CHAPTER 7

Concrete

CONCRETE

Concrete is the name given to a mixture of Portland cement and an aggregate of sand and gravel, or sand and small stones, together with water, which when allowed to set and harden takes the shape of the mould into which it has been placed. After 28 days the full strength of concrete has been achieved.

After mixing these materials together, a plastic mass is formed, which when set, becomes as hard as stone.

Concrete hardens with age, hence its usefulness as a building material.

The strength of concrete is dependent on such factors as the quantity of water used the grading of the aggregates used, the ratio of the materials used, the thoroughness of the mixing of the materials and the curing of the concrete after it has been cast.

Plain Concrete

This consists solely of cement powder, water and graded coarse and fine aggregates. No reinforcement is used. It can be manufactured on site, or can be purchased from a ready mixed concrete company.

Uses include simple foundations, garden paths and driveways; paving slabs, kerbs and channels; protection of drainage pipes, etc.

Reinforced Concrete

This consists of plain concrete reinforced with metal, usually steel bars or fabric mesh. It is stronger than plain concrete in both tension and compression, and it can be manufactured either on site or under factory conditions away from the site.

Uses include foundations, walls, columns, lintels and beams; floors, roofs, etc.

Pre-cast Concrete

Usually in the form of some kind of unit which can be manufactured either on or away from the site. The unit is made in some other place than that which it is to permanently occupy. It can be plain, reinforced or pre-stressed.

Uses include bricks, blocks, cladding panels, pad stones, copings, window sills, canopies, chimney caps, flue liners and all types of structural units.

NOTE

When the concrete is placed on site in the position where it is to remain permanently, it is termed in-situ concrete.

Composition of concrete mix

The composition of a good quality concrete mix consists of cement, sand, stone, and water as a lubricant, proportioned together to produce concrete which will satisfy the specific performance requirements (workability, compressive strength, and durability) as well as to give the correct yield or blend.

Classification and uses

A concrete mix ratio as well as the size of the course aggregate determines the strength of the concrete for a specific concrete element or component.

Various recommended concrete strengths for various uses are however provided as guidelines in the table below:

Concrete strength at 28 days MPa	Use
10	Mass filling
15	Foundations for houses and unreinforced concrete
20	Floors on the ground (surface beds) for houses
25	Reinforced concrete Home driveways
30	Reinforced concrete Floors on the ground for heavy duty – e.g. factories
35	Floors on the ground for heavy duty – e.g. factories Precast concrete
40	Precast concrete

Mix proportions and quantities

The materials in concrete, i.e. cement, course and fine aggregate, water and admixture (if required), should be proportioned to give the required properties in the fresh and hardened state.

As described above, mix requirements for a given strength of concrete can be specified in one of two ways. Proportions or quantities of each material to be used may be stated in terms of either volume or mass. Alternatively a strength requirement may be given.

Mix proportions in the following table are based on the assumption that a CEM II/A 32.5 cement will be used.

