Concrete

This training package provides information on basic concrete, including materials, reinforcement, formwork, concrete mix, placement and curing for village infrastructure and houses common in South-East Asia and the South Pacific region.

Features of Concrete in Structures

Concrete is a mixture of portland cement, sand, stone (called aggregate) and water, which sets hard.

It may include components which provide colour, increase strength, accelerate hardening, retard hardening, improve fluidity, lighten the structure and many other functions.

- Concrete is **strong in compression, but weak in tension**.

  i.e. It may crack when pulled apart, but not when squeezed together. Tensile strength is provided to concrete structures by the incorporation of steel reinforcement.

- Concrete **shrinks and cracks**. The inclusion of steel reinforcement (at close centres) will restrict the width of cracks that for in concrete as it shrinks.

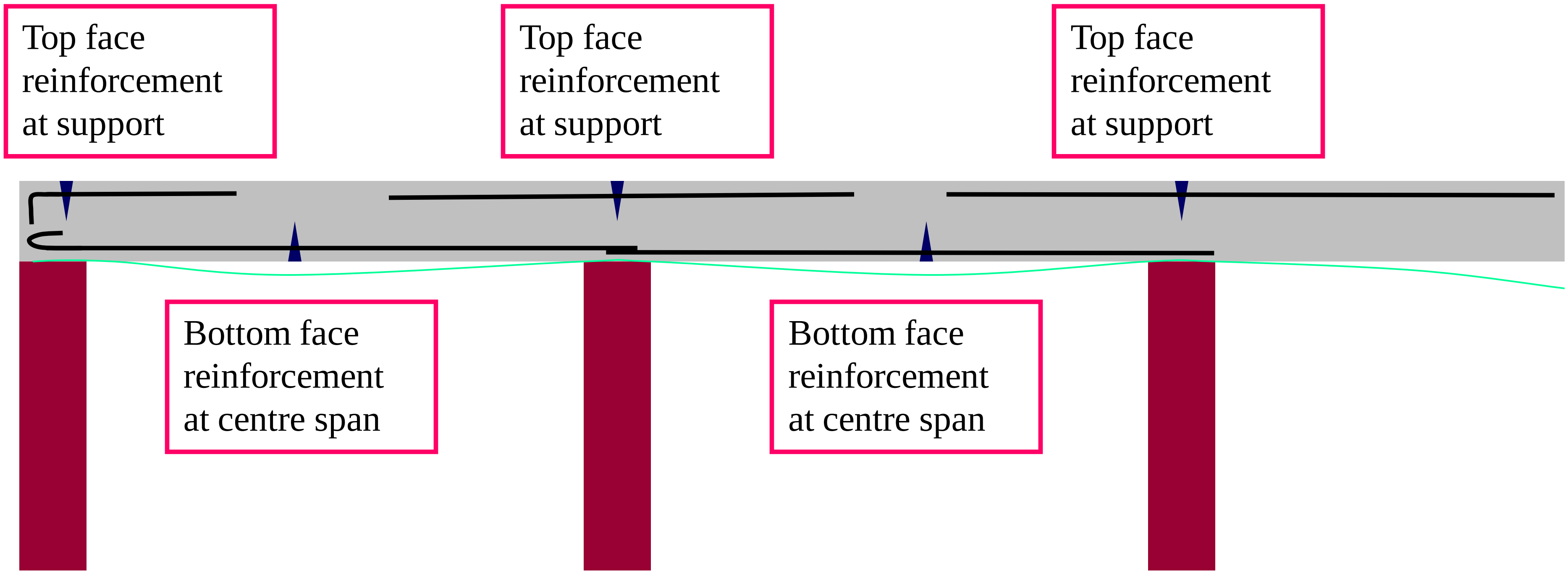
- Steel **reinforcement rusts, expands and spalls** the concrete if it is placed too close to the concrete surface or if the concrete does not include sufficient cement to protect the steel.

Deflection and Cracking of Concrete Structures

When a concrete slab is suspended, it will bend under the action of its self weight and any imposed gravity loads.

Cracks will form at the **top** of the slab **over supports** and at the **bottom** of the slab at the **centre** of the span. It is at these locations the main tensile reinforcement is placed.

