Unit-2
Fresh Concrete

Introduction

Fresh concrete or plastic concrete is a freshly mixed material which can be moulded into any shape. It is well known that water required for chemical combination with cement and to occupy the gel pores. We have seen that the theoretical water/cement ratio required for these two purposes is about 0.38. Use of water/cement ratio more than this, will result in capillary cavities; and less than this, will result in incomplete hydration and also lack of space in the system for the development of gel.

Workability

Hundred per cent compaction of concrete is an important parameter for contributing to the maximum strength. Lack of compaction will result in air voids whose damaging effect on strength and durability is equally or more predominant than the presence of capillary cavities.

To enable the concrete to be fully compacted with given efforts, normally a higher water/cement ratio than that calculated by theoretical considerations may be required. That is to say the function of water is also to lubricate the concrete so that the concrete can be compacted with specified effort forthcoming at the site of work. The lubrication required for handling concrete without segregation, for placing without loss of homogeneity, for compacting with the amount of efforts forth-coming and to finish it sufficiently easily, the presence of a certain quantity of water is of vital importance.

Factors Affecting Workability

Workable concrete is the one which exhibits very little internal friction between particle and particle or which overcomes the frictional resistance offered by the formwork surface or reinforcement contained in the concrete with just the amount of compacting efforts forthcoming.

(a) Water Content
(b) Mix Proportions
(c) Size of Aggregates
(d) Shape of Aggregates
(e) Surface Texture of Aggregate
(f) Grading of Aggregate
(g) Use of Admixtures.

(a) Water Content:

Water content in a given volume of concrete, will have significant influences on the workability. The higher the water content per cubic meter of concrete, the higher will be the fluidity of concrete, which is one of the important factors affecting workability.More water can be added, provided a correspondingly higher quantity of cement is also added to keep the water/cement ratio constant, so that the strength remains the same.

(b) Mix Proportions:

Aggregate/cement ratio is an important factor influencing workability. The higher the aggregate/cement ratio, the leaner is the concrete. In lean concrete, less quantity of paste is available for providing lubrication, per unit surface area of aggregate and hence the mobility of aggregate is restrained. On the other hand, in case of rich concrete with lower aggregate/cement ratio, more paste is available to make the mix cohesive and fatty to give better workability.

(c) Size of Aggregate:

The bigger the size of the aggregate, the less is the surface area and hence less amount of water is required for wetting the surface and less matrix or paste is required for lubricating the surface to reduce internal friction. For a given quantity of water and paste, bigger size of aggregates will give higher workability. The above, of course will be true within certain limits.

(d) Shape of Aggregates:

The shape of aggregates influences workability in good measure. Angular, elongated or flaky aggregate makes the concrete very harsh when compared to rounded aggregates or cubical shaped aggregates. Contribution to better workability of rounded aggregate will come from the fact that for the given volume or weight it will have less surface area and less voids than angular or flaky aggregate. Not only that, being round in shape, the frictional resistance is also greatly reduced

(e) Surface Texture:

The influence of surface texture on workability is again due to the fact that the total surface area of rough textured aggregate is more than the surface area of smooth rounded aggregate of same volume. From the earlier discussions it can be inferred that rough textured aggregate will show poor workability and smooth or glassy textured aggregate will give better workability. A reduction of inter particle frictional resistance offered by smooth aggregates also contributes to higher workability.

(f) Grading of Aggregates:

This is one of the factors which will have maximum influence on workability. A well graded aggregate is the one which has least amount of voids in a given volume. Other factors being constant, when the total voids are less, excess paste is available to give better lubricating effect. With excess amount of paste, the mixture becomes cohesive and fatty which prevents segregation of particles.. The better the grading, the less is the void content and higher the workability. The above is true for the given amount of paste volume.

(g) Use of Admixtures:

Of all the factors mentioned above, the most import factor which affects the workability is the use of admixtures. It is to be noted that initial slump of concrete mix or what is called the slump of reference mix should be about 2 to 3 cm to enhance the slump many fold at a minimum doze. Use of air-entraining agent being surface-active, reduces the internal friction between the particles. They also act as artificial fine aggregates of very smooth surface. It can be viewed that air bubbles act as a sort of ball bearing between the particles to slide past each other and give easy mobility to the particles.

Measurement of Workability

Some of the tests measure the parameters very close to workability and provide useful information. The following tests are commonly employed to measure workability.

(a) Slump Test

(b) Compacting Factor test

(c) Flow Test

(d) Kelly Ball Test

(e) Vee Bee Consistometer Test.

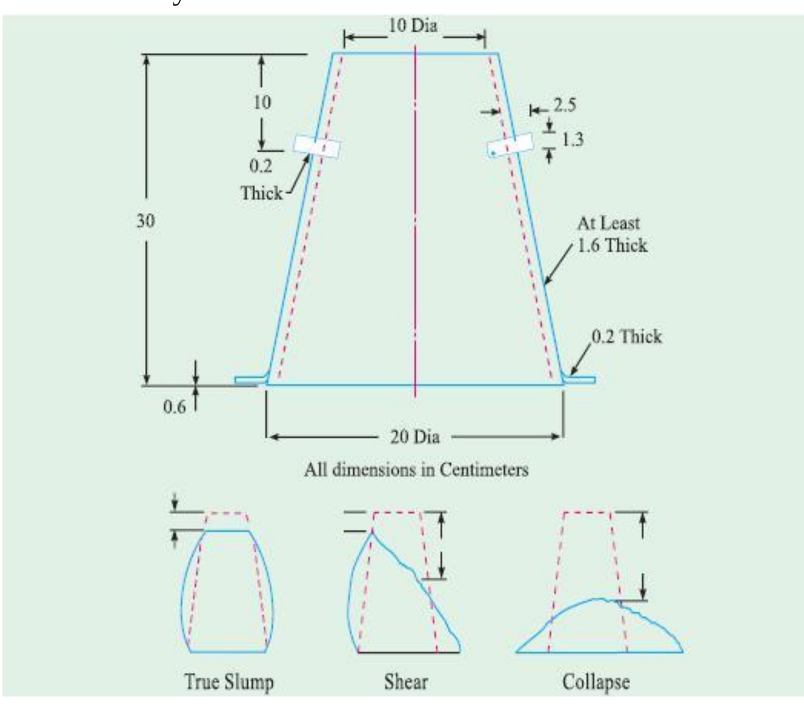
Slump Test

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete The appartus for conducting the slump test essentially consists of a metallic mould in the form of a frustum of a cone having the internal dimensions as under:

Bottom diameter : 20 cm
Top diameter : 10 cm
Height : 30 cm

The mould is placed on a smooth, horizontal, rigid and non-absorbant surface The mould is then filled in four layers, each approximately 1/ 4 of the height of the mould. Each layer is tamped 25 times by the tamping rod taking care to distribute the strokes evenly over the cross section. After the top layer has been rodded, the concrete is struck off level with a trowel and tamping rod. The mould is removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This subsidence is referred as SLUMP of concrete.