Concrete strength at 28 days, MPa	Mass or volume	9,5 or 13,2mm stone			19,0 or 26,5mm stone		
		Cement	Sand	Stone	Cement	Sand	Stone
10	Mass/bag	50 kg	238kg	128kg	50kg	230kg	196kg
	Volume/bag	**1 bag**	**0,175 m³**	**0,095 m³**	**1 bag**	**0,170 m³**	**0,145 m³**
	Mass/m³	250 kg	1 190 kg	640 kg	225 kg	1 030 kg	890 kg
	Volume/m³	5,0 bag	0,88 m³	0,47 m³	4,5 bag	0,76 m³	0,66 m³
15	Mass/bag	50 kg	175kg	106kg	50kg	170kg	164kg
	Volume/bag	**1 bag**	**0,130 m³**	**0,080 m³**	**1 bag**	**0,125 m³**	**0,120 m³**
	Mass/m³	315 kg	1 100 kg	670 kg	280 kg	950 kg	920 kg
	Volume/m³	6,3 bag	0,82 m³	0,50 m³	5,6 bag	0,70 m³	0,68 m³
20	Mass/bag	50 kg	138kg	92kg	50kg	130kg	138kg
	Volume/bag	**1 bag**	**0,100 m³**	**0,070 m³**	**1 bag**	**0,095 m³**	**0,100 m³**
	Mass/m³	375 kg	1 030 kg	690 kg	340 kg	880 kg	940 kg
	Volume/m³	7,5 bag	0,76 m³	0,51 m³	6,8 bag	0,65 m³	0,70 m³
25	Mass/bag	50 kg	114kg	84kg	50kg	106kg	125kg
	Volume/bag	**1 bag**	**0,085 m³**	**0,060 m³**	**1 bag**	**0,080 m³**	**0,090 m³**
	Mass/m³	425 kg	970 kg	710 kg	385 kg	820 kg	960 kg
	Volume/m³	8,5 bag	0,72 m³	0,53 m³	7,7 bag	0,61 m³	0,71 m³
30	Mass/bag	50 kg	95kg	78kg	50kg	90kg	114kg
	Volume/bag	**1 bag**	**0,070 m³**	**0,055 m³**	**1 bag**	**0,065 m³**	**0,085 m³**
	Mass/m³	475 kg	910 kg	730 kg	430 kg	770 kg	980 kg
	Volume/m³	9,5 bag	0,67 m³	0,54 m³	8,6 bag	0,57 m³	0,73 m³
35	Mass/bag	50 kg	80kg	72kg	50kg	75kg	105kg
	Volume/bag	**1 bag**	**0,060 m³**	**0,055 m³**	**1 bag**	**0,055 m³**	**0,080 m³**
	Mass/m³	525 kg	850 kg	750 kg	475 kg	710 kg	1000 kg
	Volume/m³	10,5 bag	0,63 m³	0,56 m³	9,5 bag	0,53 m³	0,74 m³
40	Mass/bag	50 kg	68kg	68kg	50kg	64kg	98kg
	Volume/bag	**1 bag**	**0,050 m³**	**0,050 m³**	**1 bag**	**0,045 m³**	**0,075 m³**
	Mass/m³	575 kg	780 kg	770 kg	520 kg	650 kg	1020 kg
	Volume/m³	11,5 bag	0,58 m³	0,57 m³	10,4 bag	0,49 m³	0,76 m³

Information courtesy of the Concrete Institute - www.cnci.org.za

Example:

1.3 m3 of 20 MPA concrete using 9.5 or 13.5mm stone is needed. The amount of each material required is:

Cement	8.0	x 1.3	= 10.4 bags
Sand	0.76 m3	x 1.3	= 0.988 m3
Stone	0.51 m3	x 1.3	= 0.663 m3

Allow for a little waste and order 11 or 12 sacks of cement, 1.2 m3 of sand and about 1 m3 stone.

Water requirements

Only clean fresh water, free from vegetable or organic matter, earth, clay acid or alkaline substances in either suspension or solution should be used.

Depending on the size of stone used in the mix, the amount of water required per m³ can be estimated in the following way:

Water requirement of concrete mixes for average-quality sand. [(a)]

Nominal size of stone (mm)	Water requirement of concrete (ℓ/m³)
9.5	235
13.2	225
19.0	210
26.5	200
[(a)] The volume of water is based on a 75mm slump	

Example:

If you are using a 19mm stone, the water required in the mix would be about 210ℓ for every cubic metre.

Mixing

Site Mixing

Site mixing should only be done on small work. It may also be necessary in the event that the mixer breaks down. It should never be done on the ground but on a light wooden platform, a metal tray, a concrete floor or a small area packed with bricks. If done on a porous surface, this may interfere with the mix design as the surface may absorb water.

The procedure of mixing is important.

The stone should be spread out first in a rather flat heap (not a high, conical heap, as the larger stones will roll down the sides and separate.)

Next, the sand should be spread evenly over the heap, followed by the cement - also spread evenly and not dumped in one spot.

The dry materials should be mixed at least three times by shovelling from the centre and again to the side. The materials should not be dumped from one place to another; each shovelful should be turned over by twisting the wrist and spading into the pile. About half to three-quarters of the total quantity of water required should be poured into the centre of the ring; the materials mixed into it, and then back into the ring.

The remainder of the water can now be added slowly as the materials are mixed into it, stopping the addition of water when the right workability has been obtained. Adding all the water at once will result in some running away and taking cement with it.

