VISVESVARAYA TECHNOLOGICAL UNIVERSITY
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CONCRETE TECHNOLOGY
(Subject Code : 21CV62)

LECTURE NOTES

(MODULE-2)

FRESH CONCRETE

VI-SEMESTER

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FRESH CONCRETE

Syllabus: Workability - Process of manufactures of concrete: Batching, Mixing, Assessment of Workability of Concrete, Factors affecting workability, Measurement of workability – slump test, flow test, Compaction factor test and Vee-Bee Consistometer tests, Segregation and bleeding, Transporting, Placing, Compaction, Curing, need and Types of curing, accelerated curing.

Workability

Workability is defined as "that property of freshly mixed concrete which determines the ease and homogeneity with which it can be easily mixed, transported, placed, compacted and finished without segregation and bleeding".

Workability of concrete is a term which consists of the following four partial properties of concrete namely, Mixability, Transportability Mould ability and Compatibility.

Mixability: It is the ability of the mix to produce a homogeneous green concrete from the constituent materials of the batch, under the action of the mixing forces.

Transportability: Transportability is the capacity of the concrete mix to keep the homogeneous concrete mix from segregating during a limited time period of transportation of concrete, when forces due to handling operations of limited nature act.

Mouldability: It is the ability of the fresh concrete mix to fill completely the forms or moulds without losing continuity or homogeneity under the available techniques of placing the concrete at a particular job/site. This property is complex, since the behaviour of concrete is to be considered under dynamic conditions.

Compactibility: Compactability is the ability of concrete mix to be compacted into a dense, compact concrete, with minimum voids, under the existing means of compaction at the site.

Factors affecting workability:

- **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). At the work site, supervisors/ labours are not well versed with the practice of making good concrete, resort to adding more water for increasing workability. In case, all other steps to improve workability fail, only as last recourse the addition of more water can be considered. 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.
- **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.
- **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.
- **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 betterworkability 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. This explains the reason why river sand and gravel provide greater workability to concrete than crushed sand an aggregate.

- **Surface Texture:** The influence of surface texture on workability is again clue 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.
- **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. Aggregate particles will slide past each other with the least amount of compacting efforts. 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.

Use of Admixture:-

The most important factor which affects the workability is the use of admixtures. Use of air entraining agent and pozzolonic material greatly increased the workability when other conditions are constant. Air entraining agent's means they reduce the internal friction between the particles .They also act as an artificial fine aggregates of very smooth surface. The pozzolonic materials offer better lubricating effects for giving better workability.

Measurement of Workability:

The following tests are commonly employed to measure workability.

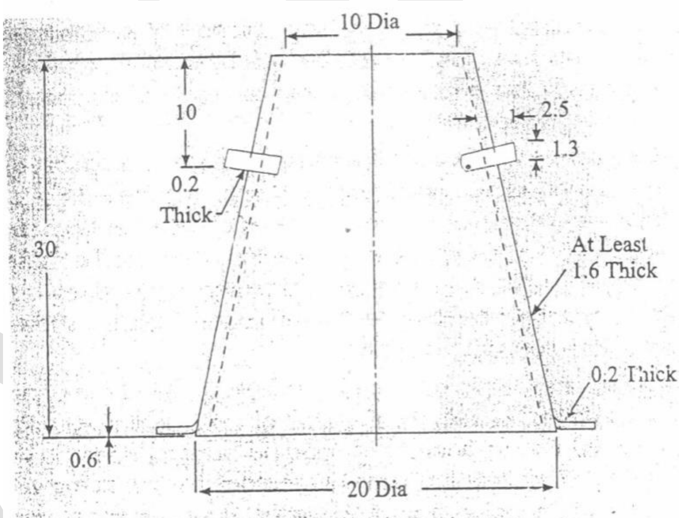
a) Slump Test
b) Flow Test
c) Compacting Factor Test
d) Vee Bee Consistometer Test
e) Keelly Ball Test.

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. Unsupported fresh concrete flows to the sides and a sinking in height takes place. This vertical settlement is known as slump. In this test fresh concrete is filled into a mould of specified shape and dimensions, and the settlement or slump measured when supporting mould is removed. ***Slump increases as water-content is increased***. For different works different slump values have been recommended.