Note: There is other reinforcement placed in concrete slabs and beams to control shrinkage cracking, support the main reinforcement and to control **diagonal shear cracking near supports**.



Cracking and Control Joints

Control joints are incorporated in concrete members to accommodate cracking due to shrinkage and movement of the structure.

The control joint material and detail that can accommodate expected movement.

20 MPa Concrete Specification

For use in slab-on-ground or for footings

Approximate mix (by volume) 1 : 2 : 4

For 1 cubic metre of 20 MPa concrete, the mix should be:

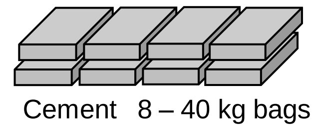
- **8 bags (40 kg each) of GP or GB portland cement**

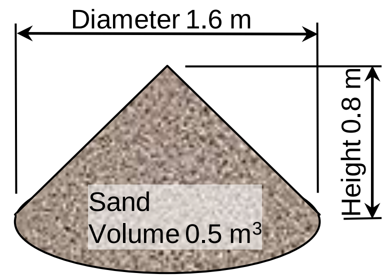
  OR 16 bags (20 kg each)

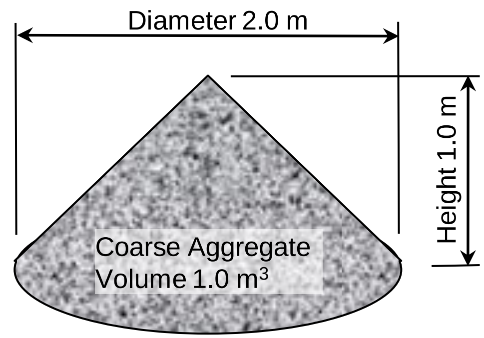
- **0.5 m^3 of sand** - Sand should be clean sharp sand, NOT brickies sand or plasters sand.

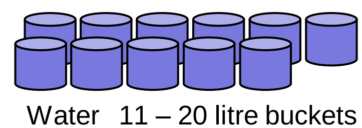
- **1.0 m^3 of 20 mm coarse aggregate** - Aggregate should be clean 20 mm river gravel, crushed aggregate or similar.

- **200 – 220 litres of water** – Approximately 12 20 litre buckets (300 mm diameter x 290 mm deep). Less water should be used if sand or aggregate are damp.









Basis of calculation:

Density of cement , dry sand and dry aggregate 1,500 kg/m^3

Includes 5% allowance for wastage.

Source: Cement Concrete & Aggregates Australia

25 MPa Concrete Specification

For columns, beams and suspended slabs

Must be designed and specified by structural engineer

Approximate mix (by volume) 1.1 : 2 : 4

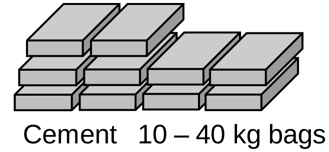
For 1 cubic metre of 20 MPa concrete, the mix should be:

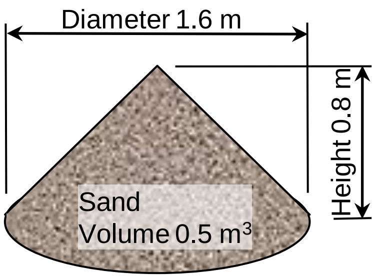
- **10 bags (40 kg each) of GP or GB portland cement**
  OR 20 bags (20 kg each)
- **0.5 m^3 of sand** - Sand should be clean sharp sand, NOT brickies sand or plasters sand.
- **1.0 m^3 of 20 mm coarse aggregate** - Aggregate should be clean 20 mm river gravel, crushed aggregate or similar.
- **200 – 220 litres of water** – Approximately 12 20 litre buckets (300 mm diameter x 290 mm deep). Less water should be used if sand or aggregate are damp.

