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Concrete Basics

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ABSTRACT

People around the world rely on concrete as a safe, strong and simple building material. It is used in all types of buildings (from residential to multi-storey office blocks) and in infrastructure projects (roads, bridges, etc).

Despite its widespread use, many people are unaware of the considerations involved in providing high quality, strong, durable concrete.

This article provides a clear, concise explanation of all aspects of making quality concrete; from the Materials and Properties involved through Planning, Preparation, Finishing and Curing.

This article addresses the needs of unskilled and semi-skilled persons undertaking general concreting projects including home and repair person projects. It also assists owner builders in the supervision of construction. It aims to develop an understanding of technical terms through clear definition accompanied by simple illustrations. A general understanding of these terms will help to facilitate communication within the building industry.

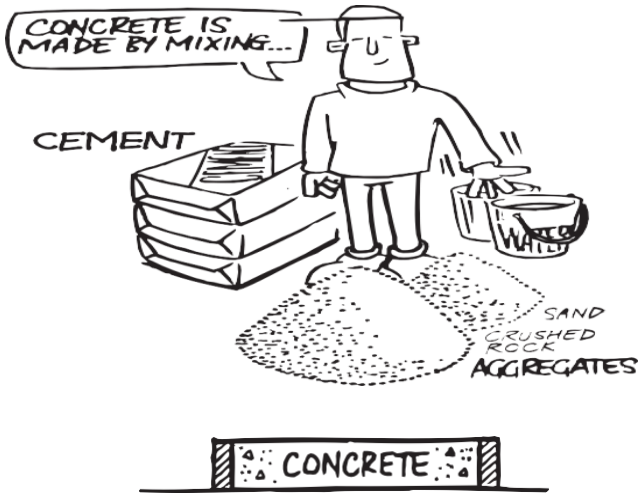
This article will help to generate a higher standard of workmanship on site and facilitate better communication among construction workers, builders, engineers, building surveyors, architects and anyone interested in understanding the processes involved in making quality concrete.

Keywords: Concrete, industry, quality, Testing, Planning, Materials, Finishing, Curing

I. INTRODUCTION

oncrete is a manufactured heterogeneous construction material composed mostly of three ingredients – aggregate, cement, and water. When these three ingredients are mixed together, the material "concrete" is formed. Concrete consists of aggregate bonded together by a paste made from Portland cement and water. Each particle of aggregate is completely coated with paste and the paste fills the voids between the aggregate. After the newly mixed concrete is placed, it hardens to form a solid structural material. The aggregates used in making concrete are hard, inert materials. They have inert chemical properties. Aggregates compose about 75% of the volume of concrete. The aggregates used in making concrete consists of both fine and coarse aggregate. The fine aggregates are usually defined as pieces less than and including 0.625mm in diameter – usually sand. The coarse aggregates are pieces larger than 0.625mm in diameter – usually gravel or crushed stone. It is important that the aggregate is well graded (i.e. grain size varies uniformly from large to small) to

enable the smaller grains to fill the voids between the larger grains of the coarse aggregate. Cement used in making concrete may be obtained from nature (natural cement) or it may be manufactured. When manufactured, and it conforms to certain specifications of the ASTM, it is called Portland cement. Portland cement is manufactured from limestone. Small amounts of lime, silica, alumna, and some other ingredients are added to influence the properties of the end product of cement. The amount of cement in concrete mix is usually specified by concrete mix design. The water used in making concrete must be clean and free from large quantities of oil, grease, acids, sugar, organic matter, and other impurities. The water must be potable – drinkable. The amount of water used in a concrete mix will vary depending on the use of the concrete. The water-to-cement ratio is very important in designing concrete mixes. Because it is so important, care must be taken to add only the proper amount of water to the mix. In fact, it is so critical that the surface water clinging to the aggregate must be taken into account to insure a proper mix. If you are using damp sand, for instance, you must reduce the amount of water added by a similar amount of water already in the damp sand. Concrete is an economical material to make because aggregate, cement, and water are available nearly everywhere. The "life" of concrete begins when the water mixes with the cement in a batch of concrete. When this mixing occurs, a complex chemical reaction is started. This reaction continues for a long time and is called **hydration.** Once the water is added to the cement in a batch of concrete, an internal time clock begins. The chemical reaction begins in earnest in about half an hour under favorable conditions (mostly warm temperatures). When using a normal concrete mix with Type I cement. The concrete should be in place within 1 ½ hours after the water is added to the Ready-Mix truck.