The apart us 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

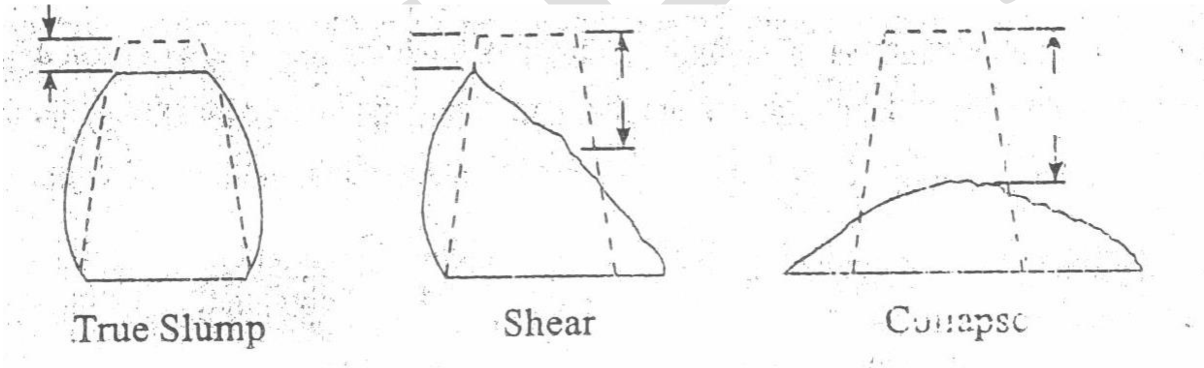


All dimensions in Centimeters
Typical mould for Slump test.

The thickness of the metallic sheet for the mould should not be thinner than 1.6 mm. Sometimes the mould is provided with suitable guides for lifting vertically up. For tamping the concrete, a steel tamping rod 16 mm dia, 0.6 meter along with bullet end is used.

Fig. Shows the details of the slump cone apparatus. The internal surface of the mould is thoroughly cleaned and freed from superfluous moisture and adherence of any old set concrete before commencing the test. The mould is placed on a smooth, horizontal, rigid and nonabsorbent 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 allows the concrete to subside. 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 as **"True slump**"
- If the one half of the concrete slides down it is called "**shear slump".**
- In case of shear slump the slump value is measured as a difference in height b/w mould and avg value of subsidence.



Slump : True, Shear and Collapse.

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 (vibrating). The spread or the flow of the concrete is measured and this flow is related to workability.

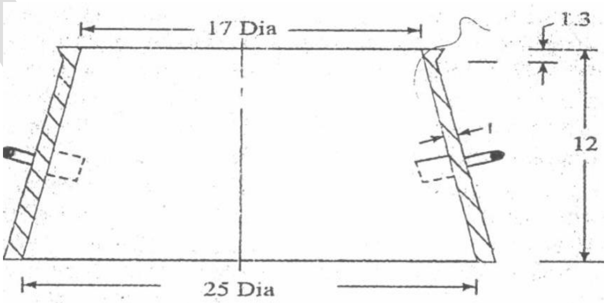
Fig. shows the details of apparatus used. It can be seen that the apparatus consists of flow table, about 76 cm. in diameter over which concentric circles are marked. A mould made from smooth metal casting in the form of a frustum of a cone is used with the following internal dimensions. The base is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

Procedure

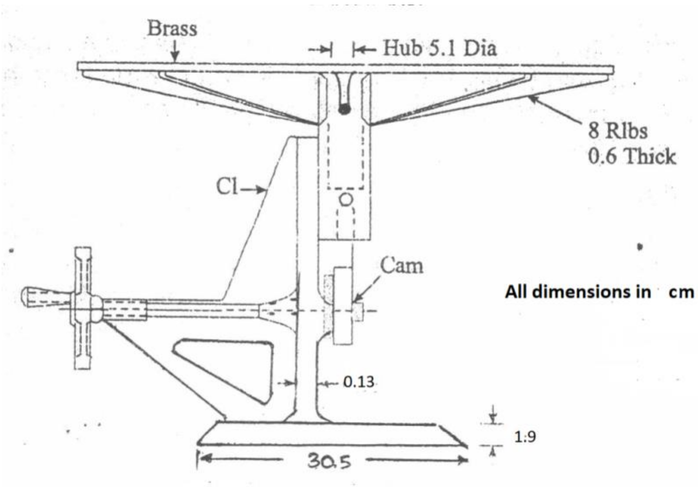
- The table top is cleaned of all gritty material and is wetted.
- The mould is kept on the centre of the table, firmly held and is filled in two layers.
- Each layer is rodded 25 times with a tamping rod 1.6 cm in diameter and 61 cm long rounded at the lower tamping end.
- After the top layer is rodded evenly, the excess of concrete which has over flowed 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 spread is measured in about 6 directions to the nearest 5 mm and the average 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.

$$Flow\ percent = \left(\frac{Spread\ diameter\ in\ cm - 25}{25}\right) \times 100$$

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.



Mould For Flow Test



Flow Table Apparatus

COMPACTION FACTOR TEST:

Compaction factor test is adopted to determine the workability of concrete, where nominal size of aggregate does not exceed 40mm, and is primarily used in laboratory. It is based upon the definition, that workability is that property of the concrete which determines the amount of work required to produce ***full compaction***. The test consists essentially of applying a standard amount of work to standard quantity of concrete and measuring the resulting compaction. To find the workability of freshly prepared concrete, the test is carried out as per specification of IS: 1199-1959. Workability gives an idea of the capability of being worked, i.e., idea to control the quantity of water in cement concrete mix to get uniform strength.