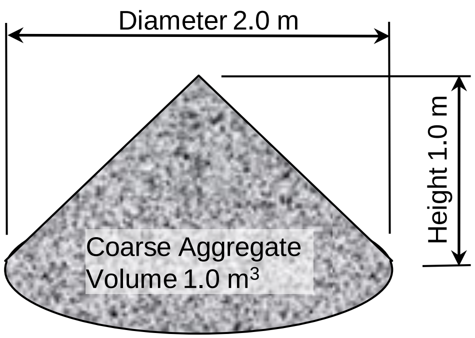
Basis of calculation:

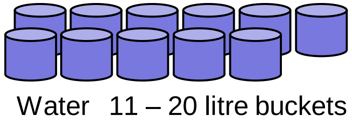
Density of cement , dry sand and dry aggregate 1,500 kg/m^3

Includes approximately 5% allowance for wastage.





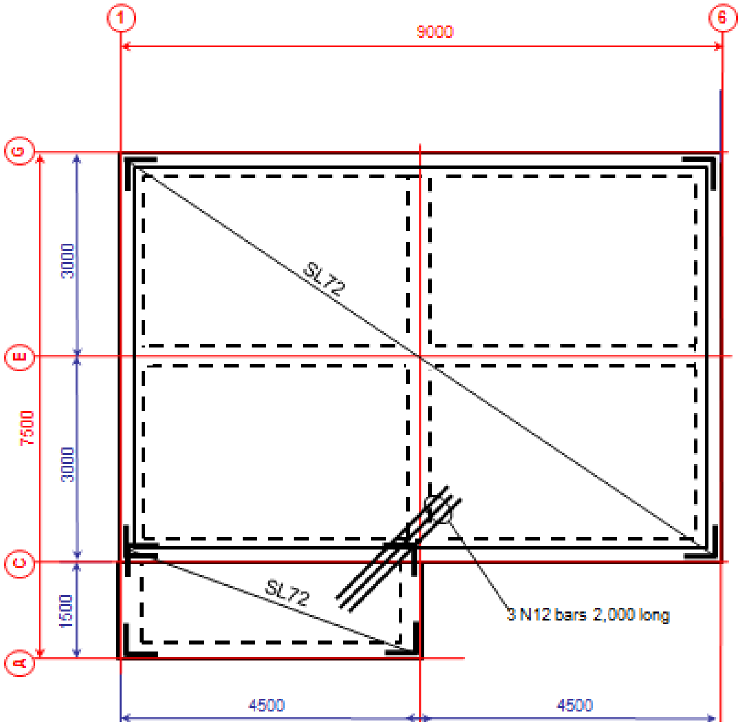


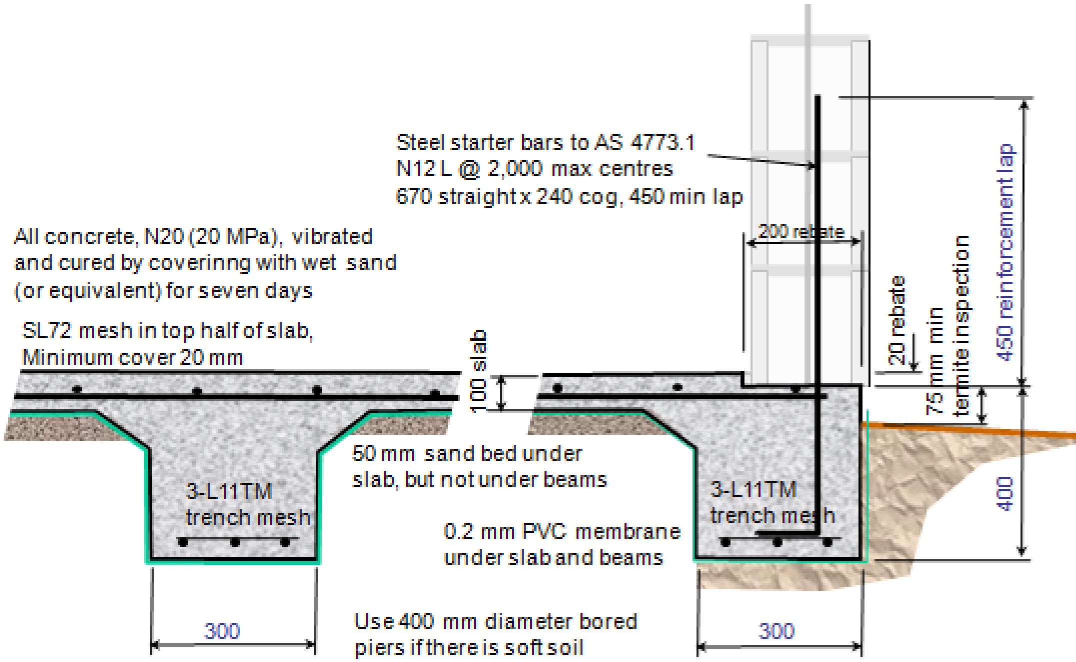


Source: Cement Concrete & Aggregates Australia

Concrete Slab-on-Ground

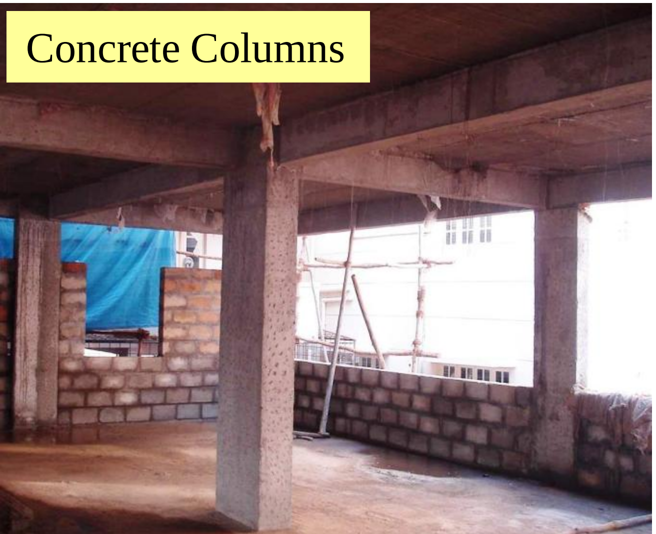
Refer to separate training module for the design and construction of concrete slab-on-ground for superstructures of reinforced single-leaf concrete masonry or clad timber or steel.





Concrete Superstructures

Refer to separate training module for the design and construction of concrete superstructures, including reinforcement and formwork for columns, suspended slabs and walls and precast walls and slabs.



Problems with Concrete

Excess Water in Concrete

Reference: *Beware of excess water*, Cement Concrete & Aggregates Australia, March 2006:

<u>Strength</u> – The strength of the concrete, and hence it's ability to support loads, can be severely diminished by too much water in the mix.

<u>Cracking</u> – As water evaporates from concrete during the hardening process, there is a tendency for "early-age cracking" and "drying shrinkage cracking". The width and extent of cracks will increase as the amount of water is increased.

<u>Delamination</u> – If concrete is too wet when finished, it could dry and shrink at the surface, which remaining moist underneath, causing delamination to occur.

<u>Abrasion / Surface Dusting</u> - Excessive moisture in concrete can lead to reduced abrasion resistance of the surface, leading to 'dusting' and possibly to exposure of the coarse aggregate

<u>Durability</u> – Concrete with excess water will be more prone to penetration by water and salts , and may exhibit increased risk of reinforcement corrosion and spalling of the surface (concrete cancer).