II. Concrete States

Concrete has three different states Plastic, Setting, and Hardened.

A. Plastic State

When the concrete is first mixed, it is like 'bread dough'. It is soft and can be worked or moulded into different shapes. In this state concrete is called PLASTIC. Concrete is plastic during placing and compaction. The most important properties of plastic concrete are workability and cohesiveness. A worker will sink into the plastic concrete.

Figure 1. Plastic Concrete

B. Setting State

Concrete then begins to stiffen. The stiffening of concrete, when it is no longer soft, is called SETTING. Setting takes place after compaction and during finishing. Concrete that is sloppy or wet may be easy to place butwill be more difficult to finish.

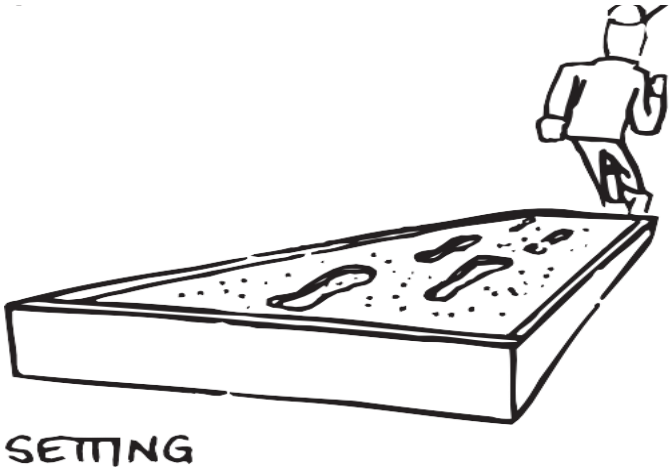


Figure 2. Setting Concrete

C. Hardened State

After concrete has set, it begins to gain strength and harden. The properties of hardened concrete are strength and durability. Hardened concrete will have no footprints on it if walked on.

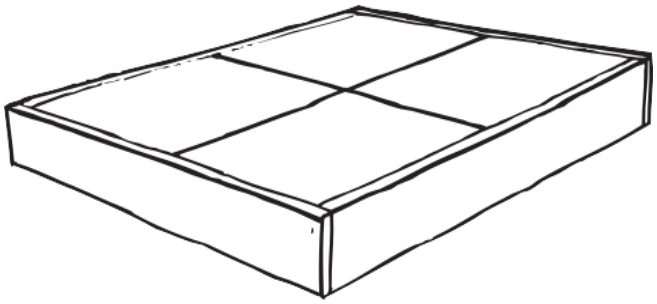


Figure 3. Hardened State

III. Concrete Properties

The Properties of Concrete are its characteristics or basic qualities. Concrete has different properties in each state, Workability, Cohesiveness, Strength and durability.

A. Workability

Means how easy it is to: Place, Handle, Compact and Finish the concrete. Concrete that is stiff or dry may be difficult to handle, place, compact and finish and, if not constructed properly, will not be as strong or durable when finally hardened. A slump test can be used to measure the workability of concrete. Workability is affected by the amount of cement paste and the aggregate properties and grading. To make a more workable mix add more cement paste, use well graded aggregates, use an admixtures (Admixtures those improve workability are called Plasticizers).

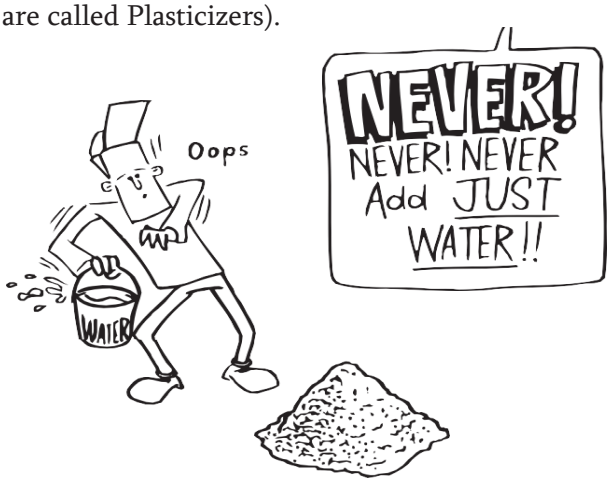


Figure 4. Depicting a person adding water to concrete

Never try to make a mixture more workable by just adding more water because this lowers the strength and durability of concrete.