It is more sensitive and precise than slump test and is particularly useful for concrete mixes of low workability. The compaction factor (C.F.) test is able to indicate small variations in workability over a wide range.

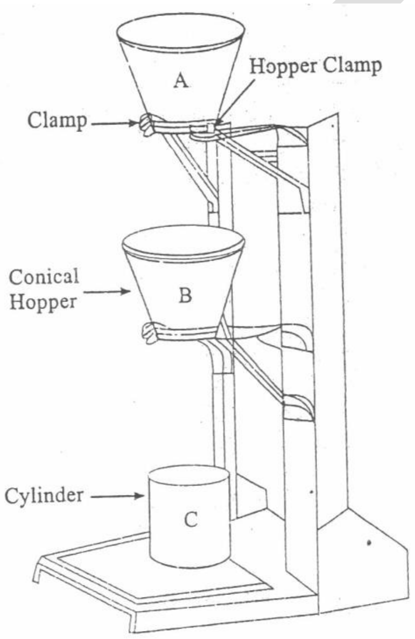
The sample of concrete to be tested is placed in the upper hopper up to the brim. The trap-door is opened so that the concrete falls into the lower hopper. Then the trap-door of the lower hopper is opened and the concrete is allowed to fall into the cylinder. In the case of a dry-mix, it is likely that 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 filledup exactly up to the top level of the cylinder.

Essential dimension of the compacting factorfor use with aggregate not exceeding 40 mm Nominal Maximum Size

Upper hopper A	**Dimension (cm)**
Top internal diameter	25.4
Bottom internal diameter	12.7
Internal height	27.9
Lower hopper B	
Top internal diameter	22.9
Bottom internal diameter	12.7
Internal height	22.9
Cylinder C	
Internal diameter	15.2
Internal height	30.5
Distance between bottom of upper hopper and top of lower hopper	20.3
Distance between bottom of lower hopper and top cylinder	20.3

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 5cm 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".

$$Compacting\ factor = \left(\frac{Weight\ of\ \ Partially\ Compacted Concrete}{Weight\ of\ \ fully\ compacted\ concrete}\right)$$



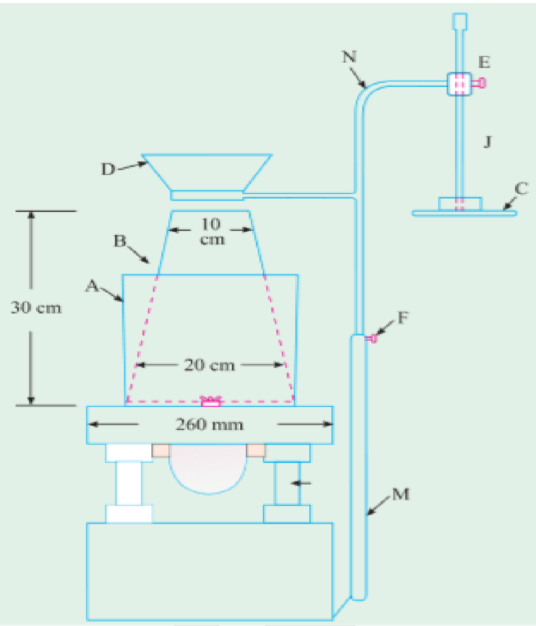
Compacting Factor Apparatus

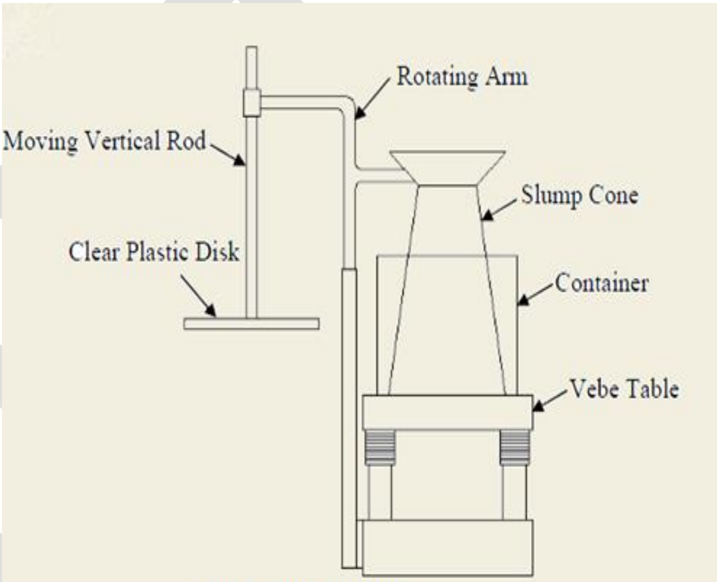
- **VEE BEE CONSISTOMETER TEST**

The workability of fresh concrete is a composite property, which includes the diverse requirements of stability, mobility, compactability, placeability and finishability. There are different methods for measuring the workability. Each of them measures only a particular aspect of it and there is really no unique test, which measures workability of concrete in its totality. This test gives an indication of the mobility and to some extent of the compactability of freshly mixed concrete.