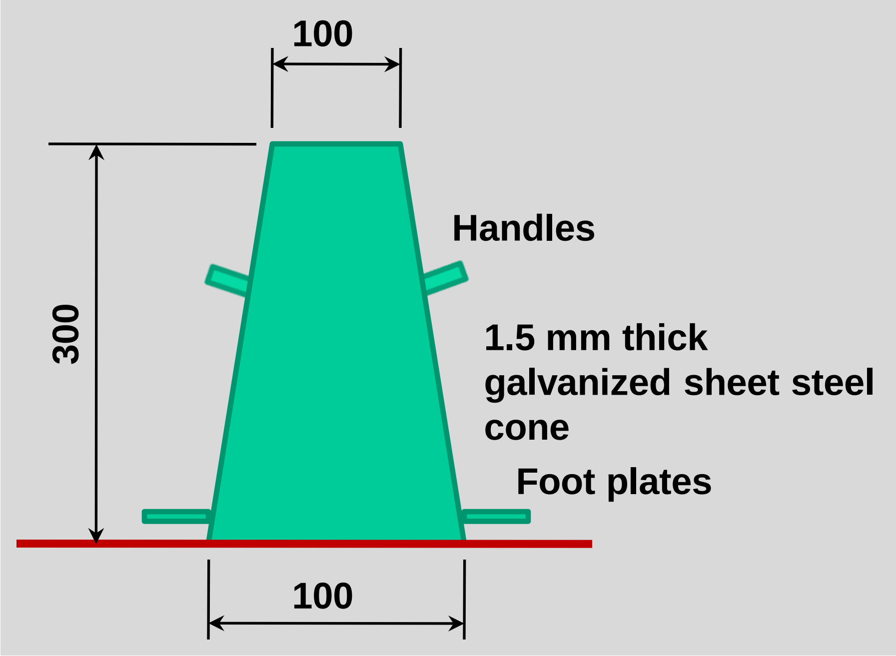
Slump Test Indicates Water in Concrete

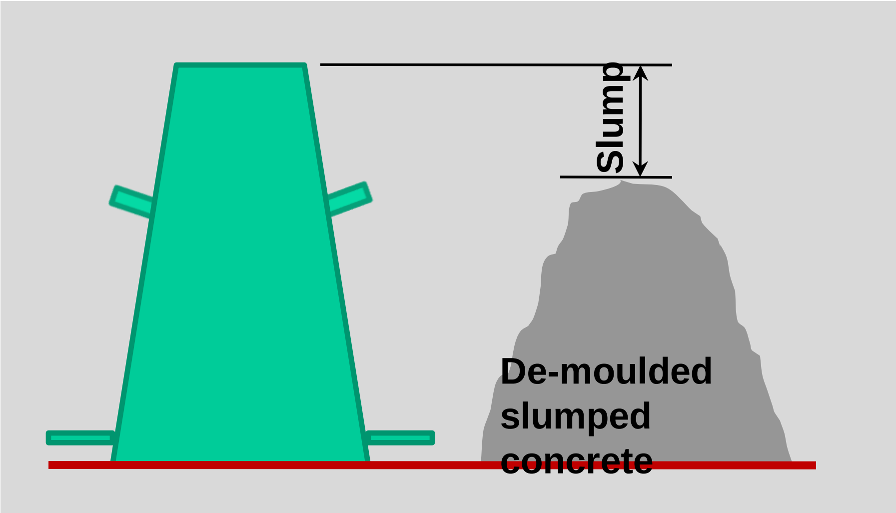
The fluidity of fresh concrete may be measured by the slump test.

Concrete slump is determined by moulding fresh concrete in a 300 mm high steel cone.

The mould is then removed and the fresh concrete will settle. The slump (the distance down from the top of the cone) can be measured.

The slump test gives an indication of the quantity of water in the fresh concrete, although slump is also influenced by the grading of the fine and coarse aggregate, the shape of the aggregate and the quantity of cement.