B. Cohesiveness

Cohesiveness is how well concrete HOLDS TOGETHER when plastic. Cohesiveness is affected by aggregate grading and water content.

C. Strength And Durability

Well-made concrete is a naturally strong and durable material. It is dense, reasonably watertight (impermeable), able to resist changes in temperature, as well as wear-and-tear from weathering and traffic. Strength and Durability are affected by the density of the concrete. Denser concrete is stronger and more watertight (or less

permeable). Concrete durability INCREASES with strength. Strength of concrete in the hardened state is usually measured by the COMPRESSIVE STRENGTH using the Compression Test. However Strength and durability are affected by Compaction and Curing of concrete.

IV. Concrete Testing

There are two main tests to be done on concrete: Slump Test and Compression test. Slump Test indicates the workability of concrete. The Compression Test shows the best possible strength concrete can reach in ideal conditions. The compression test measures concrete strength in the hardened state.

To do the test, the first step is to take a test sample from a large batch of concrete. This should be done as soon as the discharge of concrete commences. The sample should be representative of concrete supplied. The sample is taken in one of two ways. For purposes of accepting or rejecting the load: Sampling after 0.2 m3 of the load has been discharged. For routine quality checks: Sampling from three places in the load as it is discharged.

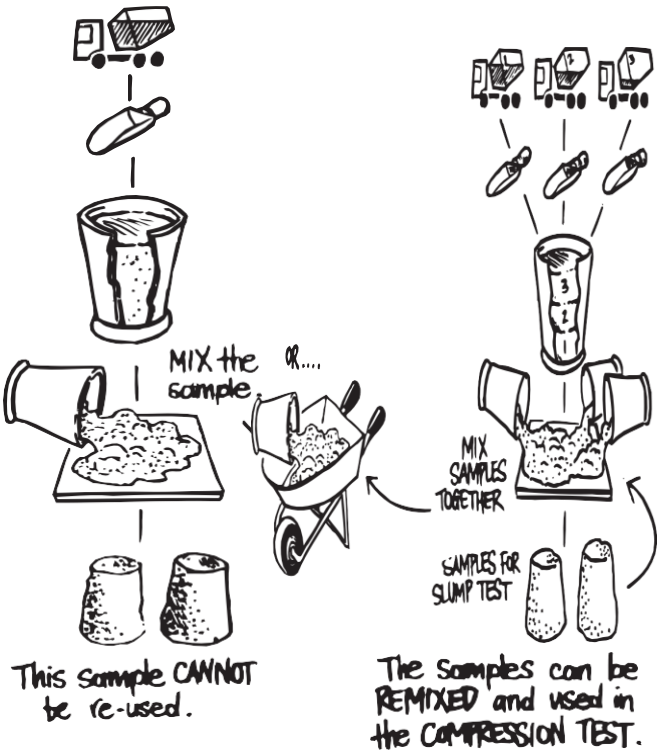


Figure 5. Illustration of sampling

1) Slump Test: The slump test is done to make sure a concrete mix is consistent and workable. The measured slump must be within a set range, or tolerance, from the specified slump (ASTM C 143). The slump Cone is filled in three layers. Every layer is evenly rodded 25 times.