The test measures the relative effort required to change a mass of concrete from one definite shape to another (i.e., from conical to cylindrical) by means of vibration. The amount of effort called remoulding effort is taken as the times in seconds are required to complete the change. The results of this test are of value in studying the mobility of the masses of concrete made with varying amounts of water, cement and with various types of gradings of aggregate. The time required for complete remoulding in seconds is considered as a measure of workability and is expressed as the number of Vee-Bee seconds. The method is suitable for dry concrete. For concrete of slump in excess of 50mm, the remoulding is so quick that the time cannot be measured.

Procedure:





Vebe Consistometer

1. Place the slump cone in the cylindrical container of the consistometer. Fill the cone in four layers, each approximately one quarter of the height of the cone. Tamp each layer with twenty five strokes of the rounded end of the tamping rod. The strokes are distributed in a uniform manner over the cross-section of the cone and for the second and subsequent layers the tamping bar should penetrate into the underlying layer. After the top layer has been rodded, struck off level the concrete with a trowel so that the cone is exactly filled.
2. Move the glass disc attached to the swivel arm and place it just on the top of the slump cone in the cylindrical container. Adjust the glass disc so as to touch the top of the concrete cone, and note the initial reading on the graduated rod.

3. Remove the cone from the concrete immediately by raising it slowly and carefully in the vertical direction. Lower the transparent disc on the top of concrete. Note down the reading on the graduated rod.
4. Determine the slump by taking the difference between the readings on the graduated rod recorded in the steps (2) and (3) above.
5. Switch on the electrical vibrations and start the stopwatch. Allow the concrete to remould by spreading out in the cylindrical container. The vibrations are continued until the concrete is completely remoulded, i.e, the surfaces becomes horizontal and the whole concrete surface adheres uniformly to the transparent disc.
6. Record the time required for complete remoulding seconds which measures the workability expressed as number of Vee-Bee seconds.

- **SEGREGATION**

Segregation is defined as the separation of the constituents of a homogeneous mixture of concrete. It is caused by the differences in sizes and weights of the constituent particles. Segregation can be controlled by properly choosing the grading of aggregates and by carefully handling wet mixes. In relatively lean and dry mixes, segregation can be caused by the coarser particles separating out because they travel further along the slope or settle to a greater extent than finer particles. The second form of segregation occurs in very wet mixes in which the cement — water paste separates from the mix.

Segregation can also be caused by poor handling, such as dropping wet concrete from a considerable height, passing long chutes along a slope, and discharging concrete carelessly against some firm obstruction. It may also be caused by the vibration of concrete. Though vibration provides a useful means of compaction, over vibration leads to segregation. This can happen when vibration is allowed to continue for too long. It leads to the separation of coarse aggregates from the mix. These aggregates settle at the bottom, and the cement — water paste moves to the top in the form of laitance (scum). This laitance is different from bleed water. Segregation is difficult to measure. However, its occurrence is easily detected. The flow test can indicate the susceptibility of a mix that is likely to segregate. In dry mixes, heavier particles move away and occupy the edges of the flow table. In wet mixes, the cement paste trends to move away from the middle and the centre of the flow table are left only with coarser particles.

- **BLEEDING**

Bleeding is also known as 'water gain'. It is the accumulation of water at the surface, which accompanies the sedimentation of freshly mixed concrete. This happens due to the inability of the solid constituents of the mix to hold all the mixing water and they settle downwards due to gravity and the water moves upwards.

Bleeding is expressed quantitatively as the total settlement per unit height of concrete or as the percentage of mixing water. In extreme cases, this can be nearly 20%. Bleeding is a function of (a) air velocity, (b) temperature, and (c)'humidity. If the rate of bleeding is roughly equal to the rate of evaporation, then bleeding will not cause any problem. If the rate of bleeding is less than the rate of evaporation, then the surface becomes dry, because of which cracks appear on it. The restraint at the bottom encourages such cracks. The evaporation of water from the surface of concrete depends on (a) the relative humidity of the surrounding air, (b) the ambient temperature, and (c) the velocity of wind.

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 about 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.

BATCHING:

The measurement of materials for making concrete is known as hatching. 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.

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. Gauge boxes are used for measuring the fine and coarse aggregates. The volume of the box is made equal to the volume of one bag of cement .Gauge boxes are generally called farmas. They can be made of timber or steel plates.

