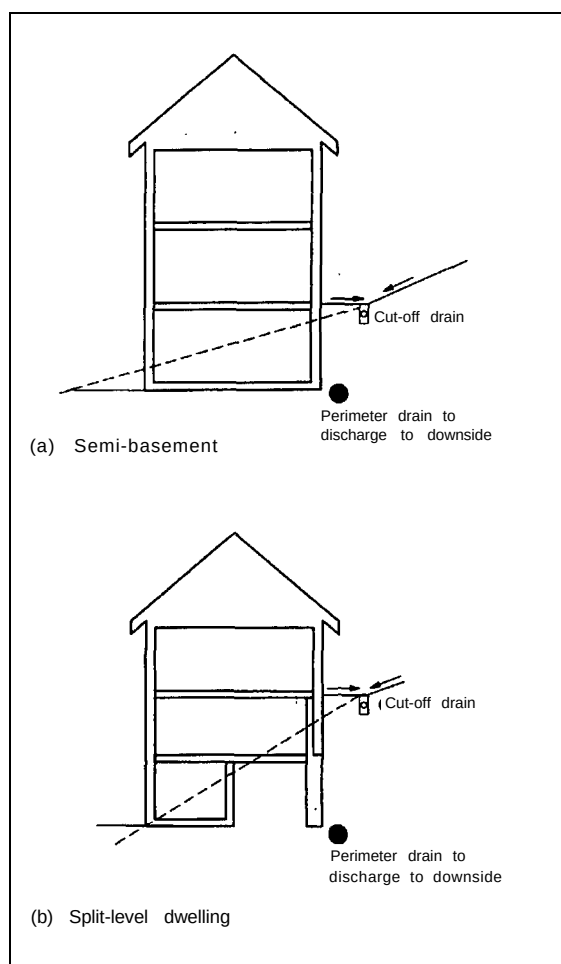


Figure 3: Basements on sloping or elevated sites

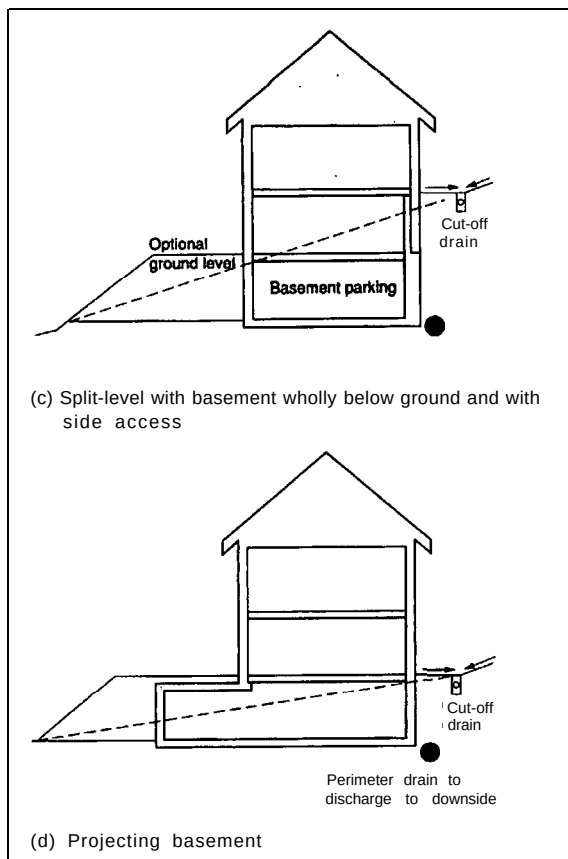


Figure 3: Continued

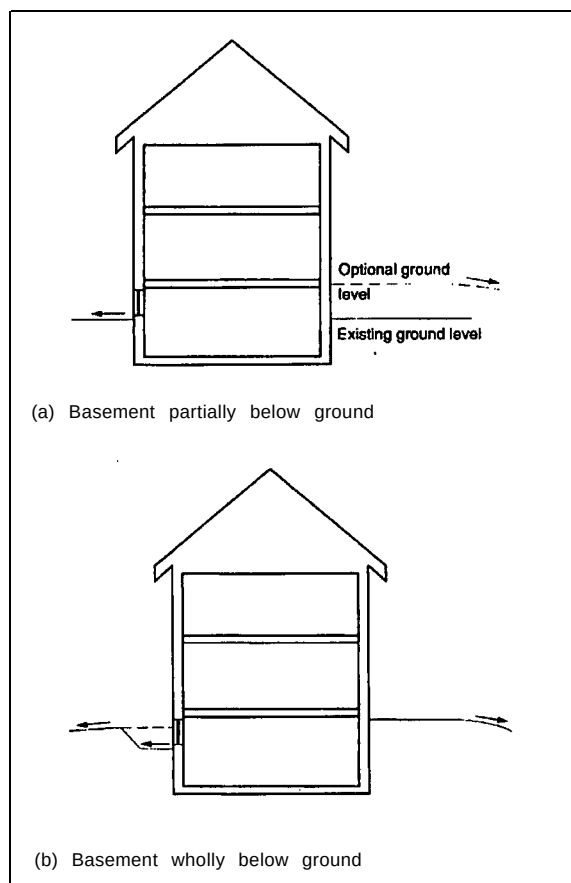


Figure 4: Basements on flat sites

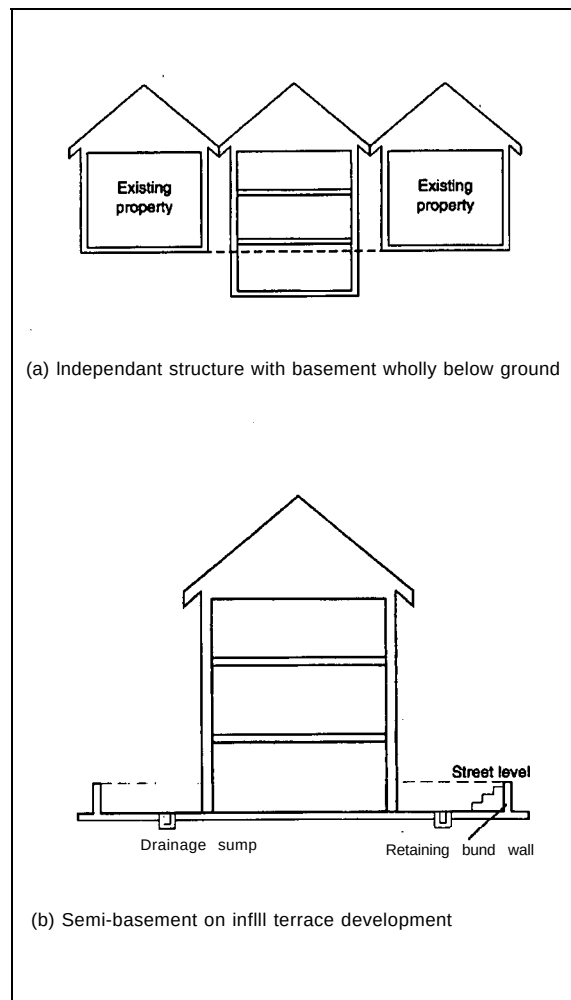
Basements constructed on a flat site in low-lying areas with impermeable soils can be difficult to drain. As there may be problems with perched, fluctuating or permanently high water tables, substructures designed in water-resistant Type B construction would therefore be advisable. Any window fire exit must be above the highest anticipated water level.

Infill sites

Inner city areas provide more opportunities for house basement construction because high land values increase property costs. Infill sites between adjacent dwellings can be developed (Figure 5). However, these may be more susceptible to periodic flooding from existing defective water mains. Design preference is for Type B construction, perhaps with internal waterproofing or drained cavity provision.

Where adjacent properties have to be underpinned, it can be difficult to achieve continuity in external or pre-applied waterproofing systems. Alternative systems should therefore be looked at.

Semi-basements on infill sites can probably use a bunded catchment area. If so, the bund walls should be designed as Type A tanked construction or Type B water-resistant concrete, with a drainage sump (Figure 5(b)) for rain-water. Clearly, this form of construction can be adopted for both flat and sloping sites.



Design factors affecting construction

Basement drainage

Attention should be given to the drainage requirements for Type A tanked structures and reinforced concrete Type B structures. Lack of proper drainage to basement surrounds may result in hydrostatic pressure and subsequent leakage through defects in the waterproofing or concrete.

Installing a geocomposite drainage sheet and fin or land drains will help deflect and drain water away from the perimeter of buildings, so improving the total waterproofing (see *Waterproofing details* on page 13).

