

7 SITE LAYOUT DESIGN

7.1.1 Access and temporary roads

Some rules for design and layout of road systems are the following:

- Give the safest route between places
- Make traffic routes wide enough – largest vehicle permitted
- Only one way if possible
- Avoid passing close to fuel or chemical tanks, or unprotected edges
- Safe areas for loading and unloading
- Avoid crossings, and signpost them clearly for the right way
- Make entrance and gateways wide enough (when possible, let enough space for a vehicle to stop without causing obstruction)
- Set sensible speed limits and clearly signpost them. Use suitable speed reduction measures if necessary
- Give warning of any height and/or weight restrictions
- Protect from potentially dangerous obstructions (electric cables, etc.)
- Maybe a signaller is needed
- Provide screens or other protection for people at risk from exhaust fumes
- Restrict access to vehicles where you store dangerous substances
- Vehicle traffic should be kept away from maintenance works on or near roads

The roads should be constructed over a suitable surface with no obstructions, and maintained to provide good grip for vehicles. Potholes must be avoided and repaired immediately. Wherever it is possible, roads should be constructed of tarmac, concrete or another suitable material. The pavement surface must be firm and properly drained. Steep slopes should be avoided, or when it is not possible, they should be signposted properly.

Roads are changed as work progresses, so they must be carefully planned. We must make sure that all drivers and pedestrians know which routes they should use at any time. It is also important to highlight the following conditions:

- Driver competence
- The provision of information and instruction for drivers
- Traffic management (temporary road signs and traffic lights)
- Supervision of drivers, vehicle activities and other employees

The access roads must be adapted to the type of vehicle and load that will use it. For that, we should design the width of the roadway, the radius at the corners and the slope. The maximum grade should be 12% when straight, and 8% when curved. For pedestrian access, this grade should be about 8%, but never more than 12%. Transitions (start and end of the ramp) should not be more than 6%. The minimum road width is 4.5 metres when straight and 6 metres when curved.

The sloping sides for a ramp should also be designed in order to know the free space we get on site to move. This slope should be according the angle of internal friction of this soil.

Pedestrian and vehicle access should be differentiated to avoid any kind of interference. Safe pedestrian routes should be designated to work locations and vehicle-only areas defined where there is limited space or heavy traffic.

Example of ramp design

We have to calculate the length of a ramp for a seven-metre-deep excavation.

As it is established, the maximum slope is 12%. So the calculations for the horizontal length of the ramp will be as follows:

$$\frac{12}{100} = \frac{7}{x}$$

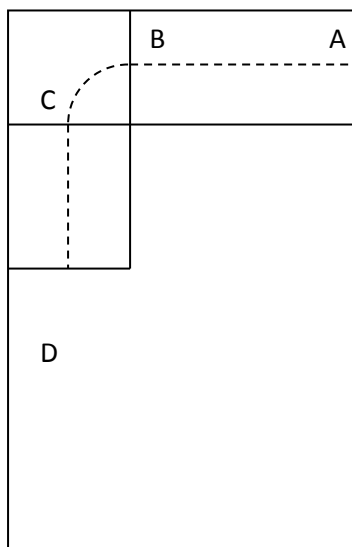
$$12x = 7 \times 100$$

$$x = \frac{700}{12} = 58.3m \text{ long}$$

Another example of ramp design

We have to design the length of a ramp for a three-metre-deep excavation in a 15x30m confined site.

The ramp is longer than the excavation limit so we have to adapt it.



The dashed line is the length to calculate but there will be different slopes: 12% straight and 8% curved, so we have to do it step by step.

Curved-road width is minimum 6 metres. The radius to consider is then 3 metres.

A-B

Maximum length = $15 - 6 = 9m$

$$\frac{12}{100} = \frac{h_1}{9} \rightarrow h_1 = 1.08m$$

If total height is 3m, we still need to go 1.92m deeper.

B-C

To calculate total length of B-C we need to calculate the perimeter of a three-metre-radius circle and then divide it by 4.

$$Perimeter = 2 \times \pi \times r = 2 \times 3.14 \times 3 = 18.84$$

$$B - C \text{ length} = \frac{18.84}{4} = 4.71m$$

Now we calculate the height we can go deeper (slope is 8% in this case)

$$\frac{8}{100} = \frac{h_2}{4.71} \rightarrow h_2 = 0.38m$$

So we still need to go 1.54m deeper.

C-D

We can finish the ramp in this interval, so the only thing we need is the horizontal length. In this case it is straight, so maximum slope is again 12%.

$$\frac{12}{100} = \frac{1.54}{x} \rightarrow x = 12.8m$$

So the total length for the ramp is as follows:

A-B: 9m

B-C: 4.71m

C-D: 12.8m

The total horizontal length is 26.5m.