The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured. This difference in height in mm. is taken as Slump of Concrete.If the concrete slumps evenly it is called true slamp. If one half of the cone slides down, it is called shear slump. In case of a shear slump, the slump value is measured as the difference in height between the height of the mould and the average value of the subsidence.In case of dry-mix, no variation can be detected between mixes of different workability

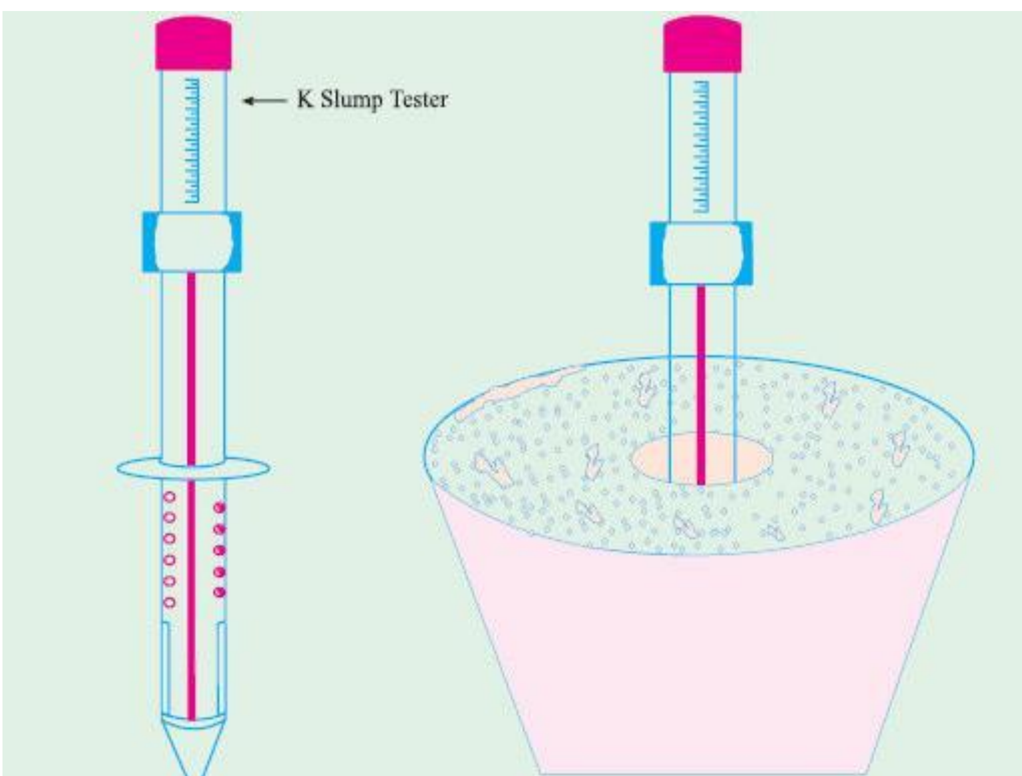


Degree of workability

K-Slump Tester

Very recently a new appartus called “K-Slump Tester” has been devised. It can be used to measure the slump directly in one minute after the tester is inserted in the fresh concrete to the level of the floater disc. This tester can also be used to measure the relative workability. The appartus comprises of the following four principal parts:-

1. Chrome plated steel tube with external and internal diameters of 1.9 and 1.6 cm respectively. The tube is 25 cm long and its lower part is used to make the test. The length of this part is 15.5 cm which includes the solid cone that facilitates inserting the tube into the concrete. Two types of openings are provided in this part rectangular slots 5.1 cm long and 0.8 cm wide and 22 round holes 0.64 cm in diameter; all these openings are distributed uniformly in the lower part as shown in Figure



Measuring the K-Slump


K-Slump Tester

2. A disc floater 6 cm in diameter and 0.24 cm in thickness which divides the tube into two parts: the upper part serves as a handle and the lower one is for testing as already mentioned. The disc serves also to prevent the tester from sinking into the concrete beyond the pre-selected level.

3. A hollow plastic rod 1.3 cm in diameter and 25 cm long which contains a graduated scale in centimeters. This rod can move freely inside the tube and can be used to measure the height of mortar that flows into the tube and stays there. The rod is plugged at each end with a plastic cap to prevent concrete or any other material from seeping inside.

4. An aluminium cap 3 cm diameter and 2.25 cm long which has a little hole and a screw that can be used to set and adjust the reference zero of the apparatus. There is also in the upper part of the tube, a small pin which is used to support the measuring rod at the beginning of the test. The total weight of the appartus is 226 g.

5. The following procedure is used:

(a) Wet the tester with water and shake off the excess.

(b) Raise the measuring rod, tilt slightly and let it rest on the pin located inside the tester.

(c) Insert the tester on the levelled surface of concrete vertically down until the disc floater rests at the surface of the concrete. Do not rotate while inserting or removing the tester.

(d) After 60 seconds, lower the measuring rod slowly until it rests on the surface of the concrete that has entered the tube and read the K-Slump directly on the scale of the measuring rod.

(e) Raise the measuring rod again and let it rest on its pin.

Remarks

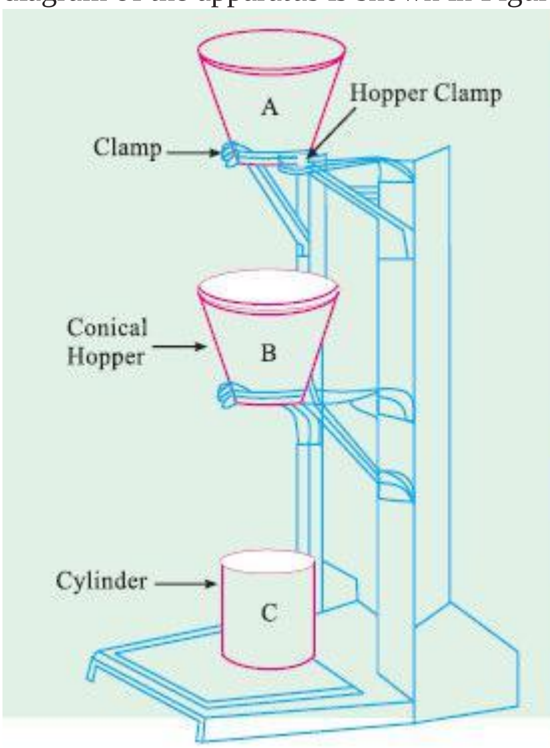
In the concrete industry, the slump test is still the most widely used test to control the consistency of concrete mixtures, even though there are some questions about its significance and its effectiveness. Many agree that the test is awkward and is not in keeping with the strides that the industry has made since 1913 when the slump cone was first introduced. Several apparatus have been proposed to replace or supplement the slump cone, but in general they have proved to be rich in theory and poor in practice. Their use is still limited mainly to research work in laboratories.

The K-slump apparatus is very simple, practical, and economical to use, both in the field and the laboratory. It has proven, with over 450 tests, that it has a good correlation with the slump cone.

The K-slump tester can be used to measure slump in one minute in cylinders, pails, buckets, wheel-barrows, slabs or any other desired location where the fresh concrete is placed. A workability index can be determined by the tester.

Compacting Factor Test

The compacting factor test is designed primarily for use in the laboratory but it can also be used in the field. It is more precise and sensitive than the slump test and is particularly useful for concrete mixes of very low workability as are normally used when concrete is to be compacted by vibration. Such dry concrete are insensitive to slump test. The diagram of the apparatus is shown in Figure:



Compacting Factor Apparatus

The sample of concrete to be tested is placed in the upper hopper up to the brim. The trap-door is opened so that the concrete falls into the lower hopper. Then the trap-door of the lower hopper is opened and the concrete is allowed to fall into the cylinder. In the case of a dry-mix, it is likely that the concrete may not fall on opening the trap-door. In such a case, a slight poking by a rod may be required to set the concrete in motion. The excess concrete remaining above the top level of the cylinder is then cut off with the help of plane blades supplied with the apparatus. The outside of the cylinder is wiped clean. The concrete is filled up exactly upto the top level of the cylinder. It is weighed to the nearest 10 grams. This weight is known as "Weight of partially compacted concrete".