An additional water-activated pump may be used to deal with run-off water. This can be particularly useful where the water table becomes perched because the soil is too impermeable to handle the percolating surface water, as with a clay soil. Such pumps, which are normally installed outside the structure, can be used to ensure that the severity of water conditions does not exceed that taken for design. They can be used either to extend the application of Type A and B construction or to provide an additional escape for water, but may not be appropriate for all water-proofing systems. The outlet from such pumps must discharge to areas where the water cannot feed back to the pump inlet.

The orientation of the basement area to the general flow of groundwater should also be considered - see *Figure 6*. Any L- or U-shapes with a re-entrant angle against the natural drainage flow can act as dams and increase the risk of hydrostatic pressure. Where basements are constructed against the flow of water, sub-drainage should be provided and graded to storm drains or open outlets on the downside of the building.

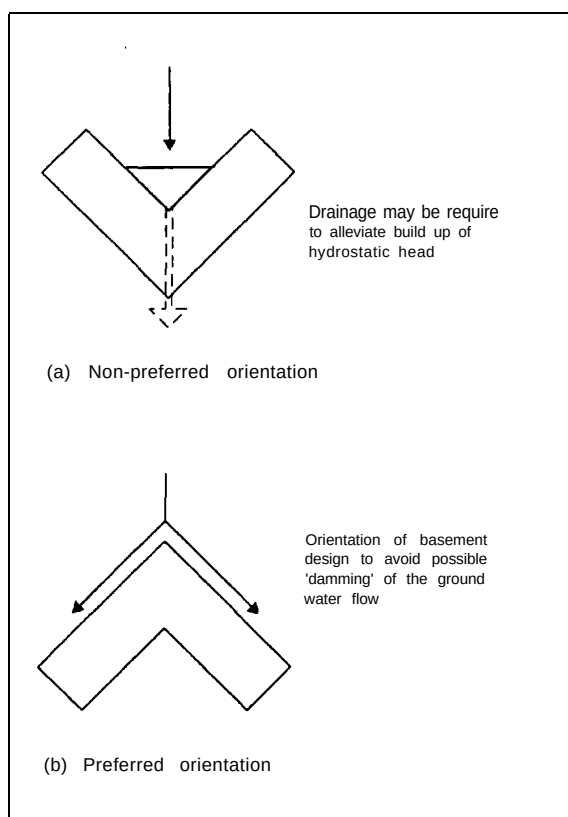


Figure 6: Drainage and orientation

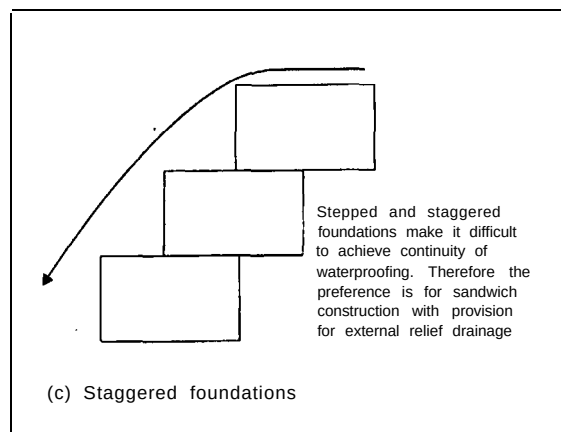


Figure 6: Continued

Foundation design

Structures should be designed to keep foundations as simple as possible. Expansion joints and complicated shapes are best avoided, since they are points of weakness and need a lot of attention to detail.

Complicated foundation designs do not lend themselves to external waterproofing. When deciding on the form of construction and waterproofing, the designer should consider 'buildability' and the acceptable level of risk, relative to cost of achieving the desired performance. Consideration must also be given to how remedial work may be carried out if this performance is not attained.

Common foundation designs are shown in *Figure 7* with suggested waterproofing options.