Pedestrian routes

Pedestrian routes should:

- be clearly separated from vehicle routes by fencing and/or a kerb, or other suitable means;
- be wide enough to safely accommodate the number of people likely to use them at peak times;
- allow easy access to work areas;
- be kept free from obstructions and tripping hazards;
- be clearly signed;
- ensure pedestrian safety where they cross main vehicle routes;
- provide pedestrians with a clear view of traffic movements at crossings and where gates used by pedestrians lead onto traffic routes;
- have clearly marked, separate access for pedestrian use at loading bays and site gates used regularly by construction vehicles.

At points where pedestrians cross busy vehicle routes, appropriate traffic control measures should be implemented.

If it is not possible physical segregation between pedestrians and vehicles, signallers and safe systems should be used. Systems of work should ensure that:

- drivers and signallers are in contact at all times;
- drivers and signallers understand the appropriate signals and site rules;

- the signaller controls the vehicle movements and gives clear warnings to pedestrians;
- the signaller is in a safe place

7.1.2 Offices and site accommodation

The contractors and clients should ensure that adequate welfare facilities are provided (CDM, 2015). This provision should be considered at the planning stage so that the location is appropriate. It usually includes:

- Toilets
- Washing facilities
 - Hot and cold water
 - Soap
 - Towels or similar
 - Sinks
 - Sanitary waste disposal in facilities
 - Showers depending on the activity
- Changing facilities
- Drinking water
- A place to rest and eat
 - Seats and tables
 - Possibilities for heating drinks and food

On open sites, the site accommodation should be located close to the entrance in order that vehicles and personnel may be readily observed entering the site. Under the CDM regulations, the principal contractor is responsible for preventing unauthorised access to the site. Site notices instructing personnel entering the site to report to the office should be displayed. Site compound areas should be adequately stoned up or surfaced and consideration should be given to the site parking of vehicles for staff and operatives. The site office area may be fenced and provided with secure gates.

The space available on site at a premium and on restricted sites, consideration may be given to stacking site accommodation on top of each other or locating the offices on a gantry over the pavement. Alternatively, the contractor may be forced to rent some space adjacent to the site. The contractor may also think about locating his offices in the building being refurbished, if this ties in with the sequence of work or moving the accommodation into completed parts of the building as it is being constructed. On restricted sites, problems also relate to the storage of materials and the location of plant and equipment.

The location of offices and accommodation will also be influenced by the location of access roads and site services. Careful attention is required with regard to site security and arrangements may need to be made to have the site well illuminated at night. Powerful security lighting may be used for this purpose in order to deter theft and break-ins. Consideration will have to be given to the siting and location of the site signboards and any sample panel areas (e.g. facing brickwork).

7.1.3 Plant and equipment

The contractor will have to consider the storage and security of plant during evenings and weekends. A locked compound may be provided. The location and working radius of cranes will need to be marked on the site layout plan in order to establish the best location for delivery points.

Considerations will have to be given to the rights of adjoining owners with regards to the swinging of tower crane jibs and booms over land adjacent to the site. The contractor has no rights to enter the air space of an adjacent site without permission from the owner, and may be sued in trespass if he does. Likewise the contractor has a duty of care to persons using footpaths, streets and highways adjacent to the works. The main contractor is responsible for the deeds of his subcontractors when working in the vicinity of an adjacent highway. The contractor may be sued for negligence in the case of an accident involving the public.

Consideration will also have to be given to site space requirements around the building for the provision of scaffolding.

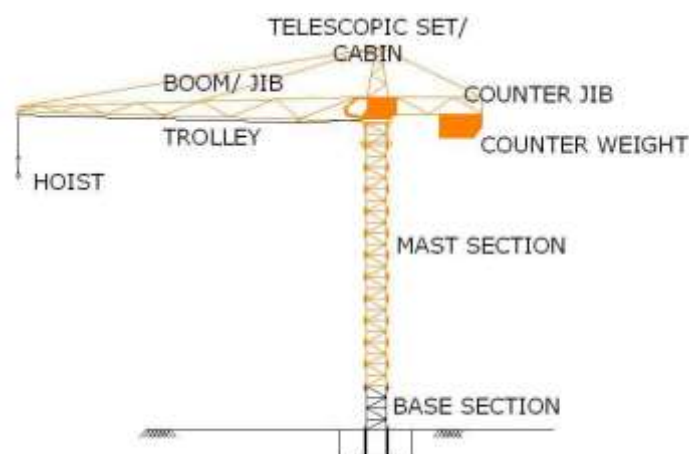
7.1.4 Cranes

Tower cranes should have several conditions:

- It must cover all the area of the construction
- It should be able to take materials from storage
- It is preferable not to cross over administration buildings and facilities, nor any other existing buildings

When we have several cranes in site, there can be problems with interferences between them. To avoid it, the following issues must be covered:

- they will have different heights
- the jibs mustn't cross over any mast
- The counter jibs of lower cranes mustn't cross the way of others



When describing a crane, the main parameters to define are:

- Maximum capacity
- Capacity at maximum jib length
- Maximum jib length
- Maximum freestanding hook height

The placement of tower cranes should be at the easiest point, considering:

- the type of foundation we need;
- the heaviest load to lift;
- the distance to reach;
- the mast must not strike any part of the construction.