The cylinder is emptied and then refilled with the concrete from the same sample in layers approximately 5 cm deep. The layers are heavily rammed or preferably vibrated so as to obtain full compaction. The top surface of the fully compacted concrete is then carefully struck off level with the top of the cylinder and weighed to the nearest 10 gm. This weight is known as "Weight of fully compacted concrete".

$$\text{The Compacting Factor} = \frac{\text{Weight of partially compacted concrete}}{\text{Weight of fully compacted concrete}}$$

The weight of fully compacted concrete can also be calculated by knowing the proportion of materials, their respective specific gravities, and the volume of the cylinder. It is seen from experience, that it makes very little difference in compacting factor value, whether the weight of fully compacted concrete is calculated theoretically or found out actually after 100 per cent compaction.

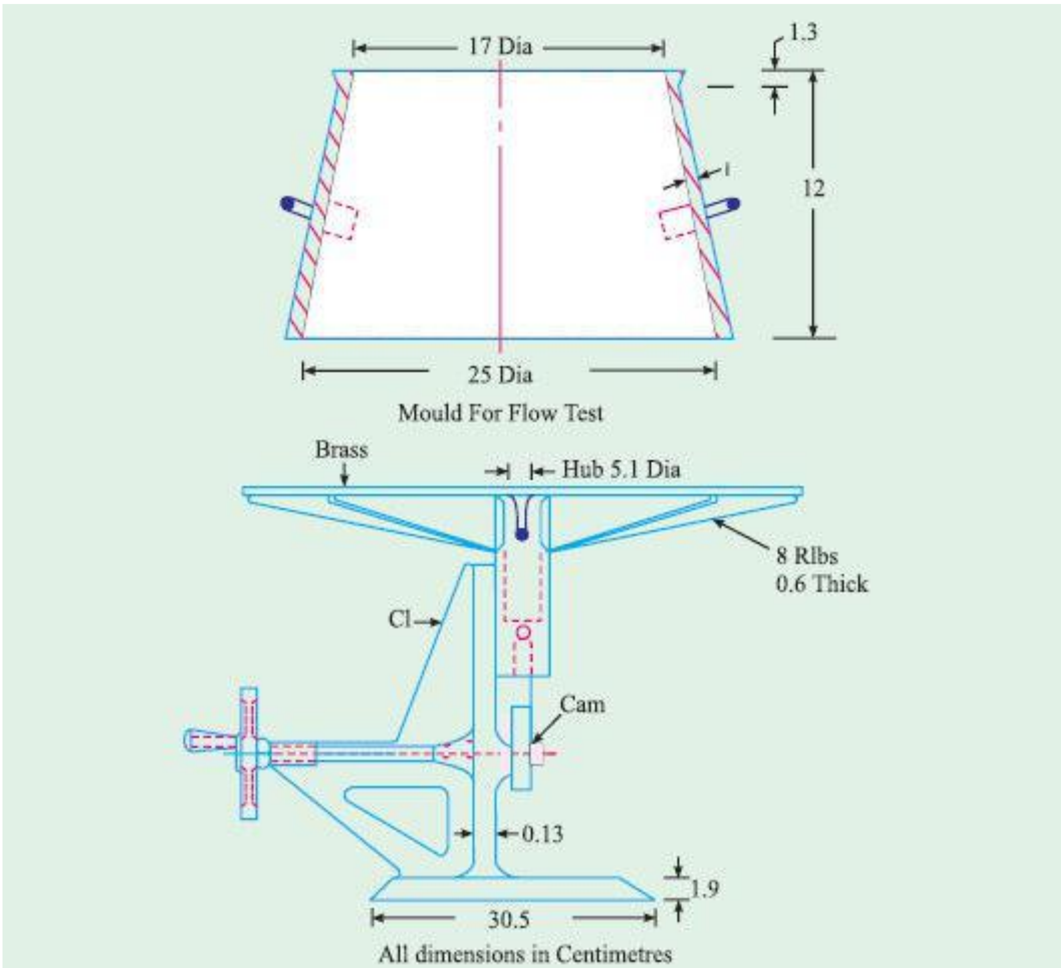
It can be realised that the compacting factor test measures the inherent characteristics of the concrete which relates very close to the workability requirements of concrete and as such it is one of the good tests to depict the workability of concrete.

Table: Workability, Slump and Compacting Factor of Concretes with 20 mm or 40 mm Maximum Size of Aggregate:

Degree of workability	*Slump mm*	*Compacting factor*		*Use for which concrete is suitable*
		Small appartus	*Large appartus*	
Very Low compacting factor is suitable	–	0.78	0.80	Roads vibrated by power-operated machines. At the more workable end of this group, concrete may be compacted in certain cases with hand-operated machines.
Low	25–75	0.85	0.87	Roads vibrated by hand-operated machines. At the more workable end of this group, concrete may be manually compacted in roads using aggregate of rounded or irregular shape. Mass concrete foundations without vibration or lightly reinforced sections with vibration.
Medium	50–100	0.92	0.935	At the less workable end of this group, manually compacted flat slabs using crushed aggregates. Normal reinforced concrete manually compacted and heavily reinforced sections with vibration
High	100–150	0.95	0.96	For sections with congested reinforcement. Not normally suitable for vibration. For pumping and tremie placing
Very High	–	–	–	Flow table test is more suitable.

Flow Test

This is a laboratory test, which gives an indication of the quality of concrete with respect to consistency, cohesiveness and the proneness to segregation. In this test, a standard mass of concrete is subjected to jolting. The spread or the flow of the concrete is measured and this flow is related to workability. Fig. shows the details of apparatus used.



It can be seen that the apparatus consists of flow table, about 76 cm. in diameter over which concentric circles are marked. A mould made from smooth metal casting in the form of a frustum of a cone is used with the following internal dimensions. The base is 25 cm. in diameter, upper surface 17 cm. in diameter, and height of the cone is 12 cm.

The table top is cleaned of all gritty material and is wetted. The mould is kept on the centre of the table, firmly held and is filled in two layers. Each layer is rodded 25 times with a tamping rod 1.6 cm in diameter and 61 cm long rounded at the lower tamping end. After the top layer is rodded evenly, the excess of concrete which has overflowed the mould is removed. The mould is lifted vertically upward and the concrete stands on its own without support. The table is then raised and dropped 12.5 mm 15 times in about 15 seconds. The diameter of the spread concrete is measured in about 6 directions to the nearest 5 mm and the average spread is noted. The flow of concrete is the percentage increase in the average diameter of the spread concrete over the base diameter of the mould.