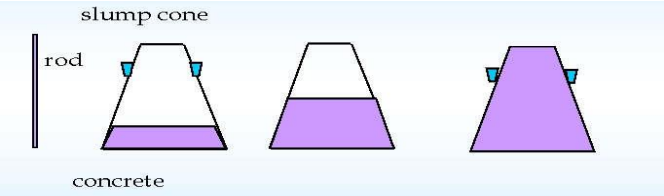


Figure 6. How to fill the Slump Cone

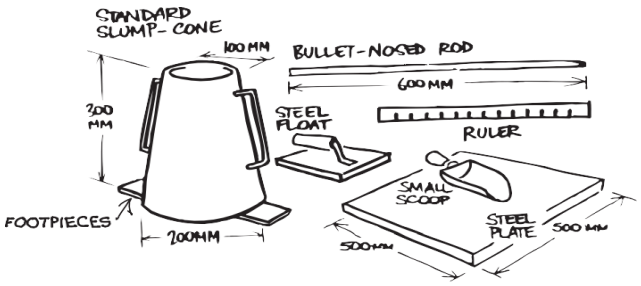


Figure 7. Equipment required for Slump Test

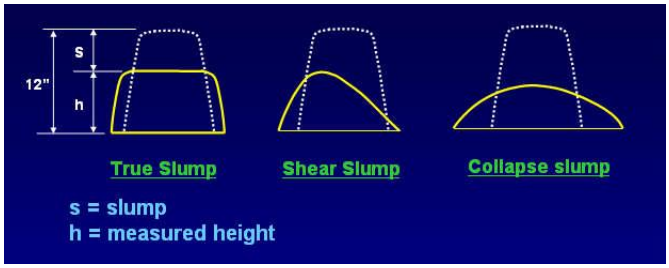


Figure 8. Different types of Slump

2) Compression Test: The compression test shows the compressive strength of hardened concrete. The testing is done in a laboratory off-site. The only work done on site is to make a concrete cylinder or cube for the test. The strength is measured in Megapascals (MPa) and is commonly specified as a characteristic strength of concrete measured at 7 or 28 days after mixing. The compressive strength is a measure of the concrete's ability to resist loads, which tend to crush it. There are two types of specimens CUBIC 15x15x15 CM and CYLINDER h/D=2 with h=15.

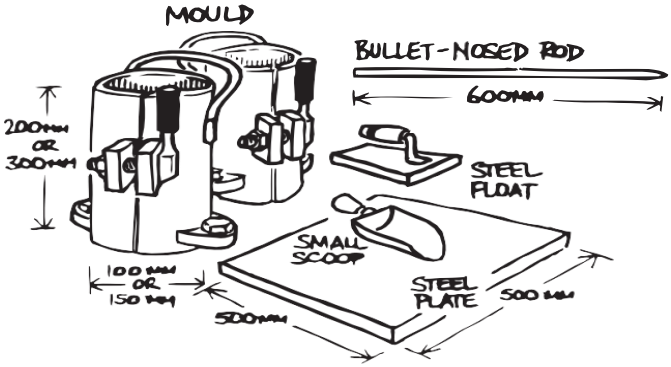


Figure 9. Equipment for Compression test (Cylinder)

V. Ordering Premixed Concrete

When ordering premixed concrete you will need to tell the supplier; NAME and ADDRESS for delivery, The use of concrete (e.g., Driveways and paths, building, bridge, substructure, superstructure), The amount of concrete you need in Cubic meters. The Class or Mix of concrete. NORMAL CLASS CONCRETE has a strength grade of C20, C25, C30, C40 and C50 with the corresponding characteristic strength of 20, 25, 30, 40 and 50 MPa at 28 days. The slump at the point of delivery should be 20–120 mm and the maximum size of coarse aggregate should be 10, 14 or 20 mm. Normal class concrete is suitable for most purposes. For most domestic applications such as driveways and paths grade C20 and C25 are the common grades. Special class concrete is specified when you have additional or alternative requirements to those for normal class concrete, eg lightweight aggregate, colour pigments, a non-standard strength grade. Special class concrete will not always be available from every concrete supplier. Always order 10% more than you need to allow for construction variations and/or wastage.

VI. Planning And Site Preparation

The most important step in placing concrete is planning. Always plan every step before any concrete is delivered. Proper planning avoids delays, wastage, segregation andproblems, which develop from these.

For the safety of all, everyone at site shall always wear protective clothing, strong boots, helmets and eye protection. Always avoid direct contact with cement and never kneel in or touch the plastic concrete directly. Wear gloves and use barrier creams. Ensure that anyone using heavy equipment, such as screeds or vibrators, has been properly trained. The following steps should be taken before any concrete is placed.

Measure and stake out the area to be concreted and consider how thick the slab must be. The thickness will depend on the weight the concrete must carry (ie a driveway carries the weight of a car and needs to be thicker than a garden path).