WEIGH BATCHING:

Strictly speaking, weigh batching is the 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. Different types of weigh batchers are available, the particular type to be used, depends upon the nature of job. Large weigh batching plants have automatic weighing equipment. The use of this automatic equipment for batching is one of sophistication and requires qualified and experienced engineers. In smaller works, the weighing arrangement consists of two weighing buckets, each connected through a system of levers to spring-loaded dials which indicate the load. The weighing buckets are mounted on a central spindle about which they rotate. Thus one can be loaded while the other is being discharged into the mixer skip. A simple spring balance or the common platform weighing machines also can be used for small jobs.

MEASUREMENT OF WATER:

When weigh batching is adopted, the measurement of water must be done accurately. Addition of water by graduated bucket in terms of litres will not be accurate enough for the reason of spillage of water etc. It is usual to have the water measured in a horizontal tank or vertical tank fitted to the mixer. These tanks are filled up after every batch. The filling is so designed to have a control to admit any desired quantity of water. Sometimes, water- meters are fitted in the main water supply to the mixer from which the exact quantity of water can be let into the mixer.

In modern batching plants sophisticated automatic microprocessor controlled weigh batching arrangements, not only accurately measures the constituent materials, but also the moisture content of aggregates.

Moisture content is automatically measured by sensor probes and corrective action is taken to deduct that much quantity of water contained in sand from the total quantity of water. A number of such sophisticated batching plants are working in our country, for the last 4-5 years.

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.

a. Hand Mixing. **b.** Machine mixing.

HAND MIXING:

Hand mixing is practiced for small scale unimportant concrete works, as the mixing cannot be carried thorough efficiently.

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.

Many types of mixers are available for mixing concrete. They can be classified as batch mixers and continuous mixers. Batch mixers produce concrete, batch by batch with time interval, whereas continuous mixers produce concrete continuously without stoppage till such time the plant is working. In this, materials are fed continuously by screw feeders and the materials are continuously mixed and continuously discharged. These types of mixers are used in large works such as dams. In normal concrete work, it is the batch mixers that are used. Batch mixer may be of pan type or drum type. The drum type may be further classified as tilting, non-tilting, reversing or forced action type.

As per I.S. 1791-1985, concrete mixers are designated by a number representing its nominal mixed batch capacity in litres. The following are the standardized sizes of three types:

a. Tilting: 85 T, 100 T, 140 T, 200 T

b. Non-Tilting: 200 NT, 280 NT, 375 NT, 500 NT, 1000 NT

c. Reversing: 200 R, 280 R, 375 R, 500 R and 1000 R

MIXING TIME:

Concrete mixers are generally designed to run at a speed of 15 to 20 revolutions per minute. For proper mixing, it is seen that about 25 to 30 revolutions are required in a well-designed mixer. In site, the normal tendency is to speed up the outturn of concrete by reducing the mixing time. This results in poor quality of concrete. On the other hand, if the concrete is mixed for a comparatively longer time, it is uneconomical from the point of view of rate of production of concrete and fuel consumption.

TRANSPORTING OF CONCRETE:

Concrete can be transported by 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. Crane, Bucket and Rope way
c. Belt Conveyors
d. Skip and Hoist
e. Pump and Pipe line
f. Wheel Barrow, Hand Cart
g. Truck mixer and Dumpers
h. Chute
i. Transit Mixer

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 m^3.

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 4 cubic metre or more. Before loading with the concrete, theinside of the body should be just wetted with water. Tarpaulins or other covers may be provided to cover the wet concrete during transit 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 be supplied continuously. A number of dumpers of 6 m^3 capacity are employed to supply concrete. Small dumpers called Tough Riders are used for factory floor construction.

BELT CONVEYORS': Belt conveyors have very limited applications in concrete construction. The principal objection is the tendency of the concrete to segregate on steep inclines, at transfer points or change of direction, and at the points where the belt passes over the rollers.

Another disadvantage is that the concrete is exposed over long stretches which causes drying and stiffening. Conveyors can place large volumes of concrete quickly where access is limited.

CHUTE: Chutes are generally provided for transporting concrete from ground level to a lower level 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 for multi-storey building construction. At the ground level, mixer directly feeds the skip and the skip travels up over rails up to the level where concrete is required. At that point, the skip discharges the concrete automatically or on manual operation. The quality of concrete i.e. the freedom from segregation will depend upon the extent of travel and rolling over the rails. If the concrete has travelled a considerable height, it is necessary that concrete on discharge is required to be turned over before being placed finally.

TRANSIT MIXER:

Transit mixer is one of the most popular equipment's for transporting concrete over a long distance particularly in Ready Mixed Concrete plant (RMC).They are truck mounted having a capacity of 4 to 7 m3. 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.

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. The precautions to be taken and methods adopted while placing concrete in the under mentioned situations, will be discussed.