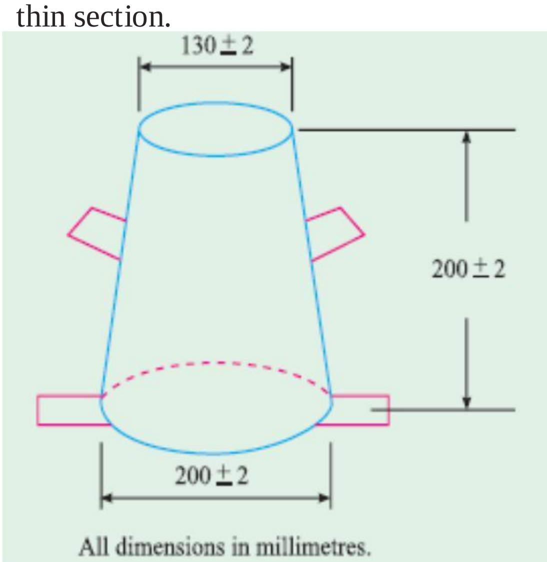
Flow, per cent = $\frac{\text{Spread diameter in cm} - 25}{25} \times 100$

The value could range anything from 0 to 150 per cent.

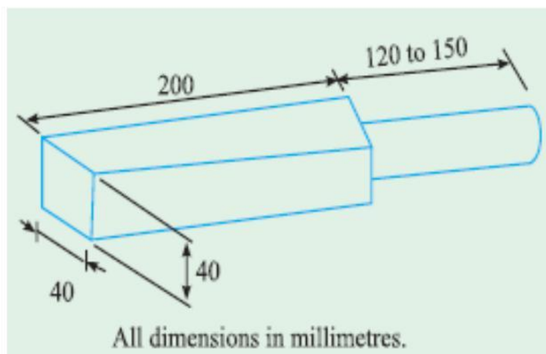
A close look at the pattern of spread of concrete can also give a good indication of the characteristics of concrete such as tendency for segregation.

Kelly Ball Test

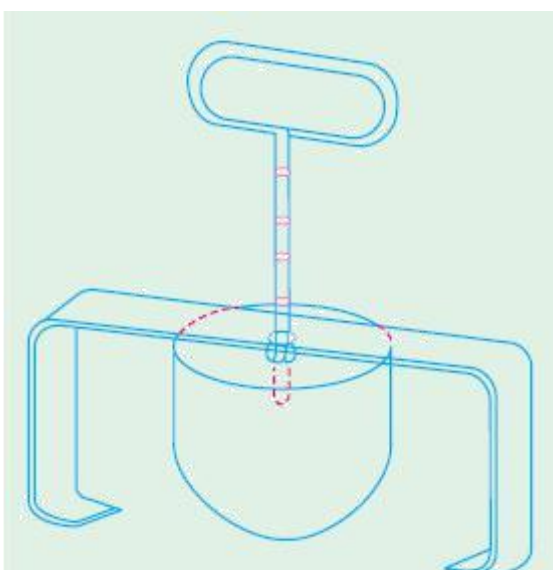
This is a simple field test consisting of the measurement of the indentation made by 15 cm diameter metal hemisphere weighing 13.6 kg when freely placed on fresh concrete. The test has been devised by Kelly and hence known as Kelly Ball Test. This has not been covered by Indian Standards Specification. The advantages of this test is that it can be performed on the concrete placed in site and it is claimed that this test can be performed faster with a greater precision than slump test. The disadvantages are that it requires a large sample of concrete and it cannot be used when the concrete is placed in thin section.



Mould



Tamping Bar

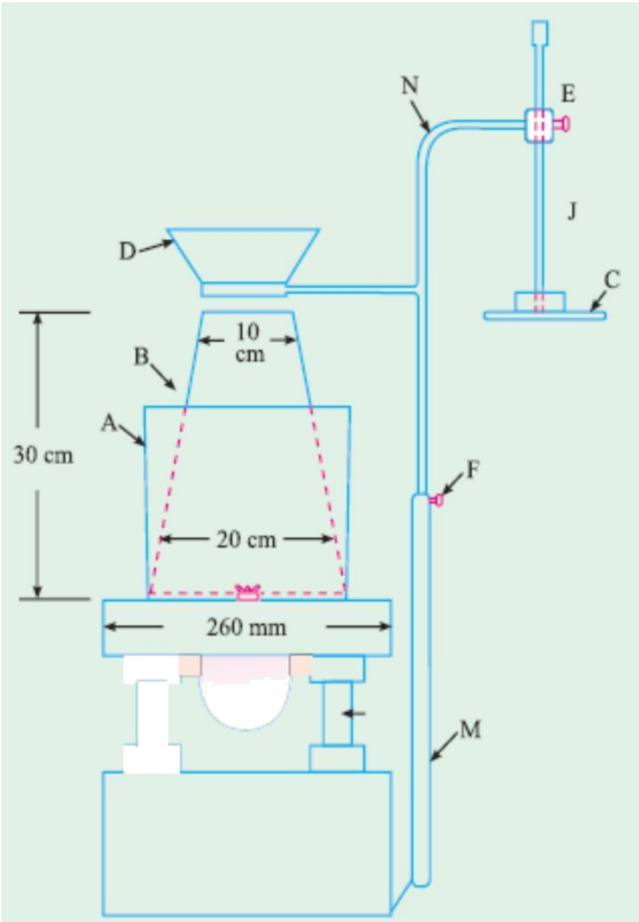


Kelly Ball

Vee Bee Consistometer Test

This is a good laboratory test to measure indirectly the workability of concrete. This test consists of a vibrating table, a metal pot, a sheet metal cone, a standard iron rod. The apparatus is shown in Figure:

Slump test as described earlier is performed, placing the slump cone inside the sheet metal cylindrical pot of the consistometer. The glass disc attached to the swivel arm is turned and placed on the top of the concrete in the pot. The electrical vibrator is then switched on and simultaneously a stop watch started. The vibration is continued till such a time as the conical shape of the concrete disappears and the concrete assumes a cylindrical shape. This can be judged by observing the glass disc from the top for disappearance of transparency. Immediately when the concrete fully assumes a cylindrical shape, the stop watch is switched off. The time required for the shape of concrete to change from slump cone shape to cylindrical shape in seconds is known as Vee Bee Degree. This method is very suitable for very dry concrete whose slump value cannot be measured by Slump Test, but the vibration is too vigorous for concrete with a slump greater than about 50 mm.



Vee-Bee Consistometer

Setting Time of Concrete

Setting time of concrete differs widely from setting time of cement. Setting time of concrete does not coincide with the setting time of cement with which the concrete is made. The setting time of concrete depends upon the w/c ratio, temperature conditions, type of cement, use of mineral admixture, use of plasticizers–in particular retarding plasticizer. The setting parameter of concrete is more of practical significance for site engineers than setting time of cement. When retarding plasticizers are used, the increase in setting time, the duration upto which concrete remains in plastic condition is of special interest.

The setting time of concrete is found by pentrometer test. The procedure given below may also be applied to prepared mortar and grouts.

The apparatus consist of a container which should have minimum lateral dimension of 150 mm and minimum depth of 150 mm. There are six penetration needles with bearing areas of 645, 323, 161, 65, 32 and 16 mm2. Each needle stem is scribed circumferentially at a distance of 25 mm from the bearing area.