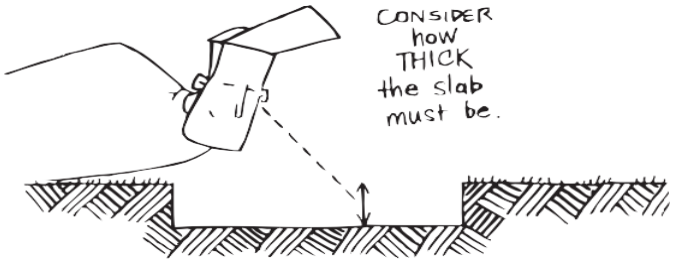


Figure 19. Illustrates the thickness

Once the thickness of concrete has been established, work out where the concrete will finish. Concrete cannot finish too high against steps or the external house wall and should not cover any part of weep holes in the wall. The finished level determines how much digging or excavation must be done. Pavements must slope away from buildings and boundaries.

1) EXCAVATION: The ground should be excavated as required by the finished levels. Any roots or grass must be dug out until there is firm soil to place on. Always dig wider than needed to allow for formwork.

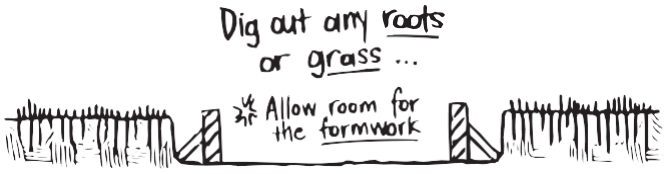


Figure 10. Illustrates excavation wider than required

2) REINFORCEMENT: Reinforcement can be used to increase the strength of concrete and /or to help control cracking. For house floors resting on the ground it is placed in the top 1/3 of slabs and in the bottom of thickening and beams. In strip footings, it is placed in the top and bottom. The reinforcement must be covered by a specified amount of concrete which protects the steel from rusting. This is called cover.

The amount of cover depends on whether the slab is inside or outside, is in contact with the ground or protected by a membrane. It is measured to the top, side or bottom of the outer surface. Reinforcement should be securely held for slab on ground construction. Bars and mesh should overlap by a specified amount and at the corners of strip footings as will be shown in respective design drawings

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VII. Transporting And Placing

A. Transportation

The method used to transport concrete depends on which one is the most cost effective and easiest for the job size and site. Transport methods include a concrete truck, a concrete pump, a crane and bucket, a chute, a conveyor or a hoist. For small jobs on which concrete cannot be placed directly from truck chute, a wheelbarrow is the easiest way to transport it. When transporting and placing concrete avoid: DELAYS, SEGGERATION AND WASTEAGE.

B. Placing

When placing concrete be careful not to damage or move the formwork and reinforcement. Place concrete as near to its final position as possible. Start placing from the corners of the formwork or, in the case of a sloping site, from the lowest level.

1) Delays: Delays can cause the concrete to dry-out and stiffen. Delays are more of a problem on hot and/or windy days when the concrete will dry-out and stiffen more quickly. To avoid delays plan ahead. Check that all labour, tools and containers are ready and that all preparations for placing have been done before the concrete is delivered.

2) Segregation: When the coarse and fine aggregate, and cement paste, become separated it is called segregation. Segregation may occur when the concrete is mixed, transported, placed or compacted. Segregation makes the concrete Weaker, Less Durable, and will leave a poor surface finish. To avoid the segregation check the concrete is not 'Too Wet' or

'Too Dry'. Make sure the concrete is properly mixed. It is important that the concrete is mixed at the correct speed in a transit mixer for at least two minutes immediately prior to discharge. The concrete should be placed as soon as possible. When transporting the mix, load carefully. If placing concrete straight from a truck, place vertically and never let the concrete fall more than one-and-a-half meters.

3) Wastage: It can be costly, especially on small jobs. To minimize wastage; mix, load, transport and place carefully.

VIII. Compaction

Compaction is shaking or vibrating of the concrete to liquefy it and expel any trapped air. The concrete settles, filling all the space in the forms. Compaction must be done as concrete is placed, while it is still plastic. Never let concrete dry out and stiffen because it will be too difficult to compact. Properly compacted concrete is more dense, strong and durable. External vibrations or internal vibrations can obtain proper compaction.