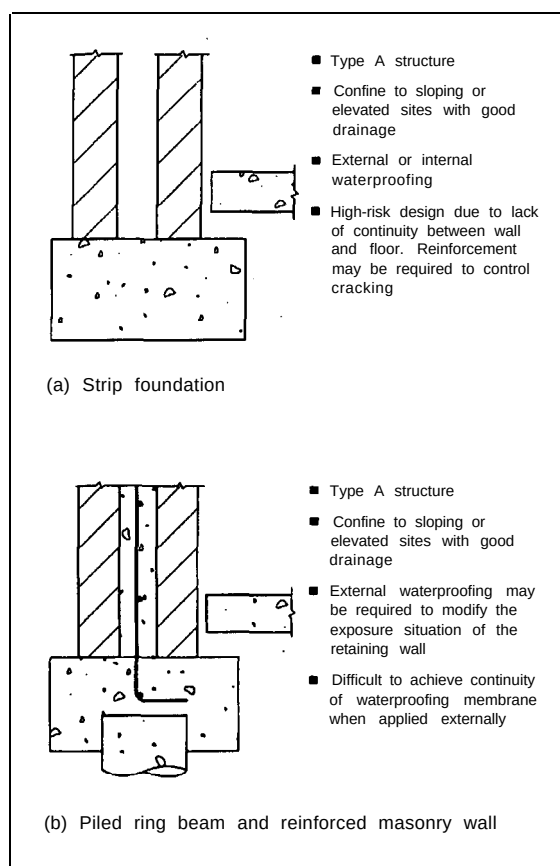


Figure 7: Typical foundation designs

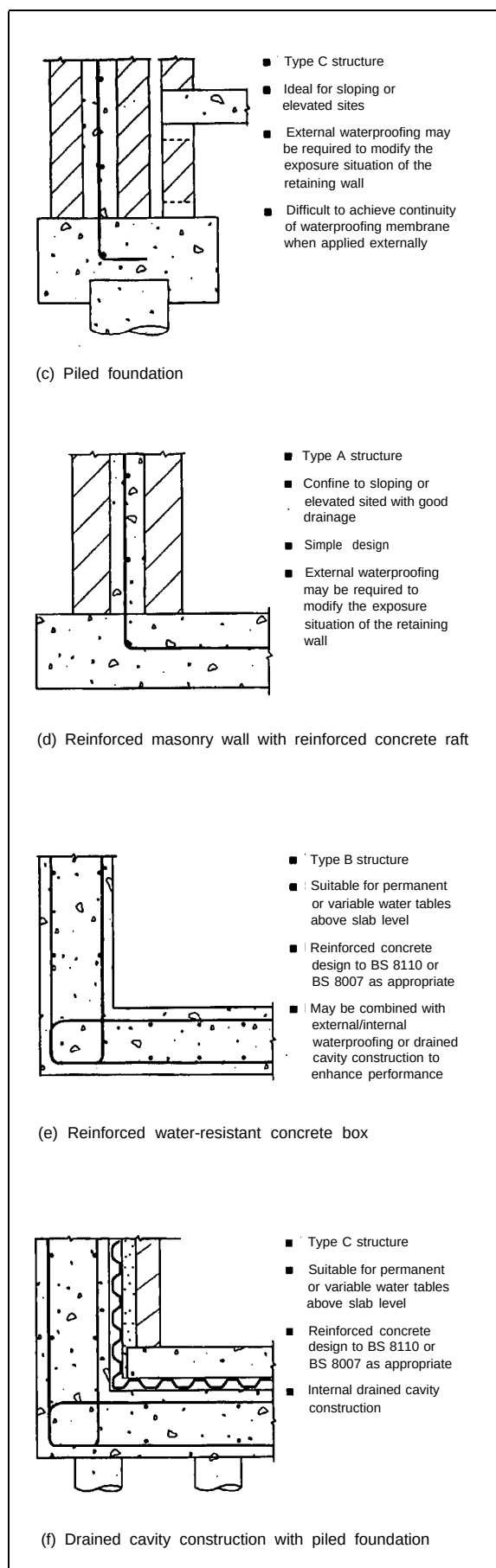


Figure 7: Continued

Waterproofing details

Details of waterproofing options and forms of construction

The principal form of construction outlined in *Deciding on form of construction* on page 3 may involve a variety of waterproofing options. The principal details and elements of the main waterproofing systems are shown in Figure 8.

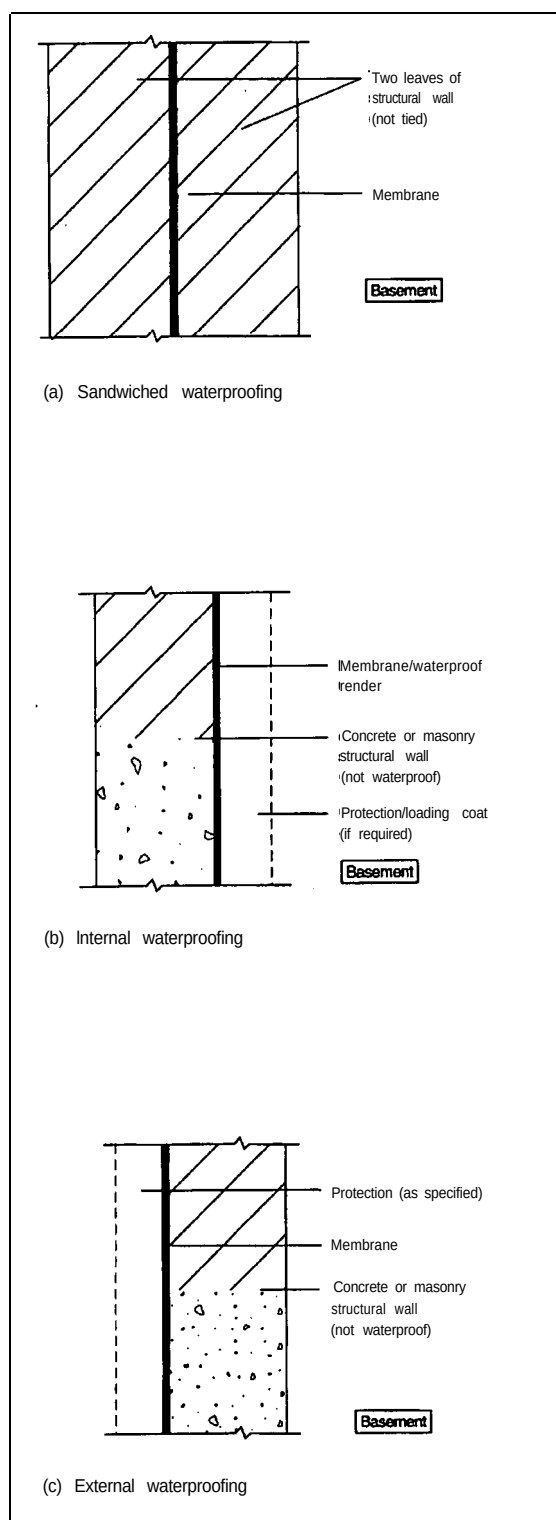
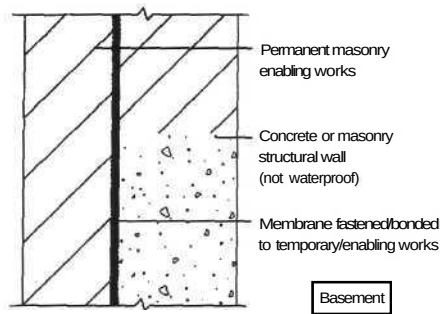
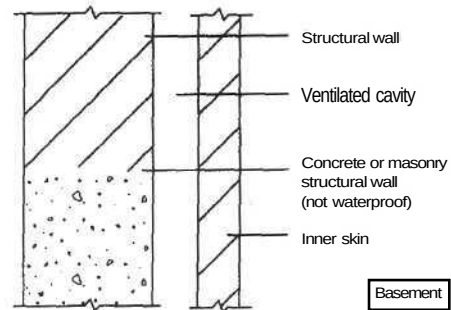