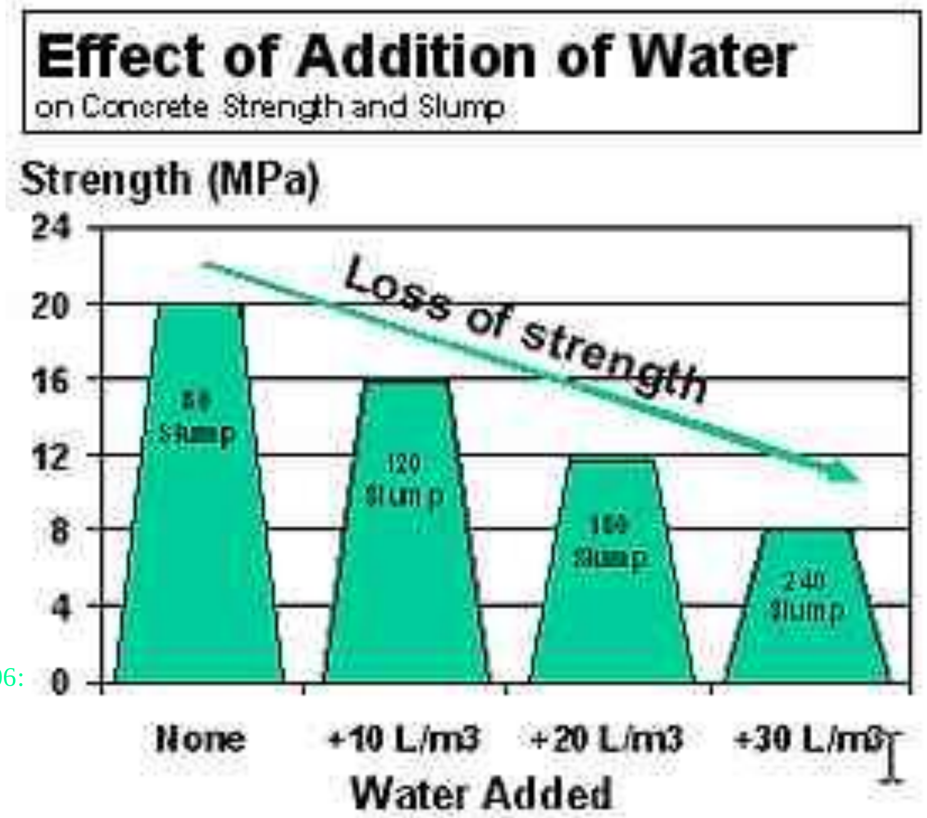




Excess Water Reduces Strength

- If no other adjustments to a mix are made, 25% increase in slump from 80 mm to 100 mm could result in a reduction in strength of approximately 1.5 MPa (approximately 7.5% in 20 MPa concrete)
- If no other adjustments to a mix are made, 50% increase in slump from 80 mm to 120 mm could result in a reduction in strength of approximately 25%.

This chart shows that as increasing quantities of water are added, there is a resulting loss of strength.



Source: Readymix - The Effect of Excess Water in Concrete
http://www.readymix.com.au/Toolbox/DIY/excessWater.shtml

Similar information is available in:
Beware of excess water, Cement Concrete & Aggregates Australia, March 2006:

Excess Water in Premixed Concrete

Site Practices

Often concrete will stiffen rapidly, particularly in hot or windy conditions.

Concretors will request that "water be added" to the mixer trucks.

The consequence of refusal is the risk of uncompacted and poorly finished concrete.

Because the water addition is made on site, there is very little control, and the resulting concrete most often has more water than necessary, with a resulting unpredictable increase in the risk of shrinkage, cracking and low strength.

Provided that no water is added on site, concrete may be specified with a 100 mm slump.

Footing Reinforcement

The diameter, dimensions and position of reinforcement should be inspected before placing concrete.

A common footing design is
1000 x 1000 x 500 with 10 mm diameter reinforcement.

In some cases the reinforcement diameter is too small and the dimensions of bent bars are incorrect.

Strip Footings and Ground Beams

Do not put too much reinforcement in the footings and ground beams.

It is just a waste of money.

Footings and ground beams should have enough, but not too much reinforcement

Thickness and Reinforcement in Concrete Slabs-on-Ground

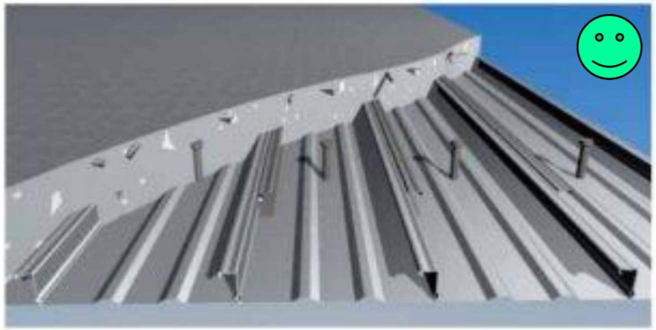
Often infill concrete slabs on ground are only 50 mm thick and do not contain any steel reinforcement. This can lead to cracking and moisture penetration.

The thickness of slabs-on-ground (that are bigger than 3.0 m x 3.0 m) should be at least 70 mm thick with at least SL42 steel reinforcement mesh (3.8 diameter at 200 mm centres) over compacted fill. If the thickness is increased, so should the reinforcement be increased.

Australia – The thickness of slabs-on-ground should be 100 mm thick with at least SL72 steel reinforcement over compacted fill.

Formwork

Edge forms for suspended concrete slabs are often difficult to secure and keep straight.