(a) Placing concrete within earth mould **(example: Foundation concrete for a wall or column).**

(b) Placing concrete within large earth mould or timber plank formwork **(example: Road slab and Airfield slab).**

(c) Placing concrete in layers within timber or steel shutters **(example: Mass concrete in dam construction or construction of concrete abutment/ pier).**

(d) Placing concrete within usual from work **(example: Columns, beams and floors)**

(e) Placing concrete under water.

Concrete is invariably laid as foundation bed below the walls or columns. Before placing the concrete in the foundation, all the loose earth must be removed from the bed. Any root of trees passing through the foundation must be cut, charred or tarred effectively to prevent its further growth and piercing the concrete at a later date. The surface of the earth, if dry, must be just made damp so that the earth does not absorb water from concrete.

On the other hand if the foundation bed is too wet and rain-soaked, the water and slush must be removed completely to expose firm bed before placing concrete. If there is any seepage of water taking place into the foundation trench, effective method for diverting the flow of water must be adopted before concrete is placed in the trench or pit.

For the construction of road slabs, airfield slabs and ground floor slabs in buildings, concrete is placed in bays. The ground surface on which the concrete is placed must be free from loose earth, pool of water and other organic matters like grass, roots, leaves etc. The earth must be properly compacted and made sufficiently damp to prevent the absorption of water from concrete. If this is not done, the bottom portion of concrete is likely to become weak. Sometimes, to prevent absorption of moisture from concrete, by the large surface of earth, in case of thinroad slabs, use of polyethylene film is used in between concrete and ground. Concrete is laid in alternative bays giving enough scope for the concrete to undergo sufficient shrinkage. Provisions for contraction joints and dummy joints are given. It must be remembered that the concrete must be dumped and not poured. It is also to be ensured that concrete must be placed in just required thickness. The practice of placing concrete in a heap at one place and then dragging it should be avoided.

When concrete is laid in great thickness, as in the case of concrete raft for a high rise building or in the construction of concrete pier or abutment or in the construction of mass concrete dam concrete is placed in layers. The thickness of layers depends upon the mode of compaction. In reinforced concrete, it is a good practice to place concrete in layers of about 15 to 30 cm thick and in mass concrete, the thickness of layer may vary from 35 to 45cm. Several such layers may be placed in succession to form one lift, provided they follow one another quickly enough to avoid cold joints. The thickness of layer is limited by the method of compaction and size and frequency of vibrator used.

Before placing the concrete, the surface of the previous lift is cleaned thoroughly with water jet and scrubbing by wire brush. In case of dam, even sand blasting is also adopted. The old surface is sometimes hacked and made rough by removing all the laitance and loose material. The surface is wetted. Sometimes, neat cement slurry or a very thin layer of rich mortar with fine sand is dashed against the old surface, and then the fresh concrete is placed.

The whole operation must be progressed and arranged in such a way that, cold joints are avoided as far as possible. When concrete is laid in layers, it is better to leave the top of the layer rough, so that the succeeding layer can have a good bond with the previous layer. Where the concrete is subjected to horizontal thrust, bond bars, bond rails or bond stones are provided to obtain a good bond between the successive layers. Of course, such arrangements are required for placing mass concrete in layers, but not for reinforced concrete.

Certain good rules should be observed while placing concrete within the formwork, as in the case of beams and columns. Firstly, it must be checked that the reinforcement is correctly tied, placed and is having appropriate cover. The joints between planks, ply woods or sheets must be properly and effectively plugged so that matrix will not escape when the concrete isvibrated. The inside of the formwork should be applied with mould releasing agents for easy stripping. Such purpose made mould releasing agents is separately available for steel or timber shuttering. The reinforcement should be clean and free from oil. Where reinforcement is placed in a congested manner, the concrete must be placed very carefully, in small quantity at a time so that it does not block the entry of subsequent concrete. The above situation often takes place in heavily reinforced concrete columns with close lateral ties, at the junction of column and beam and in deep beams.

Generally, difficulties are experienced for placing concrete in the column. Often concrete is required to be poured from a greater height. When the concrete is pouredfrom a height, against reinforcement and lateral ties, it is likely to segregate or block the space to prevent further entry of concrete. To avoid this, concrete is directed by tremie, drop chute or by any other means to direct the concrete within the reinforcement and ties. Sometimes, when the formwork is too narrow, or reinforcement is too congested to allow the use of tremie or drop chute, a small opening in one of the sides is made and the concrete is introduced from this opening instead of pouring from the top. It is advisable that care must be taken at the stage of detailing of reinforcement for the difficulty in pouring concrete. In long span bridges the depth of pre-stressed concrete girders may be of the order of even 4- 5 meters involving congested reinforcement. In such situations planning for placing concrete in one operation requires serious considerations on the part of designer.

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.