Ten per cent more cement than specified for machine mixing should be allowed for possible loss. Mixing must be done until the colour is uniform and the consistency the same throughout the pile.

Machine Mixing

The stone should be placed in the skip first, then the sand and cement, so that the stone is the last material to enter the drum of the mixer. With very small mixers, where materials are placed directly into the drum, the stone should not be added too quickly, otherwise 'balling' of the cement is likely to occur.

After all the material and the water have been added, mixing should continue for at least one minute, though one and a half minutes is preferable and should be sufficient for all but very dry mixes, for which two minutes would be better. The mixing time should never exceed twenty minutes.

The drum should be completely emptied of a batch before refilling, otherwise it is impossible to control the water for each batch accurately. At the end of concreting, the drum should be washed out thoroughly. Concrete must never be allowed to harden in the drum.

Placing

Before the concrete is placed in position, whether in forms or foundation trenches, the place into which the concrete is poured must be wetted thoroughly. Whatever method is used for transporting the concrete - whether by wheelbarrow, skip, hoist or chute - segregation of the materials must not occur.

The period between discharge from the mixer and placing in position should never exceed 30minutes. All equipment must be thoroughly clean. The filling of the foundation trenches or forms should be completed in one operation if possible, to prevent joints. If construction joints are unavoidable, the old surface must be clean, rough, wet and concrete, otherwise a bond will not be obtained and a crack will result.

As the foundation trenches and forms are filled, puddle the mixture well with a stick or heavy iron rod, especially in the corners, to eliminate the trapped air and to obtain a dense, uniform concrete.

Puddling, or working the concrete with a spade or trowel, will always bring the lighter mortar to the surface so that the face of the structure will have a thin film of mortar on the surface without holes and stones. It should not be carried too far, however, as segregation of the materials could result, leaving the interior short of mortar.

Curing

Concrete will gain in strength for several years after the initial set provided enough water is present. In hot weather rapid withdrawal of moisture from the mix may result in shrinkage of the concrete and cracks appearing. An effective remedy is to keep the concrete moist by spraying daily with a garden hose or you can keep the concrete covered. In general, the longer the period of curing the better will be the quality of the concrete.

Hints on Concrete

In this chapter, we have discussed the different ways of mixing concrete.

For the do-it-yourselves, mixing small quantities of concrete by hand is by far the most economical way. The next best is, to hire a small mixer which adds to the cost of the concrete, but the speed at which different batches can be mixed, makes up for the additional cost. Pre-packed sacks of concrete material obtainable from most hardware shops is an easy way of obtaining the material you require for small jobs.

This method is certainly recommended if you need up to, say, one quarter cubic metre of concrete. For jobs requiring more concrete, it is advisable to order the materials in small quantities from your hardware shop. Merchants deliver small quantities.

If the quantity of the material that you need is say 4m^3, it is often cheaper to buy a whole load, as you will be required to pay a full load cartage rate.

Ready-mixed concrete

Ready-mixed concrete, albeit more expensive than the other methods, has the advantage that the concrete can be of the same consistency, well mixed and strength of the concrete of different loads is the same.

When ordering ready-mixed concrete for foundations and surface beds, a suitable workable mix should be asked for. Further, a minimum concrete strength of 15MPa should be specified for foundations and 20MPa for surface beds. This concrete should be placed, consolidated and levelled as soon as possible. A delay will result in a stiffening of the mix and badly consolidated and honeycombed concrete.

Where ready-mixed concrete is used and the strength of the concrete can be accurately specified and obtained, a slightly lower strength for the footings than for the surface beds is acceptable 15MPa as against 20 MPa. This can be explained as follows:

- The footings have a shape that minimises drying out and the concrete therefore goes on curing (and gaining strength) over a prolonged period.
- The footings do not have a wearing surface.
- The weaker the mix, the more susceptible it is to bleeding, which is less serious for footings than it is for surface beds, which are exposed to wear.

IMPORTANT NOTE:

It is illegal to sell cement in South Africa if it does not have the SABS mark indicating its compliance with the requirements of the standard. Portland cement extenders

- SANS 1491: Part 1 - Ground granulated blast- furnace slag
- SANS 1491: Part 2 - Fly ash
- SANS 1491: Part 3 - Silica fume

NOTES

CHAPTER 8

Concrete Work