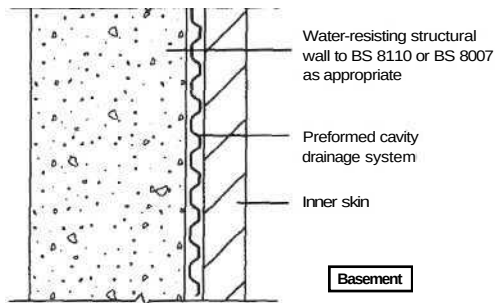
Figure 8: Alternative waterproofing systems



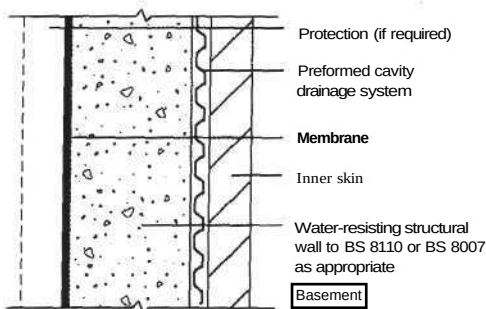
(d) External (reverse) waterproofing



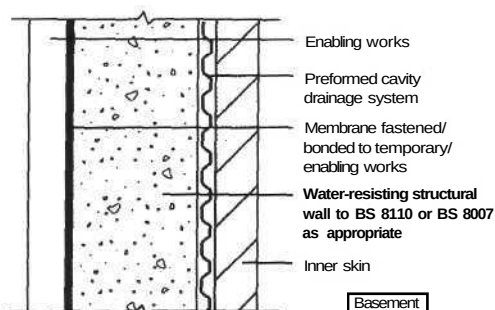
(h) Drained cavity, no waterproofing to walls, structure not providing Type B standard



(e) Drained cavity with integral protection



(f) Drained cavity with integral protection and external waterproofing



(g) Drained cavity with integral protection and external (reverse) waterproofing

Figure 8: Continued

Figure 8: Continued

As already indicated, each waterproofing system may be used as the sole protection or combined to give additional protection. The final choice depends on the site conditions and the level of waterproofing necessary. Some systems may also make use of externally applied geocomposite drainage sheets to prevent or lessen hydrostatic pressure reaching the external structure or waterproofing system (*Figure 9*).

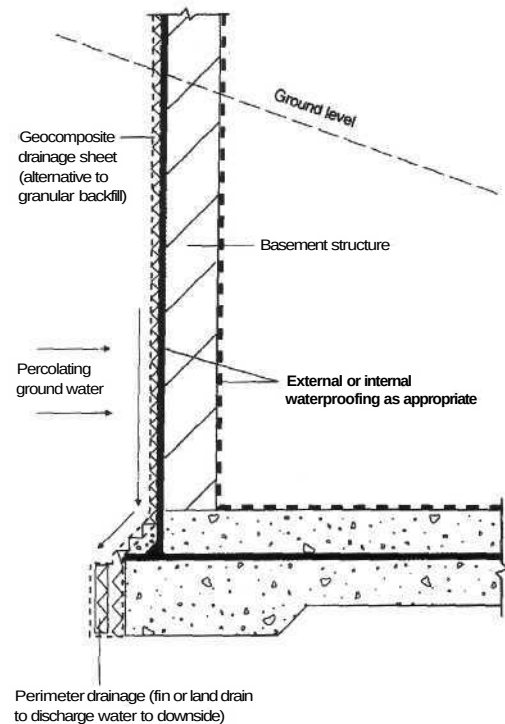


Figure 9: External drainage

To be effective, all laps in the waterproofing system must be fully weathered and sealed. The system will generally need to be continuous around the basement walls and floors (*Figure 10*) and extend at least 150 mm above ground level. Continuity of waterproofing between the junction of the superstructure and the basement walls must also be assured (*Figure 11*).