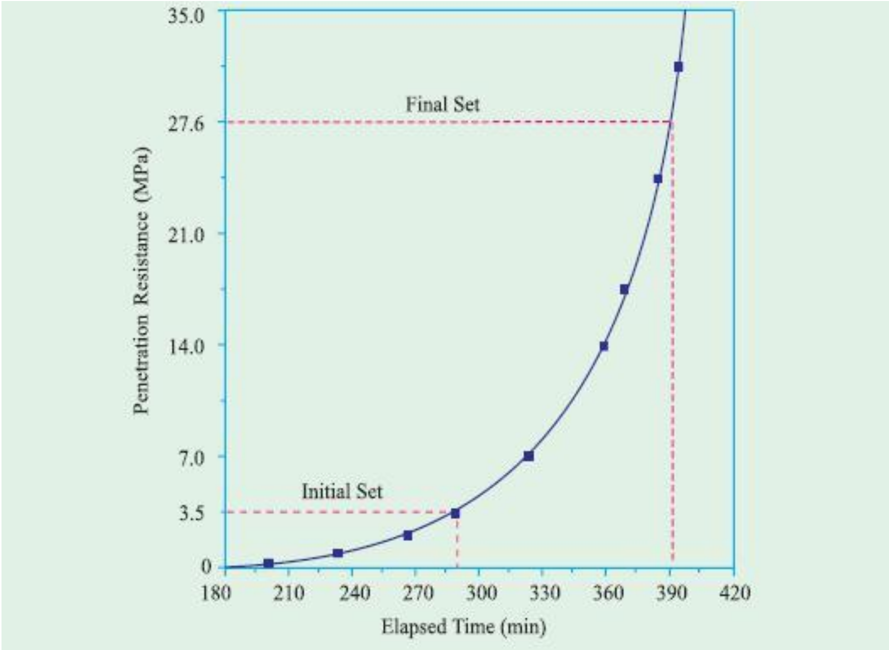
A device is provided to measure the force required to cause penetration of the needle. The test procedure involves the collection of representative sample of concrete in sufficient quantity and sieving it through 4.75 mm sieve and the resulting mortar is filled in the container.

Compact the mortar by rodding, tapping, rocking or by vibrating. Level the surface and keep it covered to prevent the loss of moisture. Remove bleeding water, if any, by means of pipette .Insert a needle of appropriate size, depending upon the degree of setting of the mortar in the following manner.

Bring the bearing surface of needle in contact with the mortar surface. Gradually and uniformly apply a vertical force downwards on the apparatus until the needle penetrates to a depth of 25 ± 1.5 mm, as indicated by the scribe mark. The time taken to penetrate 25 mm Depth could be about 10 seconds. Record the force required to produce 25 mm penetration and the time of inserting from the time water is added to cement. Calculate the penetration resistance by dividing the recorded force by the bearing area of the needle. This is the penetration resistance. For the subsequent penetration avoid the area where the mortar has been disturbed. The clear distance should be two times the diameter of the bearing area. Needle is inserted at least 25 mm away from the wall of container. Plot a graph of penetration resistance as ordinate and elapsed time as abscissa.

Not less than six penetration resistance determination is made. Continue the tests until one penetration resistance of at least 27.6 MPa is reached. Connect the various point by a smooth curve. From penetration resistance equal to 3.5 MPa, draw a horizontal line. The point of intersection of this with the smooth curve, is read on the x-axis which gives the initial setting time. Similarly a horizontal line is drawn from the penetration resistance of 27.6 MPa and point it cuts the smooth curve is read on the x-axis which gives the final set.

A typical graph is shown in Fig.



Segregation

Segregation can be defined as the separation of the constituent materials of concrete. A good concrete is one in which all the ingredients are properly distributed to make a homogeneous mixture. If a sample of concrete exhibits a tendency for separation of say, coarse aggregate from the rest of the ingredients, then, that sample is said to be showing the tendency for segregation. Such concrete is not only going to be weak; lack of homogeneity is also going to induce all undesirable properties in the hardened concrete. There are considerable differences in the sizes and specific gravities of the constituent ingredients of concrete. Therefore, it is natural that the materials show a tendency to fall apart.

Segregation may be of three types

- **firstly,** the coarse aggregate separating out or settling down from the rest of the matrix,
- **secondly**, the paste or matrix separating away from coarse aggregate and
- **thirdly**, water separating out from the rest of the material being a material of lowest specific gravity.

A well made concrete, taking into consideration various parameters such as grading, size, shape and surface texture of aggregate with optimum quantity of waters makes a cohesive mix. Such concrete will not exhibit any tendency for segregation.

The conditions favourable for segregation are, as can be seen from the above para,

1. The badly proportioned mix (where sufficient matrix is not there to bind and contain the aggregates.)
2. Insufficiently mixed concrete
3. excess water content shows a higher tendency for segregation.
4. Dropping of concrete from heights as in the case of placing concrete in column concreting will result in segregation. When concrete is discharged from a badly designed mixer, or from a mixer with worn out blades, concrete shows a tendency for Segregation.
5. Conveyance of concrete by conveyor belts, wheel barrow, long distance haul by dumper, long lift by skip and hoist are the other situations promoting segregation of concrete. Vibration of concrete is one of the important methods of compaction. It should be remembered that only comparatively dry mix should be vibrated.

Segregation is difficult to measure quantitatively, but it can be easily observed at the time of concreting operation. The pattern of subsidence of concrete in slump test or the pattern of spread in the flow test gives a fair idea of the quality of concrete with respect to segregation.

Bleeding

Bleeding is sometimes referred as water gain. It is a particular form of segregation, in which some of the water from the concrete comes out to the surface of the concrete, being of the lowest specific gravity among all the ingredients of concrete. Bleeding is predominantly observed in a highly wet mix, badly proportioned and insufficiently mixed concrete. In thin members like roof slab or road slabs and when concrete is placed in sunny weather show excessive bleeding.

Due to bleeding, water comes up and accumulates at the surface. Sometimes, along with this water, certain quantity of cement also comes to the surface. When the surface is worked up with the trowel and floats, the aggregate goes down and the cement and water come up to the top surface. This formation of cement paste at the surface is known as “Laitance”. In such a case, the top surface of slabs and pavements will not have good wearing quality. This laitance formed on roads produces dust in summer and mud in rainy season.

Water while traversing from bottom to top, makes continuous channels. If the water cement ratio used is more than 0.7, the bleeding channels will remain continuous and UN segmented by the development of gel. These continuous bleeding channels are often responsible for causing permeability of the concrete structures. The bleeding water is likely to accumulate below the aggregate. This accumulation of water creates water voids and reduces the bond between the aggregates and the paste. The above aspect is more pronounced in the case of flaky aggregate. The poor bond between the aggregate and the paste or the reinforcement and the paste due to bleeding can be remedied by re-vibration of concrete. The formation of laitance and the consequent bad effect can be reduced by delayed finishing operations.

Bleeding rate increases with time up to about one hour or so and thereafter the rate decreases but continues more or less till the final setting time of cement.. All the same, it can be reduced by proper proportioning and uniform and complete mixing. Use of finely divided pozzolanic materials reduces bleeding by creating a longer path for the water to traverse.

Process of Manufacture of Concrete

Production of quality concrete requires meticulous care exercised at every stage of manufacture of concrete. It is interesting to note that the ingredients of good concrete and bad concrete are the same. If meticulous care is not exercised, and good rules are not observed, the resultant concrete is going to be of bad quality. With the same material if intense care is taken to exercise control at every stage, it will result in good concrete. Therefore, it is necessary for us to know what are the good rules to be followed in each stage of manufacture of concrete for producing good quality concrete. The various stages of manufacture of concrete are:

(a) Batching
(b) Mixing
(c) Transporting

(d) Placing
(e) Compacting
(f) Curing
(g) Finishing.