The most appropriate place is that one outside the construction, but if it is not possible, they can be installed in patios, lift holes or other future vertical installations.

Mast anchorages can be used to hold it to the building structure. This way we can increase height and load capacity.

There is also the possibility to use mobile cranes. The most common examples are rail mounted tower cranes and vehicle mounted cranes. Rough terrain cranes and crawler cranes are used for soils that are deficient or impossible to work on wheels.

7.1.5 Storage

One of the major considerations is the safe and secure storage of materials and components, in order to reduce waste and ensure safe working procedures. Materials are expensive and care must be taken when handling, storage and placing on site.

This storage should be clearly defined at the start of works, ensuring that it will be enough at all times. It is necessary to calculate this area with the following considerations:

- Calculate the quantity of materials you are going to need at any time;
- Estimate (with your programme) when you need them on site;
- Establish a material flow and the quantity for storage;
- With it, dimension your storage place.

It is also required considerations about possibilities to move them on site and the equipment used, as well as loading and unloading operations. Sometimes, it is useful to have a dedicated labour team to unload and distribute materials directly to their place so that we avoid double handling.

Other times, we do not have enough space on site for storage. In that case, we can have different solutions:

- Store outside your site (it can be more expensive and you should take specific measures in your health and safety plan);
- Occupy public space (you should ask for permission to the Council and probably pay any fee);
- Adapt supply to immediate production (it can be risky if suppliers are not on time).

Specific considerations for material storage are required on the site layout plan:

- Bricks and blocks should be stored on a firm clean surface or on pallets suitable for handling with a fork lift truck. Blocks should not be stacked too high. Bricks should be stored in locations which do not become waterlogged and where the brick stockpiles will not become contaminated by mud.
- Structural timber should be ordered in cut or stock lengths to avoid cutting waste and may be handed for ease of handling. Timber must not be stored clear of the ground and protected with polythene or tarpaulin sheets to avoid changes in moisture content.
- Finishing timbers such as architraves, skirtings and door linings should be ordered in door sets. Skirtings and timber mouldings must be stored internally on horizontal racking. On housing projects and similar, garages should be constructed early in the project where possible and used for storage purposes.
- Roof trusses may be stored on purpose-built, timber or steel storage racks, which support the trusses clear of the ground. It is preferable to deliver the trusses to site in phased deliveries so that they may be lifted directly into position.
- Scaffolding and props may be stored on horizontal racking with the fittings stored in drums or bins. These are expensive components to lose, as the contractor will be charged for losses by the hire firm.
- Drainage goods are fragile and easily damaged if mishandled. Drainage fittings may be delivered to site in a crate. Pipes may be banded and stored on timber separators. Materials may be stored adjacent to the works in a small compound.

7.1.6 Waste

The site must be organised and clean. It is a very important matter for health and safety. According to the dimensions of the site, we may need a gang for waste management or even can be developed by the same gang responsible for storage.

It is important to study waste movement. Vertical movement can be helped with cranes, but also special equipment can be used, such as plastic pipes. These pipes should be covered with noise insulation and muffling material. Besides, dust can be prevented watering the waste or with better with plastic sheet or similar.

Waste should be split in different fractions so that treatment or disposal can be easier. This means that we need different containers, what requires more space. In addition, the waste storage should have easy access for loading and unloading. Hazardous waste will need special requirements for storage and disposal.

Possibilities of waste reuse or treatment should be considered on site or off site. This will be included in the Site Waste Management Plan.

7.1.7 Site services

Unless the contract period is short, the site will need to be services with permanent water, power and sewerage facilities and existing services will need to be located. Water and drainage connections

will need to be made and the site will have to be hooked up to electricity and telephone services. Services crossing the site may have to be diverted.

The statutory authorities will need to be contacted in order to establish existing locations and entry points for new services. The contractor will be required to establish the proposed location of temporary standpipes for site mortar mixing or facilities for the washing down of site vehicles. On open, greenfield sites, permanent services may have to be laid early in the project to provide temporary service connections.

7.1.7.1 Electric power supply

Power supplies to major items of plant such as tower cranes will need consideration, together with the provision of electrical service connections for site power tools and site temporary lighting.

We should make an estimation of electric power demand for our site. For that, we can use the following formula:

$$W = \Sigma(w_e \cdot k_e) + \Sigma(w_t \cdot k_t) + \Sigma w_i$$

W_e : engine/equipment (pile driver, batching plant, tower crane, etc.)

W_t : power tool (power saw, poker vibrator, vibro-hammer, etc.)

W_i : illumination, lighting (lamp, spotlight, reflector tower, sign, office, etc.)

k_e and k_t are coincidence factors

If we have only one unit, then $k = 1$

If we have more:

- Tower cranes: $k_e = 0.7 - 0.8$
- Pile drivers: $K_e = 0.6 - 0.8$
- Dewatering pumps: $k_e = 1$
- Power tools: $k_t = 0.2 - 0.3$

REFERENCES

Cooke, B. & Williams, P. (2009) Construction Planning, Programming and Control. 3rd Edition. Blackwell Publishing.