UNDERWATER CONCRETING:

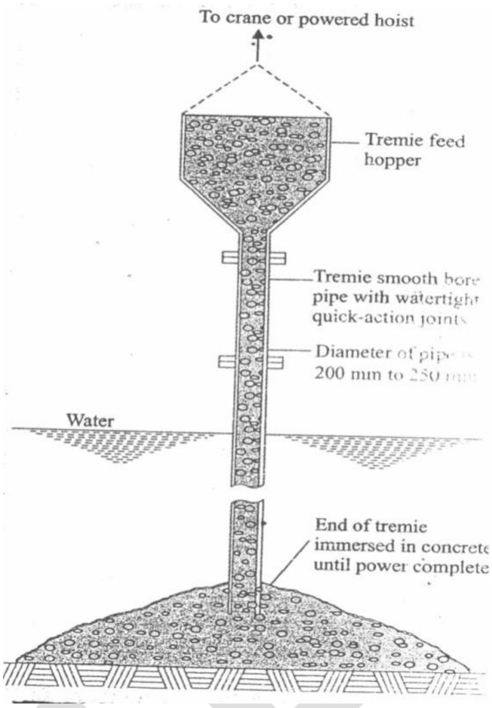
Concrete is often required to be placed underwater or in a trench filled with the bentonite slurry. In such cases, use of bottom dump bucket or tremie pipe is made use of. In the bottom dump bucket concrete is taken through the water in a water-tight box or bucket and on reaching the final place of deposition the bottom is made to open by some mechanism and the whole concrete is dumped slowly. This method will not give a satisfactory result as certain amount of washing away of cement is bound to occur.

In some situations, dry or semi-dry mixture of cement, fine and coarse aggregate are filled in cement bags and such bagged concrete is deposited on the bed below the water. This method also does not give satisfactory concrete, as the concrete mass will be full of voids interspersed with the putrescible gunny bags. The satisfactory method of placing concrete under water is by the use of tremie pipe.

The word **"tremie"** is derived from the French word **hopper.**

A tremie pipe is a pipe having a diameter of about 20 cm capable of easy coupling for increase or decrease of length. A funnel is fitted to the top end to facilitate pouring of concrete. The bottom end is closed with a plug or thick polyethylene sheet or such other material and taken below the water and made to rest at the point where the concrete is going to be placed. Since the end is blocked, no water will have entered the pipe. The concrete having a very high slump of about 15 to 20 cm is poured into the funnel. When the whole length of pipe is filled up with the concrete, the tremie pipe is lifted up and a slight jerk is given by a winch and putty arrangement.

When the pipe is raised and given a jerk, due to the weight of concrete, the bottom plug falls and the concrete gets discharged. Particular care must be taken at this stage to see that the end of the tremie pipe remains inside the concrete, so that no water enters into the pipe from the bottom. In other words, the tremie pipe remains plugged at the lower end by concrete. Again concrete is poured over the funnel and when the whole length of the tremie pipe is filled with concrete, the pipe is again slightly lifted and given slight jerk. Care is taken all the time to keep the lower end of the tremie pipe well embedded in the wet concrete. The concrete in the tremie pipe gets discharged. In this way, concrete work is progressed without stopping till the concrete level comes above the water level.



Under Water Concreting by Tremie Method.

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. 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 effort 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. Rodding is done continuously over the complete area to effectively pack the concrete and drive away entrapped air. Sometimes, instead of iron rod, bamboos or cane is also used for rodding purpose.

Ramming should be done with care. Light ramming can be permitted in unreinforced 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. If ramming is adopted in the above case the position of the reinforcement may be disturbed or the formwork may fail, particularly, if steel rammer is used.

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. Tamping consists of beating the top surface by wooden cross beam of section about 10 x 10 cm. Since the tamping bar is sufficiently long it not only compacts, but also levels the top surface across the entire width.

COMPACTION BY VIBRATION:

It is pointed out that the compaction by hand, if properly carried 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.

The modern high frequency vibrators make it possible to place economical concrete which is impracticable to place by hand. A concrete with about 4 cm slump can be placed and compacted fully in a closely spaced reinforced concrete work, whereas, for hand compaction, much higher consistency say about 12 cm slump may be required. 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 Electromagnet, pulsating equipment is also available. The frequency of vibration varies up to 12,000 cycles of vibration per minute.

The needle diameter varies from 20 mm to 75 mm and its length varies from 25 cm to 90 cm. The bigger needle is used in the construction of mass concrete dam. Sometimes, arrangements are available such that the needle can be replaced by a blade of approximately the same length. This blade facilitates vibration of members, where, due to the congested reinforcement, the needle would not go in, but this blade can effectively vibrate. They are portable and can be shifted from place to place very easily during concreting operation. They can also be used in difficult positions and situations.

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. Use of formwork vibrator will produce a good finish to the concrete surface. Since the vibration is given to the concrete indirectly through the formwork, they consume more power and the efficiency of external vibrator is lower than the efficiency of 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 through 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. In the modern construction practices like vacuum dewatering technique, or slip-form paving technique, the use of screed board vibrator are common feature. In the above situations double beam screed board vibrators are often used.