(a) Batching

The measurement of materials for making concrete is known as batching. There are two methods of batching:
(i) Volume batching (ii) Weigh batching

(i) Volume batching: Volume batching is not a good method for proportioning the material because of the difficulty it offers to measure granular material in terms of volume.
Volume of moist sand in a loose condition weighs much less than the same volume of dry compacted sand. The amount of solid granular material in a cubic metre is an indefinite quantity. Because of this, for quality concrete material have to be measured by weight only. However, for unimportant concrete or for any small job, concrete may be batched by volume. Cement is always measured by weight. It is never measured in volume. Generally, for each batch mix, one bag of cement is used. The volume of one bag of cement is taken as thirty five (35) litres. Water is measured litres as may be convenient. In this case, the two units are same, as the density of water is litre.
(ii) correct method of measuring the materials. For important concrete, invariably, weigh batching system should be adopted. Use of weight system in batching, facilitates accuracy, flexibility and simplicity.

Mixing

Thorough mixing of the materials is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency. There are two methods adopted for mixing concrete:
(i) Hand mixing (ii)Machine mixing

Hand Mixing: Hand mixing is practised for small scale unimportant concrete works. As the mixing cannot be thorough and efficient, it is desirable to add 10 per cent more cement to cater for the inferior concrete produced by this method.

Machine Mixing: Mixing of concrete is almost invariably carried out by machine, for reinforced concrete work and for medium or large scale mass concrete work. Machine mixing is not only efficient, but also economical, when the quantity of concrete to be produced is large.

Transporting Concrete

Concrete can be transported by a variety of methods and equipments. The precaution to be taken while transporting concrete is that the homogeneity obtained at the time of mixing should be maintained while being transported to the final place of deposition. The methods adopted for transportation of concrete are:
(a) Mortar Pan
(b) Wheel Barrow, Hand Cart
(c) Crane, Bucket and Rope way
(d) Truck Mixer and Dumpers

(e) Belt Conveyors
(f) Chute
(g) Skip and Hoist
(h) Tansit Mixer
(i) Pump and Pipe Line

Mortar Pan:

Use of mortar pan for transportation of concrete is one of the common methods adopted in this country. It is labour intensive. In this case, concrete is carried in small quantities. Mortar pan method of conveyance of concrete can be adopted for concreting at the ground level, below or above the ground level without much difficulty.

Wheel barrow:

Wheel barrows are normally used for transporting concrete to be placed at ground level.
This method is employed for hauling concrete for comparatively longer distance as in the case of concrete road construction. If concrete is conveyed by wheel barrow over a long distance, on rough ground, it is likely that the concrete gets segregated due to vibration. The coarse aggregates settle down to the bottom and matrix moves to the top surface. To avoid this situation, sometimes, wheel barrows are provided with pneumatic wheel to reduce vibration. A wooden plank road is also provided to reduce vibration and hence segregation.

Crane, Bucket and Rope Way:

A crane and bucket is one of the right equipment for transporting concrete above ground level. Crane can handle concrete in high rise construction projects and are becoming familiar sites in big cities. Cranes are fast and versatile to move concrete horizontally as well as vertically along the boom and allows the placement of concrete at the exact point. Cranes carry skips or buckets containing concrete. Skips have discharge door at the bottom, whereas buckets are tilted for emptying. For a medium scale job the bucket capacity may be 0.5 m3.
Rope way and bucket of various sizes are used for transporting concrete to a place, where simple method of transporting concrete is found not feasible. For the concrete works in a valley or the construction work of a pier in the river or for dam construction, this method of transporting by rope way and bucket is adopted. The mixing of concrete is done on the bank or abutment at a convenient place and the bucket is brought by a pulley or some other arrangement. It is filled up and then taken away to any point that is required. The vertical movement of the bucket is also controlled by another set of pullies. Sometimes, cable and car arrangement is also made for controlling the movement of the bucket. This is one of the methods generally adopted for concreting dam work or bridge work. Since the size of the bucket is considerably large and concrete is not exposed to sun and wind there would not be much change in the state of concrete or workability.

Truck Mixer and Dumpers:

For large concrete works particularly for concrete to be placed at ground level, trucks and dumpers or ordinary open steel-body tipping lorries can be used As they can travel to any part of the work, they have much advantage over the jubilee wagons, which require rail tracks.Dumpers are of usually 2 to 3 cubic metre capacity, whereas the capacity of truck may be 4cubic metre or more. Before loading with the concrete, the inside of the body should be justwetted with water. Tarpaulins or other covers may be provided to cover the wet concrete duringtransit to prevent evaporation when the haul is long; it is advisable to use agitators which prevent segregation and stiffening. The agitators help the mixing process at a slow speed. For road construction using Slip Form Paver large quantity of concrete is required to besupplied continuously. A number of dumpers of 6 m^3 capacity are employed to supply concrete.

Small dumper called Tough Riders are used for factory floor construction.

Belt Conveyors:

Belt conveyors have very limited applications in concrete construction. The principalobjection is the tendency of the concrete to segregate on steep inclines, at transfer points orchange of direction, and at the points where the belt passes over the rollers. Anotherdisadvantage is that the concrete is exposed over long stretches which causes drying andstiffening particularly, in hot, dry and windy weather. Segregation also takes place due to thevibration of rubber belt. It is necessary that the concrete should be remixed at the end of deliverybefore placing on the final position.

Chute:

Chutes are generally provided for transporting concrete from ground level to a lowerlevel. The sections of chute should be made of or lined with metal and all runs shall haveapproximately the same slope, not flatter than 1 vertical to 2 1/2 horizontal. The lay-out is madein such a way that the concrete will slide evenly in a compact mass without any separation orsegregation. The required consistency of the concrete should not be changed in order to facilitatechuting. If it becomes necessary to change the consistency the concrete mix will be completelyredesigned.

Transporting and placing concrete by chute

This is not a good method of transporting concrete. However, it is adopted, when movement of labour cannot be allowed due to lack of space or for fear of disturbance to reinforcement or other arrangements already incorporated.

Skip and Hoist:

This is one of the widely adopted methods for transporting concrete vertically up formultistorey building construction. Employing mortar pan with the staging and human ladder fortransporting concrete is not normally possible for more than 3 or 4 storeyed building constructions. For laying concrete in taller structures, chain hoist or platform hoist or skip hoistis adopted. At the ground level, mixer directly feeds the skip and the skip travel up over rails upto the level where concrete is required.

Transit Mixer:

Transit mixer is one of the most popular equipments for transporting concrete over a long distance particularly in Ready Mixed Concrete plant (RMCJ. In India, today (2000 AD) there are about 35 RMC plants and a number of central batching plants are working. It is a fair estimate that there are over 600 transit mixers in operation in India. They are truck mounted having a capacity of 4 to 7 m^3. There are two variations. In one, mixed concrete is transported to the site by keeping it agitated all along at a speed varying between 2 to 6 revolutions per minute. In the other category, the concrete is batched at the central batching plant and mixing is done in the truck mixer either in transit or immediately prior to discharging the concrete at site.

Transit Mixer, a popular mathod of transporting concrete over a long distance.

With the development of twin fin process mixer, the transit mixers have become more efficient in mixing. In these mixers, in addition to the outer spirals, have two opposed inner spirals. The outer spirals convey the mix materials towards the bottom of the drum, while the opposed mixing spirals push the mix towards the feed opening. The repeated counter current mixing process is taking place within the mixer drum Sometimes a small concrete pump is also mounted on the truck carrying transit mixer.