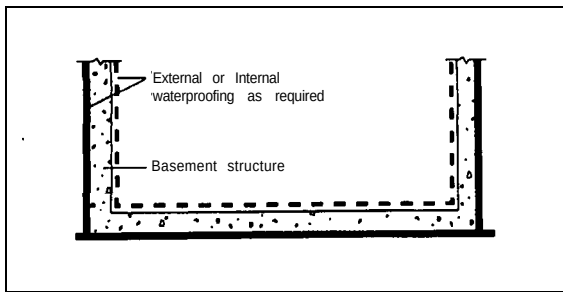


Figure 10: Continuous waterproofing to basement

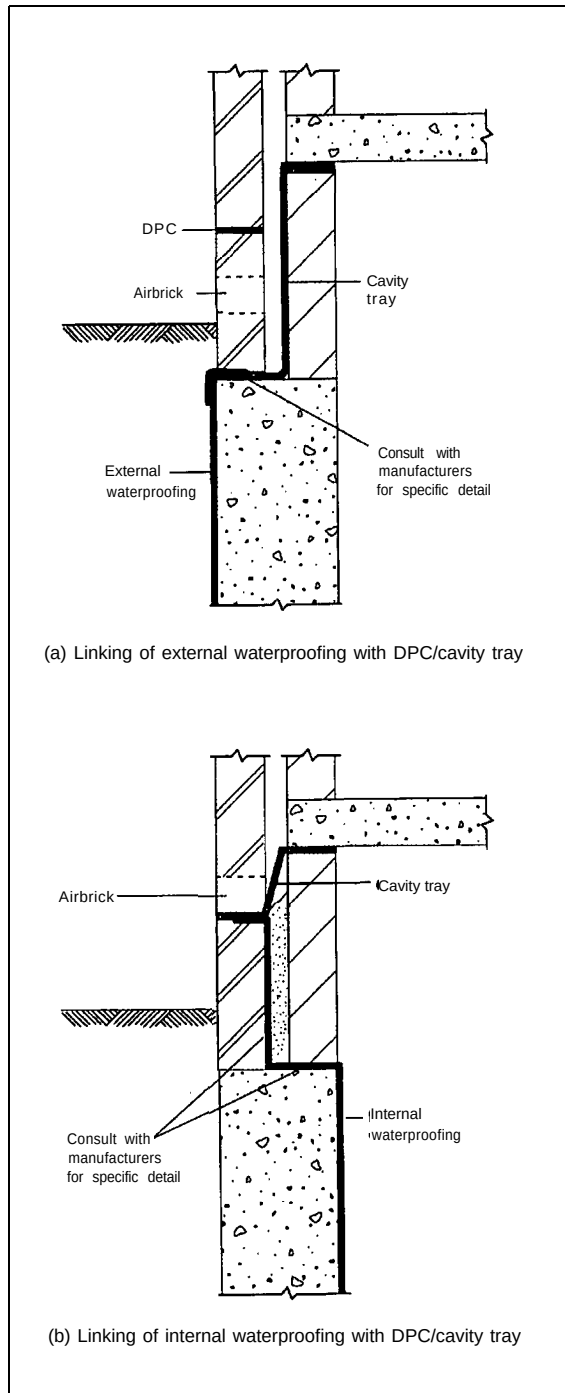


Figure 11: Continuity of waterproofing - linking with superstructure

The effect foundations have on achieving continuity in the waterproofing system must be assessed (see *Foundation design* on page 12). Details to cater for steps in the foundation can be produced as in *Figure 12*.