A. External Vibration

Screeding levels and compacts thin concrete slabs and the top layers of thicker slabs. A screed board will not compact the concrete very well. Mechanical vibration or hand rodding is required to provide adequate compaction. A double-beam mechanical screed compacts the concrete TWICE. The first beam levels the concrete roughly and compacts it. The second beam levels and compacts the concrete further. Two workers pull the screed along the top of the forms. Always keep a small amount, or surcharge, of concrete, in front of both beams of the screed to avoid hollows, forming in the surface. If a hollow develops, the screed will not compact the concrete. The mechanical screed compacts the concrete as it vibrates.

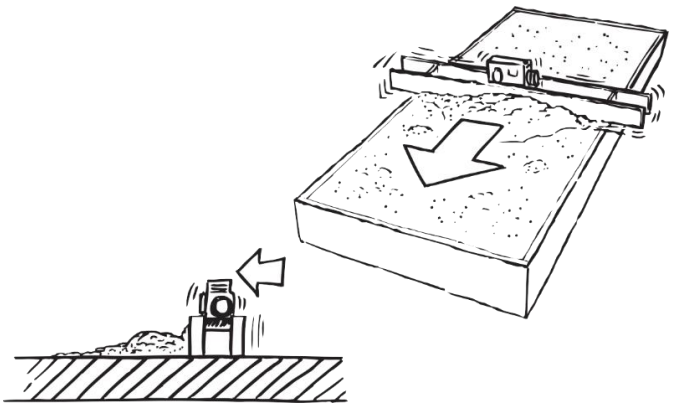


Figure 11. A double beam mechanical screed

B. Internal Vibration

It is done with a mechanical vibrator or poker vibrator. The Poker is put in the concrete and vibrates it from the inside.

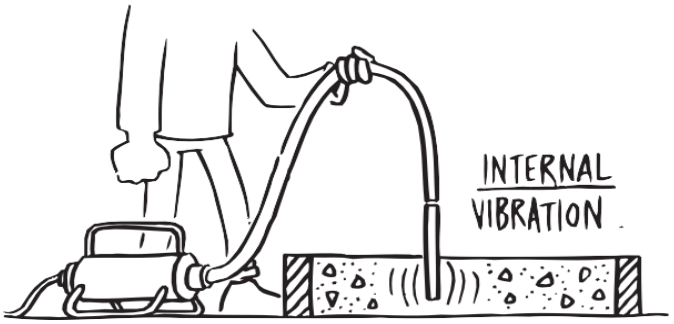


Figure 12. Poker Viberator

The size of the poker determines how much concrete is vibrated at one time. The area vibrated at one time is called the Radius of Action. This can be seen by the radius over which air bubbles rise to the surface. The radius of action will be greater with a larger poker and more-workable concrete. Always compact in a definite pattern so the radius of action overlaps and covers the whole area of the concrete. Where concrete is placed in layers, the poker should be long enough to reach and enter into the layers of concrete under the one being compacted. For concrete of

average workability (ie slump of 80 mm) with a poker size between 25–75 mm, concrete should usually be vibrated for between5 and 15 seconds.

IX. Finishing

Finishing is screeding, floating and/or troweling the concrete surface to densify and further compact the surface layer of concrete, as well as giving it the look you want. Finishing takes place in two stages, initial and final finishing.

A. Initial Finishing

Concrete is first screeded to the level of the formwork, then bullfloated and left to set. In some cases screeding leaves a good enough finish, especially if floor coverings are to be used over the concrete. Water then appears on the surface of the concrete. This water is called bleed water. Excess bleed water can be removed by dragging an ordinary garden hose across the surface of the concrete. Never try to dry up the bleed water using stone dust or cement as this will weaken the concrete surface in the long run. Once the bleed water dries up and concrete can support a person's weight, with only a slight marking to the surface, the final finishing can begin. There are actually two stages in floating. The BullFloat which is part of initial finishing and Power or Hand Float which is part of final finishing. Floating can be done by hand or with a power float. Power float leaves a better finish than hand float.