When permanent steel sheet formwork is used, preformed metal edge forms can also be screwed to the sheeting by short metal straps.

Reinforcement Cover

Steel reinforcement must be surrounded with sufficient thickness of well compacted concrete to prevent corrosion of the steel and spalling of the concrete, commonly known as "concrete cancer".

Suspended concrete roof corrosion (India)

Concrete wall corrosion (Australia)

Concrete lintel reinforcement corrosion (India)

Concrete corrosion (Australia)

The lapping of welded fabric reinforcement in the top face of a slab will significantly increase the thickness of reinforcement and reduce the cover.

Reinforcement Congestion

Congestion of reinforcement within beams, columns and the like reduces the cover and leads to difficulties in compacting the concrete around the reinforcement. This can cause both corrosion and loss of bond between reinforcement and concrete.

Vibration

The strength of concrete members (footings, slabs, beams, and columns) is dependent on the density of the concrete.

Concrete density can be maximized by adequate mechanical vibration.

Mechanical vibration is recommended for all concrete members. Although AS 2870 does not make mechanical vibration of residential footings and slab-on-ground construction mandatory, it is strongly recommended.

Photo: Wacker

Curing

Contractors often neglect the correct curing of slabs, resulting in excessive cracking and/or dusting and abrasion. It may be expedient for the Builder to assume responsibility for applying and maintaining the curing system.

Sprayed curing compounds require less attention than moistening and covering the slab for an extended period. Curing compounds should comply with AS 3799 and shall be hydrocarbon, solvent-based acrylic, water-based acrylic or wax-based acrylic. However, wax-based compounds should not be used in areas requiring the subsequent application of curing adhesives.

Concrete Finishing

Mechanical trowelling is used to produce a fine surface.

If the concrete has not achieved sufficient hardness, the mechanical trowel (helicopter) may “dig into” the surface.

Photo: Wacker

Excessive trowelling will lead to concentration of bleed water at the surface and eventual dusting and/or abrasion.

Recesses and Toppings in Concrete Slabs

In order to achieve falls in tiled floors in bathrooms and the like, it is preferable to recess the concrete slabs, otherwise there will be a lip at the tiled edge. This recess may be formed after the concrete has been screeded level. The corner position of recesses can be marked by fixing temporary vertical reinforcing bars to the fabric. Such bars should not puncture the membrane.

For large tiled areas, the slab should have uniform falls to wastes and associated pipework. If there is likely to be difficulty in achieving such uniform falls, it may be advisable to allow for a 40 to 50 mm topping laid subsequently by the tiler in accordance with AS 3958.1 Appendix A.. The thickness of the topping (if required), tile bedding and tiles should be shown on the structural concrete details, to ensure that the finished levels are appropriate.

Termite Management

Termites must be prevented from entering the building. Barriers force the termites to the surface, where they can be detected and destroyed.

An exposed concrete edge ensures the termites are visible

Termite barriers and membranes prevent termites from entering at the junction between walls and slabs.

Termite collars prevent termites from entering beside drainage pipes.

Waffle Pod Slab-on-Ground

As an alternative to conventional excavated ground beams, expanded polystyrene waffle pods may be used to form the ground beams on top of compacted foundations. For details, refer to AS 2870.

The builder must adhere closely to the tight tolerances specified in AS 2870 and on the engineering drawings.

Cracking Due to Excessive Retardant

Overdosing premixed concrete with retardant will cause excessive cracking and surface defects consistent with the extremely slow hardening.

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Disclaimer

This training package covers broad engineering principles and building practices, with particular emphasis on affordable housing and associated village infrastructure in the Asia-Pacific region. These broad principles and practices must be translated into specific requirements for particular projects by professional architects, engineers or builders with the requisite qualifications and experience. Associated sample specifications and drawings are available in electronic format, with the express intention that architects, engineers and builders will edit them to suit the particular requirements of specific projects. The design, construction and costing of structures must be carried out by qualified and experienced architects, engineers and builders, who must make themselves aware of any changes to the applicable standards, building regulations and other relevant regulations. The authors, publishers and distributors of these documents, specifications and associated drawings do not accept any responsibility for incorrect, inappropriate or incomplete use of this information.

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