Placing Concrete

It is not enough that a concrete mix correctly designed, batched, mixed and transported; it is of utmost importance that the concrete must be placed in systematic manner to yield optimum results.

Form work: Form work shall be designed and constructed so as to remain sufficiently rigid during placing and compaction of concrete. The joints are plugged to prevent the loss of slurry from concrete.

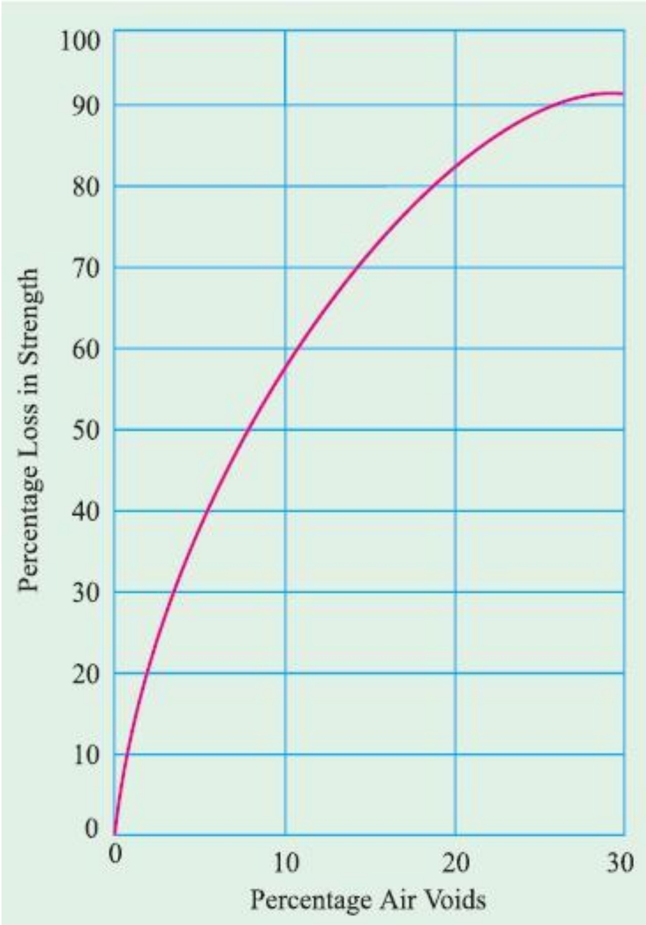
Stripping Time: Formwork should not be removed until the concrete has developed strength of at least twice the stress to which concrete may be subjected at the time of removal of formwork. In special circumstances the strength development of concrete can be assessed by placing companion cubes near the structure and curing the same in the manner simulating curing conditions of structures. In normal circumstances, where ambient temperature does not fall below 15°C and where ordinary Portland cement is used and adequate curing is done, following striking period can be considered sufficient as per IS 456 of 2000.

Table: Stripping Time of Formwork

Sr. No.	Type of Formwork	Minimum period before striking formwork
1.	Vertical formwork to columns walls and beams	16 – 24 hours
2.	Soffit formwork to slabs (props to be refixed immediately after removal of formwork)	3 days
3.	Soffit formwork to beams (Props to be refixed immediately after removal of formwork)	7 days
4.	Props to slab	
	spanning up to 4.5 m	7 days
	spanning over 4.5 m	14 days
5.	Props to beam and arches	
	Spanning up to 6 m	14 days
	Spanning over 6 m	21 days

Compaction of Concrete

Compaction of concrete is the process adopted for expelling the entrapped air from the concrete. In the process of mixing, transporting and placing of concrete air is likely to get entrapped in the concrete. The lower the workability, higher is the amount of air entrapped. In other words, stiff concrete mix has high percentage of entrapped air and, therefore, would need higher compacting efforts than high workable mixes. If this air is not removed fully, the concrete loses strength considerably. The following Fig. shows the relationship between loss of strength and air voids left due to lack of compaction.



It can be seen from the figure that 5 per cent voids reduce the strength of concrete by about 30 per cent and 10 per cent voids reduce the strength by over 50 per cent. Therefore, it is imperative that 100 per cent compaction of concrete is one of the most important aim to be kept in mind in good concrete-making practices. It must be borne in mind that 100 per cent compaction is important not only from the point of view of strength, but also from the point of durability. In recent time, durability becomes more important than strength.

Insufficient compaction increases the permeability of concrete resulting in easy entry for aggressive chemicals in solution, which attack concrete and reinforcement to reduce the durability of concrete. Therefore, 100 per cent compaction of concrete is of paramount importance.

In order to achieve full compaction and maximum density, with reasonable compacting efforts available at site, it is necessary to use a mix with adequate workability. It is also of common knowledge that the mix should not be too wet for easy compaction which also reduces the strength of concrete. For maximum strength, driest possible concrete should be compacted 100 per cent. The overall economy demands 100 per cent compaction with a reasonable compacting efforts available in the field. The following methods are adopted for compacting the concrete: (a) Hand Compaction:

(i) Rodding (ii) Ramming (iii) Tamping

(b) Compaction by Vibration

(i) Internal vibrator (Needle vibrator)
(ii) Formwork vibrator (External vibrator)
(iii) Table vibrator
(iv) Platform vibrator
(v) Surface vibrator (Screed vibrator)
(vi) Vibratory Roller.

(c) Compaction by Pressure and Jolting

(d) Compaction by Spinning.

Hand Compaction: Hand compaction of concrete is adopted in case of unimportant concrete work of small magnitude. Sometimes, this method is also applied in such situation, where a large quantity of reinforcement is used, which cannot be normally compacted by mechanical means. Hand compaction consists of rodding, ramming or tamping. When hand compaction is adopted, the consistency of concrete is maintained at a higher level. The thickness of the layer of concrete is limited to about 15 to 20 cm.

Rodding is nothing but poking the concrete with about 2 metre long, 16 mm diameter rod to pack the concrete between the reinforcement and sharp corners and edges. Ramming should be done with care. Light ramming can be permitted in un reinforced foundation concrete or in ground floor construction. Ramming should not be permitted in case of reinforced concrete or in the upper floor construction, where concrete is placed in the formwork supported on struts.

Tamping is one of the usual methods adopted in compacting roof or floor slab or road pavements where the thickness of concrete is comparatively less and the surface to be finished smooth and level.

Compaction by Vibration:

It is pointed out that the compaction by hand, if properlycarried out on concrete with sufficient workability, gives satisfactory results, but the strength of the hand compacted concrete will be necessarily low because of higher water cement ratio required for full compaction. Where high strength is required, it is necessary that stiff concrete, with low water/cement ratio be used. To compact such concrete, mechanically operated vibratory equipment, must be used. The vibrated concrete with low water/cement ratio will have many advantages over the hand compacted concrete with higher water/cement ratio.

The action of vibration is to set the particles of fresh concrete in motion, reducing the friction between them and affecting a temporary liquefaction of concrete which enables easy settlement. While vibration itself does not affect the strength of concrete which is controlled by the water/cement ratio, it permits the use of less water Concrete of higher strength and better quality can, therefore, be made with a given cement factor with less mixing water. Where only a given strength is required, it can be obtained with leaner mixes than possible with hand compaction, making the process economical. Vibration, therefore, permits improvement in the quality of concrete and in economy.

Internal Vibrator:

Of all the vibrators, the internal vibrator is most commonly used. This is also called, “Needle Vibrator”, “Immersion Vibrator”, or “Poker Vibrator”.