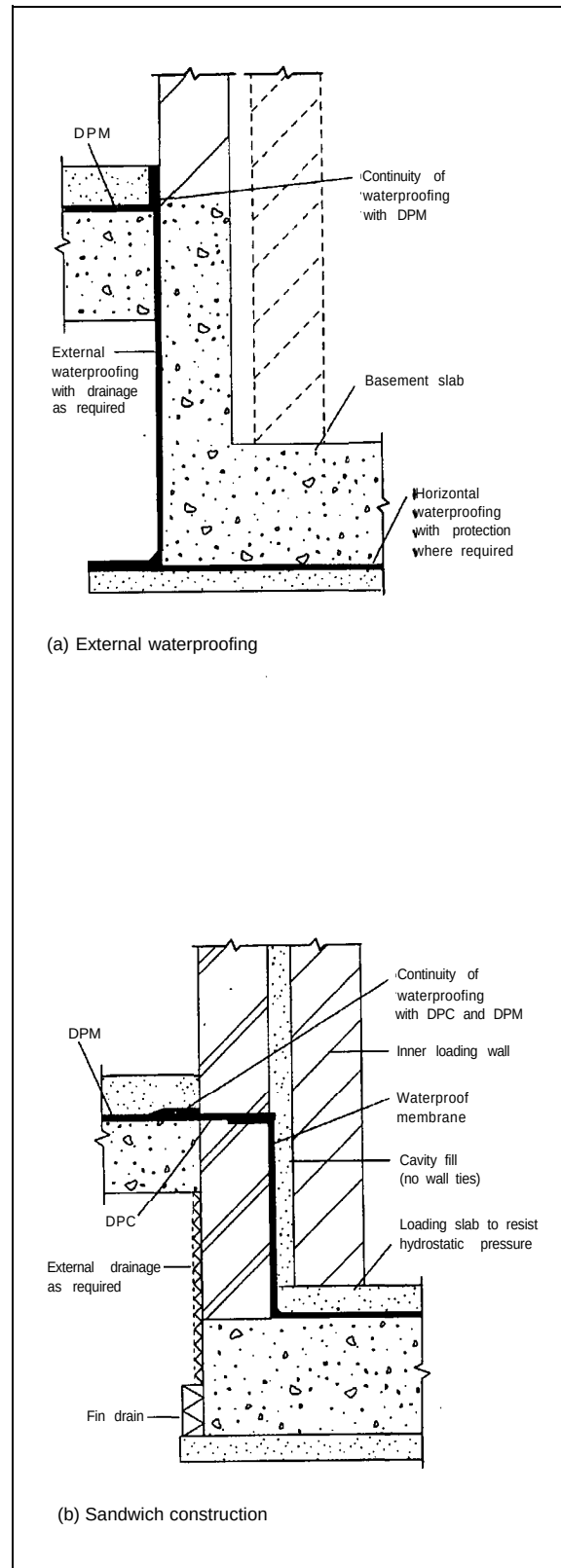


Figure 12: Continuity of waterproofing - step changes in construction

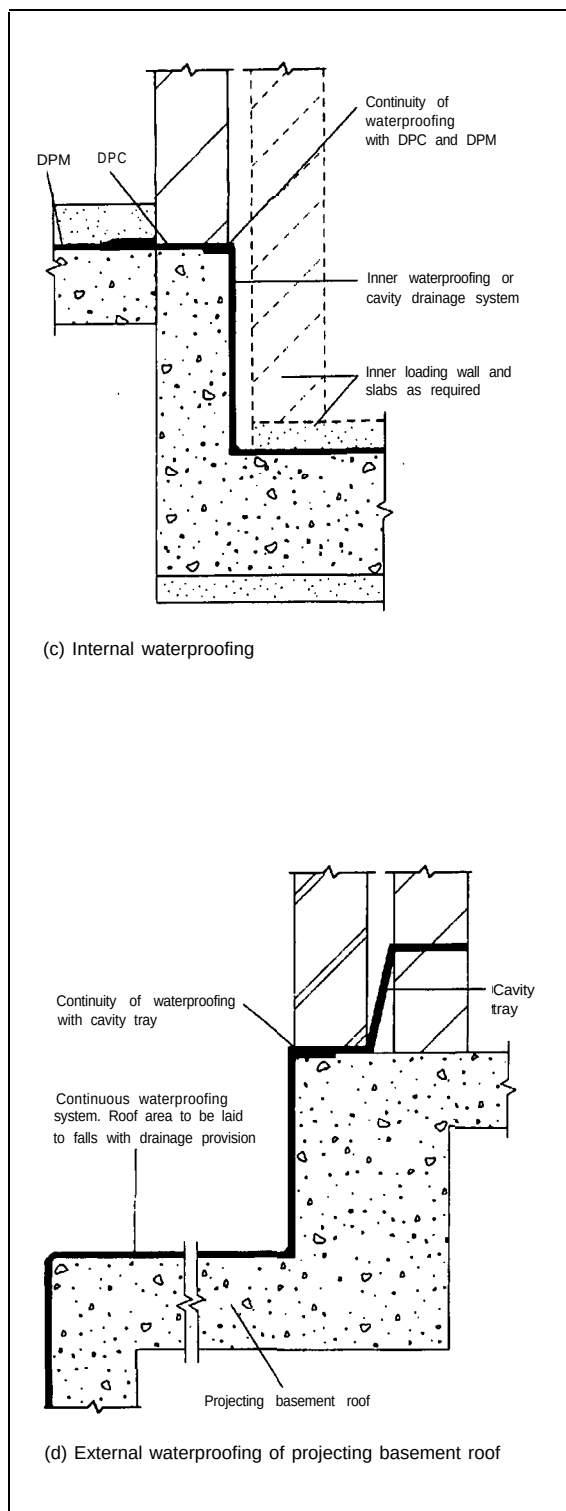


Figure 12: Continued

Discontinuity can sometimes be acceptable, as shown in Figure 13 where a masonry wall is detailed for use on a sloping site. The detail could also be appropriate on a free-draining flat site. This is not a cavity drain system (Type C) but in effect a Type A construction that can intercept water finding its way through the outer leaf. The Figure also shows the necessary ventilation of the cavity, and waterproofing to the top of the retaining wall. The detail is shown with the inner leaf tied to the outer leaf. Where the cavity is to be the main intercept, with

no outer waterproofing, it would be acting as a cavity-drained system. The wall ties would therefore need to be omitted and the inner leaf designed as a loadbearing single-leaf wall. Appropriate floor details would also have to be adopted.

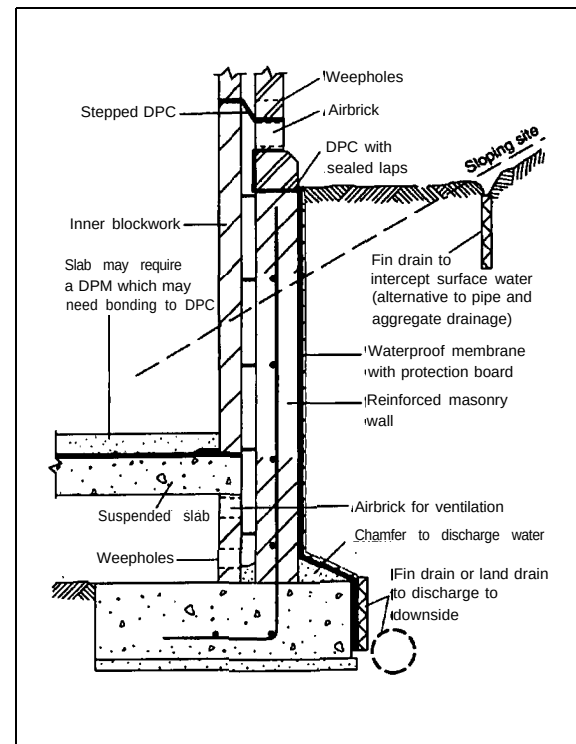
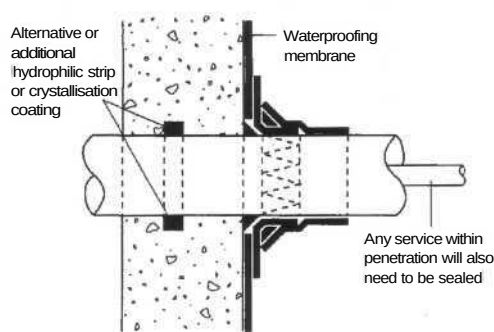


Figure 13: Discontinuity of waterproofing on free draining site

Discontinuity of waterproofing is possible here because any water rising by capillary action is effectively prevented from reaching the inside face of the inner leaf. In addition, any water penetrating the outer leaf is intercepted by the cavity and discharged below the slab level. Such construction cannot be used where the water table is high or variable. Nor is it feasible with soils of low permeability on a flat site, as water could build up within the cavity and rise above slab level. Discontinuity of the waterproofing system must, therefore, be considered only where the ground and structure are able to prevent water ingress. This is possible only with certain constructions on sloping sites or in freely draining soils with a low water table. Discontinuity may also only be acceptable where natural gases such as methane and radon are not present.

Preference should always be given to taking services up and over the walls to avoid penetrating the basement walls below ground. If holes are unavoidable, they must be properly detailed. Details will vary according to the category and size of the penetration and the waterproofing system being used. Figure 14 shows a typical approach. The service itself must also be waterproofed into the service penetration.

Because of the variations between different waterproofing systems and type and form of service, they must be discussed with the manufacturer and specific details decided for the project in hand. Avoid using general manufacturer's details as they are most unlikely to suit every case.



Note: Service penetrations below ground should be avoided wherever possible

Figure 14: Service penetrations through waterproofing

Selection procedure

To ensure that the risk of moisture penetration is kept to an acceptably low level for the life of the structure, the appropriate systems must be combined and considered together. Having completed the investigation already outlined, the design team should now be able to decide the waterproofing strategy. *Figure 15* is provided to help in the selection process. However, it was shown at the beginning that choosing and specifying a waterproofing system is a specialised task. It is therefore most desirable that the manufacturers of the likely systems are contacted early. Their expertise will help ensure success.