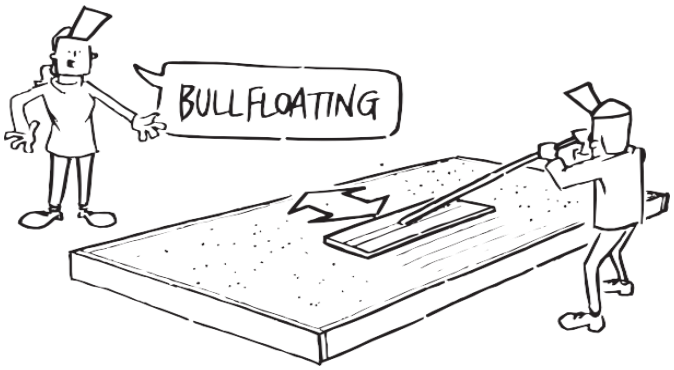


Figure 13. Bull Float

Figure 14. Hand Float

A. Final Finishing

This involves floating, troweling, edging, jointing or patterning the concrete. Special finishes such as booming, coloring or patterned finishes can be applied to the surface. Troweling leaves a dense, hard, smooth and durable surface. The surface should be troweled TWICE. A well troweled surface will be very smooth and can be slippery when wet. Troweling can be done by hand or power trowel. Edging and grooving all the edges of a slab should be finished with a special edging tool. This gives a neater and stronger edge, less prone to chipping. Joints should be planned before placing and are usually formed into the concrete during finishing. Once any surface has been finished, the concrete must be cured.

X. Curing

Curing means to keep concrete moist for some time (typically 3–7 days. By keeping concrete, moist the bond between the paste and the aggregates gets stronger. Concrete does not harden properly if it is left to dry out quickly. When curing leave the formwork in place to help reduce moisture loss. In hot weather (above 30°C), or during high winds and low humidity, concrete can dry out quickly. In these conditions, take extra care with curing. Concrete that is properly cured is less likely to crack, Stronger and more durable. Cured concrete has a surface that

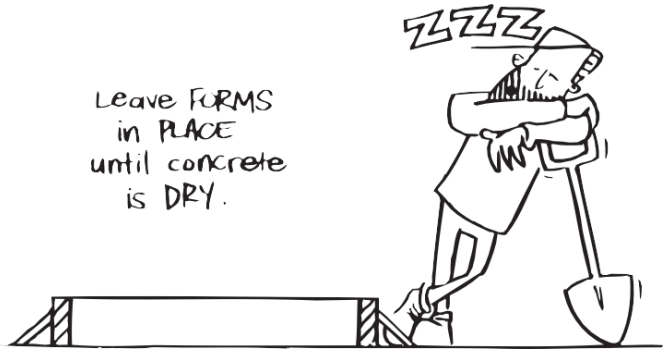
wears better, lasts longer and better protects the steel reinforcement. Properly cured concrete is stronger and can carry more weight without breaking.

Figure 15. Curing using gunny bags

Figure 16. Ponding Method

XI. Form Work

Formwork gives concrete its Shape. Formwork provides a mould, into which concrete is placed. When concrete has hardened the formwork is removed. Formwork must be, ACURATE, STRONG and WELLMADE. This is necessary so that the concrete will not leak from the joints, and so that the formwork will not sag, bulge or move and, especially in large construction, will be safe. The surface of the forms in contact with concrete affects how concrete will look. If the final appearance of the concrete is important, choose a material that will give the required surface texture. Be sure that formwork is placed so it can be removed. If formwork is placed in awkward positions or tight corners it may be difficult to remove when the concrete has hardened. Formwork sections should be of simple design, not too big and of standard sizes if they are to be re-used. Formwork is normally made from steel or timber. Timber formwork is easier to make while steel formwork will allow a greater number of re-uses. Formwork can be made on site or bought from formwork suppliers. Special forms made from various materials can be purchased for forming waffle slabs, circular columns and other special profiles. Form Oil should be applied to the inside of the formwork to stop it sticking to the concrete and thus make removal easier. Formwork may be left in place to help curing. Removal time will vary according to the weather. In cold weather, concrete will take longer to gain strength than in warm weather, removal times will therefore be longer. In mild conditions (around 20°C) 7 days is long enough to leave the forms in place, unless the concrete is suspended when other considerations apply.



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