This essentially consists of a power unit, a flexible shaft and a needle. The power unit may be electrically driven or operated by petrol engine or air compressor. The vibrations are caused by eccentric weights attached to the shaft or the motor or to the rotor of a vibrating element.

Formwork Vibrator (External Vibrator):

Formwork vibrators are used for concreting columns, thin walls or in the casting of precast units. The machine is clamped on to the external wall surface of the formwork. The vibration is given to the formwork so that the concrete in the vicinity of the shutter gets vibrated. This method of vibrating concrete is particularly useful and adopted where reinforcement, lateral ties and spacers interfere too much with the internal vibrator.

Table Vibrator: This is the special case of formwork vibrator, where the vibrator is clamped to the table. or table is mounted on springs which are vibrated transferring the vibration to the table. They are commonly used for vibrating concrete cubes. Any article kept on the table gets vibrated. This is adopted mostly in the laboratories and in making small but precise prefabricated R.C.C. members.

Platform Vibrator:

Platform vibrator is nothing but a table vibrator, but it is larger in size. This is used in the manufacture of large prefabricated concrete elements such as electric poles, railway sleepers, prefabricated roofing elements etc. Sometimes, the platform vibrator is also coupled with jerking or shock giving arrangements such that a thorough compaction is given to the concrete.

Surface Vibrator:

Surface vibrators are sometimes knows as, “Screed Board Vibrators”. A small vibrator placed on the screed board gives an effective method of compacting and levelling of thin concrete members, such as floor slabs, roof slabs and road surface. Mostly, floor slabs and roof slabs are so thin that internal vibrator or any other type of vibrator cannot be easily employed. In such cases, the surface vibrator can be effectively used. In general, surface vibrators are not effective beyond about 15 cm.

Compaction by Pressure and Jolting:

This is one of the effective methods of compacting very dry concrete. This method is often used for compacting hollow blocks, cavity blocks and solid concrete blocks. The stiff concrete is vibrated, pressed and also given jolts. With the combined action of the jolts vibrations and pressure, the stiff concrete gets compacted to a dense form to give good strength and volume stability. By employing great pressure, a concrete of very low water cement ratio can be compacted to yield very high strength.

Compaction by Spinning:

Spinning is one of the recent methods of compaction of concrete. This method of compaction is adopted for the fabrication of concrete pipes. The plastic concrete when spun at a very high speed, gets well compacted by centrifugal force. Patented products such a “Hume Pipes”, “spun pipes” are compacted by spinning process.

Vibratory Roller:

One of the recent developments of compacting very dry and lean concrete is the use of Vibratory Roller. Such concrete is known as Roller Compacted Concrete. This method of concrete construction originated from Japan and spread to USA and other countries mainly for the construction of dams and pavements. Heavy roller which vibrates while rolling is used for the compaction of dry lean concrete.

General Points on Using Vibrators:

Vibrators may be powered by any of the following units:

(a) Electric motors either driving the vibrator through flexible shaft or situated in the Head of the vibrator.

(b) Internal combustion engine driving the vibrator needle through flexible shaft, and

(c) Compressed-air motor situated near the head of the vibrator.

Curing Methods:

Curing methods may be divided broadly into four categories:

a. Water curing
b. Membrane curing
c. Application of heat
d. Miscellaneous

Water Curing:

This is by far the best method of curing as it satisfies all the requirements of curing, namely, promotion of hydration, elimination of shrinkage and absorption of the heat of hydration. It is pointed out that even if the membrane method is adopted, it is desirable that a certain extent of water curing is done before the concrete is covered with membranes.

Water curing can be done in the following ways:

a. Immersion
b. Ponding
c. Spraying or Fogging
d. Wet covering

The precast concrete items are normally immersed in curing tanks for certain duration. Pavement slabs, roof slab etc. are covered under water by making small ponds. Vertical retaining wall or plastered surfaces or concrete columns etc. are cured by spraying water. In some cases, wet coverings such as wet gunny bags, hessian cloth, jute matting, straw etc., are wrapped to vertical surface for keeping the concrete wet. For horizontal surfaces saw dust, earth or sand are used as wet covering to keep the concrete in wet condition for a longer time so that the concrete is not unduly dried to prevent hydration.

Membrane Curing:

Sometimes, concrete works are carried out in places where there is acute shortage of water. The lavish application of water for water curing is not possible for reasons of economy. It has been pointed out earlier that curing does not mean only application of water; it means also creation of conditions for promotion of uninterrupted and progressive hydration. It is also pointed out that the quantity of water, normally mixed for making concrete is more than sufficient to hydrate the cement, provided this water is not allowed to go out from the body of concrete. For this reason, concrete could be covered with membrane which will effectively seal off the evaporation of water from concrete. It is found that the application of membrane or a sealing compound, after a short spell of water curing for one or two days is sometimes beneficial.

Membrane curing by spraying

Membrane curing is a good method of maintaining a satisfactory state of wetness in the body of concrete to promote continuous hydration when original water/cement ratio used is not less than 0.5. To achieve best results, membrane is applied after one or two days' of actual wet curing. Since no replenishing of water is done after the membrane has been applied it should be ensured that the membrane is of good quality and it is applied effectively. Two or three coats may be required for effective sealing of the surface to prevent the evaporation of water.Increase in volume of construction, shortage of water and need for conservation of water, increase in cost of labour and availability of effective curing compounds have encouraged the use of curing compounds in concrete construction.

Curing vertical surface by wet covering.

Application of Heat:

The development of strength of concrete is a function of not only time but also that of temperature. When concrete is subjected to higher temperature it accelerates the hydration process resulting in faster development of strength. Concrete cannot be subjected to dry heat to accelerate the hydration process as the presence of moisture is also an essential requisite.

Steam curing at ordinary pressure:

This method of curing is often adopted for prefabricated concrete elements. Application of steam curing to i n s i t u construction will be a little difficult task. However, at some places it has been tried for i n s i tu construction by forming a steam jacket with the help of tarpaulin or thick polyethylene sheets. But this method of application of steam for i n s i t u work is found to be wasteful and the intended rate of development of strength and benefit is not really achieved

Beam under steam curing

Steam curing at ordinary pressure is applied mostly on prefabricated elements stored in chamber. The chamber should be big enough to hold a day's production. The door is closed and steam is applied. The steam may be applied either continuously or intermittently. An accelerated hydration takes place at this higher temperature and the concrete products attain the 28 days strength of normal concrete in about 3 days.

High Pressure Steam Curing:

In the steam curing at atmospheric pressure, the temperature of the steam is naturally below 100°C. The steam will get converted into water, thus it can be called in a way, as hot water curing. This is done in an open atmosphere.

The high pressure steam curing is something different from ordinary steam curing, in that the curing is carried out in a closed chamber. The superheated steam at high pressure and high temperature is applied on the concrete. This process is also called "Autoclaving". The autoclaving process is practised in curing precast concrete products in the factory, particularly,for the lightweight concrete products. In India, this high pressure steam curing is practised in the manufacture of cellular concrete products, such as Siporex, Celcrete etc.

Curing by Infra-red Radiation:

Curing of concrete by Infra-red Radiation has been practised in very cold climatic regions in Russia. It is claimed that much more rapid gain of strength can be obtained than with steam curing and that rapid initial temperature does not cause a decrease in the ultimate strength as in the case of steam curing at ordinary pressure. The system is very often adopted for the curing of hollow concrete products. The normal operative temperature is kept at about 90°C.