Guide to assessing basement designs

Figure 15 gives general guidance on the suitability of various forms of construction under differing water table positions.

The broken lines represent the maximum acceptable risk and therefore the minimum acceptable construction for

the prevailing water table. Constructions to the right of the broken lines have progressively lower risk, quantified by the variation in depth of tint. A line running through a box indicates a variable risk of acceptance and unacceptance, depending on the prevailing soil conditions as learned from the site survey.

The position of the line within the box is an attempt to further quantify the risk. For example, a Type A construction with waterproofing in a low water table is likely to provide an acceptable solution in many soils but may be unsuitable or require additional drainage or waterproofing in soils with particularly low permeability. At the extreme, the low permeability might cause a temporary perched water table, so creating in effect a variable water table or hydrostatic pressure on the wall.

Similarly, if a variable water table stays high for some time, thus behaving like a permanently high water table, a Type A construction with drainage might not be acceptable without further upgrading. Such upgrading could involve internal waterproofing or the creation of a drained cavity.

An example of a degree of upgrading of a Type A construction is given in *Figure 13* in which a conventional cavity wall provides a secondary means of defence against water ingress, and would be effective under certain ground/soil conditions (see *Waterproofing details* on page 13).

The above shows the significant effect that the water table has on the selection process, and how, in consultation with the waterproofing manufacturers, it may be possible to modify a basic construction to make it suitable for a more severe situation.

A Grade 3 or Grade 4 environment can be achieved by using a similar construction to that required for Grade 2, but with additional ventilation or dehumidification, the cost of which may be influenced by the initial type of construction and the external soil conditions.

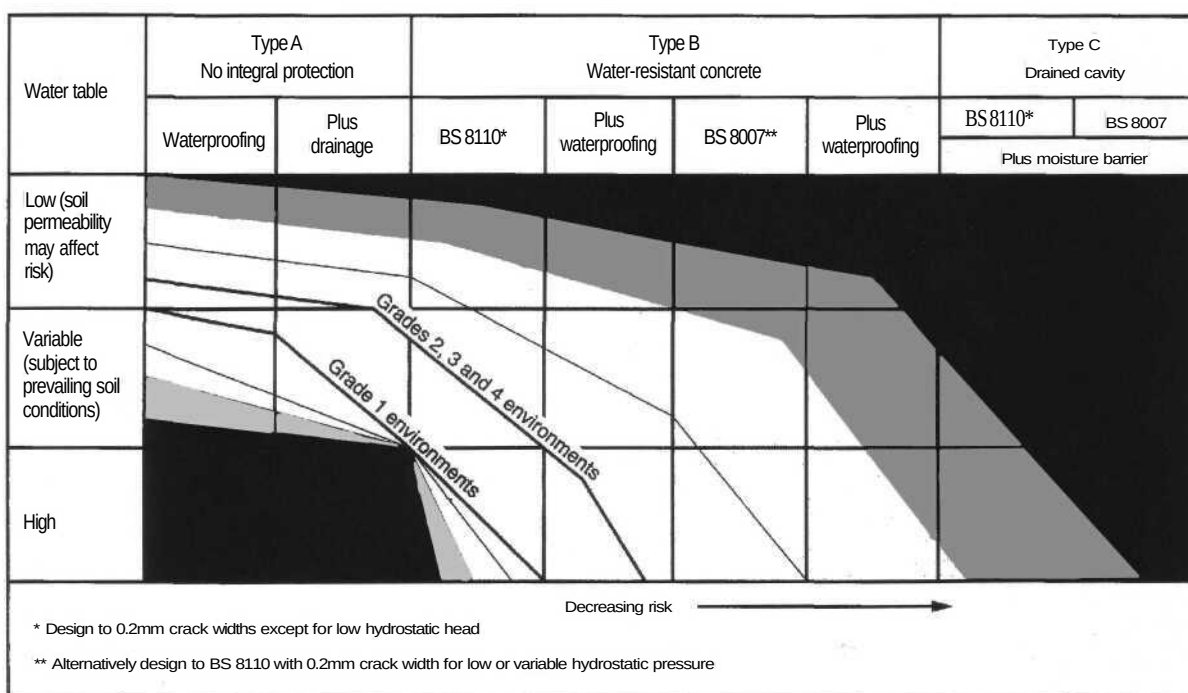


Figure 15: Design assessment guide to assessing designs for basements

Assessing risk

Ground conditions dictate the options available. The least severe give the most options, while the most severe leave the design team with very few. The severity falls into three basic categories according to the position of the water table, although variations can occur within them. If natural gases are present, specialist advice should be sought.

Permanently low water table

If the water table is permanently low, and there is no significant risk of percolating water building up a hydrostatic head, then conditions are the least severe. In this situation, the design team has an almost free hand to choose the most appropriate form of construction and waterproofing system.

With low-permeability soils such as some clays, there is a risk of a perched or variable water table - and therefore of water pressure against the structure - unless adequate drainage can be provided. Such drainage could, for example, consist of land drains discharging to the downside on a sloping site.

An alternative would be a water-activated submersible sump-pump taken below the lowest slab level. This may also be considered on a normally free-draining site to cater for unexpected adverse conditions.

Where groundwater contains aggressive chemicals such as sulfates, the choices are reduced to Type A or B construction in consultation with the membrane manufacturer. If Type A is used, the structure should be tanked with an external membrane capable of resisting the aggressive chemical. With Type B, the concrete must be able to withstand the aggressive chemicals. If in doubt, consider applying a suitable external protective membrane.

Variable water table

If the site cannot be drained and the water table rises occasionally, the severity is increased. Just how severe depends on how high and for how long the water table rises. Generally, in these circumstances, only a Type B or C construction can be considered to carry an acceptably low level of risk.

When selecting a Type B construction, consider incorporating some form of waterstop in construction joints (see Figure 2). If the water table remains high for long periods, then a second, back-up waterproofing system could be considered. However, do not lose sight of the fact that the water-resistant structure must remain the first line of defence against water penetration.

When a Type C construction is selected, the structure must still play a major role in keeping out water. If moisture ingress is too rapid, the cavity is more likely to be unable to cope with the water. In addition, the method of getting the ingress water away plays an important part in assessing the risk. If pumps or drains fail, water is likely to enter the basement.

If the groundwater contains aggressive chemicals such as sulfates, a Type B construction should consist of a suitably resistant concrete or have an appropriate externally applied membrane. Type C construction should include an externally applied membrane to protect the structure.

Permanently high water table

If the water table is permanently above floor level, the severity is increased. However, if a drainage system can be installed to lower the water table permanently, the severity is proportionally reduced, leaving the design team with the same options as given above for *Permanently low water table*.

However, if there is any doubt about the long-term effectiveness of the drainage system, the risk is increased and the structure must be considered to be in a category of either variable or permanently high water table.

In this, the most severe category, the nature of the risk is the same as for a variable water table except that the risk is higher. This is because the water exerts a permanent pressure on the structure. To reduce risk, a back-up waterproofing system should always be considered.

All other factors discussed under *Variable water table* apply.

Glossary

Air dry	When the surface humidity of a material is equal to that of the ambient surrounding air
Combined system	Two or more waterproofing systems used together
Construction joint	Joint formed in-situ, for example in concrete, when continuity is not possible
Damp	The condition of a material when wetter than air dry
Damp-proof	Impervious to moisture, not permitting moisture to enter
Damp resistance	The ability of a material to exclude moisture
Damp-resistant	Having a high resistance to moisture penetration
Drained cavity	A continuous cavity which intercepts and drains away incoming water
Expansion joint	Joint that permits relative movement caused by expansion and contraction due to changes of temperature or moisture
External waterproofing	Where the waterproofing system is positioned and placed against the outside face of the main structure
External(reverse) waterproofing	Where the waterproofing is positioned outside the main structure but placed against the enabling works
Free-draining	Ground through which free water rapidly drains away
High water table	Where the water table is above the underside of the lowest floor level
Hydrostatic head	Water pressure, expressed as an equivalent depth of water

Hydrostatic pressure	The water pressure exerted as a result of a hydrostatic head
Integral protection	Where the structure itself provides the necessary protection to the passage of water
Kicker	Small concrete upstand, cast above floor level to position wall or column formwork for the next lift
Kickerless construction	A mechanical means of retaining formwork in position, eliminating a kicker
Loading coat	A material applied to the waterproofing membrane to enable it to resist hydrostatic pressure
Low-permeability	Resistant to water penetration
Low water table	Where the water table is permanently below the underside of the lowest floor level
Membrane	A material which forms a continuous effective barrier to the passage of water
Moisture	Water in the form of vapour as well as liquid
Perched water table	Where, because of insufficient permeability of the soil, percolating water is held above the underside of the lowest floor level, resulting in hydrostatic pressure
Protection layer	An element used to provide protection to a waterproofing system
Sandwiched waterproofing	Where the waterproofing system is between the two non-tied leaves of the main structure
Vapour check	A continuous vapour-resistant layer
Vapour resistance	The ability of a material to resist vapour penetration
Vapour-resistant	Excludes water and has a high resistance to vapour penetration
Variable water table	Where the water is occasionally above the underside of the lowest floor level
Water	Water in its liquid form
Waterstop	A product or system, placed in-situ, to prevent the passage of water through a discontinuity or joint in site-placed concrete
Waterproof	Impervious to water, not permitting water to penetrate
Waterproofing system	The total method or combination of materials used to create a waterproof protection
Water-resistant	Having a high resistance to water penetration
Water vapour	Water in its gaseous form

References

- (1) BRITISH CEMENT ASSOCIATION. *Options for quality in housing: Basements 1: - benefits, viability and costs*. Slough (now Crowthorne), British Cement Association, 1992. 37 pp. (Ref. C/10).
- (2) BRITISH CEMENT ASSOCIATION & BRITISH STRUCTURAL WATERPROOFING ASSOCIATION. *Basement waterproofing: Site guide*. BCA, Crowthorne, 1994. 20 pp. (Ref. 48.059)
- (3) BUILDING RESEARCH ESTABLISHMENT. *Interstitial condensation and fabric degradation*. BRE, Garston, 1992. Digest 369. 8 pp.
- (4) BRITISH STANDARDS INSTITUTION. BS 5930 : 1981. *Code of Practice for site investigations*. London, BSI, 1981. 148 pp.
- (5) JACKSON, N AND DHIR, R. (Editors) *Civil engineering materials*. Basingstoke, Macmillan Education 4th Ed., 1988. 429 pp.
- (6) BUILDING RESEARCH ESTABLISHMENT. *Radon: guidance on protective measures for new dwellings*. BRE, Garston, 1991. BR211. 10 pp.
- (7) DEPARTMENT OF THE ENVIRONMENT AND THE WELSH OFFICE. *The Building Regulations 1991. Approved Document C. Site preparation and resistance to moisture*. London, HMSO, 1991. 23 pp.

Other publications relating to basement structures

BRITISH STANDARDS

BS 8007: *Code of practice for design of concrete structures for retaining aqueous liquids*.

BS 8102: *Code of practice for protection of structures against water from the ground*.

BS 8110: *Structural use of concrete. Part 1: Code of practice for design and construction*.

BS 8301: *Code of practice for building drainage*.

NATIONAL HOUSEBUILDING COUNCIL. *NHBC Standards*. Vol. 1. Parts 1-5. Amersham, NHBC, 1991.

Chapter 3.1 'Siting of dwellings' reviews items to be taken into account when developing sites. Relevant areas include waterlogging, retaining walls and ground stability.

Chapter 4.1 'Foundations - finding the hazards' gives guidance on the identification of hazardous site conditions which need to be considered (e.g. groundwater). Chapter 5.1 'Substructure and ground-bearing floors' includes guidance on habitable rooms wholly or partially below ground level, masonry below DPC and tanking materials.

Chapter 5.3 'Drainage below ground' includes guidance on groundwater drainage.

ZURICH MUNICIPAL. *Building guarantee technical manual*. Farnborough, Zurich Municipal, 1994.

Section 3 'Damp proofing' includes requirements and guidance on subsoil drainage to prevent waterlogging, and on the application of basement tanking.

Section 13, Clause 13.5 'Damp proofing' gives guidance on the application of tanking to existing walls in basements.