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 ofcompaction 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. Such roller compacted concrete of grade M 10 has been successfully used as base course, 15 cm thick, for the Delhi-Mathura highway and Mumbai-Pune express highways.

CURING OF CONCRETE:

Curing can be described as keeping the concrete moist and warm enough so thatthe hydration of cement can continue. More elaborately, it can be described as the process of maintaining satisfactory moisture content and a favourable temperature in concrete during the period immediately following placement, so that hydration of cement may continue until the desired properties are developed to a sufficient degree to meet the requirement of service.

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 thata 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 thebody 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 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 usedis 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.

- **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. Therefore, subjecting the concrete to higher temperature and maintaining the required wetness can be achieved by subjecting the concrete to steam curing.

The exposure of concrete to higher temperature is done in the following manner:

a. Steam curing at ordinary pressure.
b. Steam curing at high pressure.
c. Curing by Infra-red radiation.
d. Electrical curing.

MISCELLANEOUS METHODS OF CURING

Calcium chloride is used either as a surface coating or as an admixture. It has been used satisfactorily as a curing medium. Both these methods are based on the fact that calcium chloride being a salt shows affinity for moisture. The salt not only absorbs moisture from atmosphere but also retains it at the surface. This moisture held at the surface prevents the mixing water from evaporation and thereby keeps the concrete wet for a long time to promote hydration.

Formwork prevents escaping of moisture from the concrete, particularly, in the case of beams and columns. Keeping the formwork intact and sealing the joint with wax or any other sealing compound prevents the evaporation of moisture from the concrete. This procedureof promoting hydration, can be considered as one of the miscellaneous methods of curing

STEAM CURING:

It has been pointed out earlier that hydration accelerates with temperature. When heat is applied to concrete it is important to see that water held in concrete is not lost or in other words high humidity is required with an application of heat. This type of curing fulfils this requirement. This can be done at atmospheric pressure or under pressure. Steam curing under pressure is very costly as it requires pressure chambers. One day strength of concrete steam cured under pressure, can be equal to 28 day's strength of normally cured concrete. However steam curing reduces the bond strength of concrete and shall be used only in exceptional cases.

The concrete mixes with w/c ratio ranging from 0.3-0.7 can be cured by steam curing. The mixes with low w/c ratio respond more favourably to steam curing than mixes with higher w/c ratio. The 28days strength after treatment will almost be equal to those of the normally cured concrete,if slow temperature rise are adopted. In case of high w/c ratio & if the rate of temperature rise is rapid, the strengths obtained by steam curing at 28days are less than that of normally cured concrete.

Steam curing can serve as an effective method for achieving early strengths in the factory production of precast concrete products. By adopting steam curing stripping strength of concrete, which is normal about 50% of the specified strength, can be achieved in short period.

Steam curing is of two types

1. Low pressure steam curing.

2. High pressure steam curing.

1. LOW PRESSURE STEAM CURING:-

The steam curing carried out at atmospheric pressure is known as low pressure steam curing. It may be continuous or intermittent type. In case of intermittent process the concrete products are stacked in the curing chamber until it is full. The chamber is then closed and steam is allowed into the chamber. The general practice is to have a sufficient size of chamber to hold the complete days output such that the chamber is filled during the day and steam curing of the products is affected during night. In case of continuous process, the products move on conveyor belts from one end of a long curing chamber to the other end.

The length of the curing chamber and the speed of movement of the conveyor belt being so designed that the products remain in the curing chamber for required time.

The procedure of steam – curing can be divided in to three stages.

1. Heating up stages.
2. The steam treatment stage
3. Cooling off stage.

Steam curing must never be used be used with high – alumina cement because of the advises effect of the hot-wet conditions on the strength of that cement.

2. **HIGH PRESSURE STEAM CURING :-**

In the case of steam curing at atmospheric pressure, the temperature of the steam is naturally below 100'c .This is done in an open atmosphere. As the steam gets convert into water it may be called hot water curing.

In high pressure steam curing the concrete elements are cured at the steam pressure of 8 atmospheres (about 1MPa) and a maximum temperature of about 175°C, High pressure steam curing is done in the cylindrical steel chambers called autoclaves.

The concrete products after a suitable pre-steaming period are wheeled on racks into the autoclaves. The steam is let in gradually until the prescribed pressure (about 175 °C) is reached.

ACCELERATED CURING:

In the accelerated curing the standard curing is cast, they are covered with top plate & the joints are sealed with special grease to prevent drying, this is then switched on. The oven temperature bought to 93°C in about one hour time. It is kept at this temperature for 5hous. At the end of this period the cubes are removed from oven, stripped, cooled & tested. The time allowed for this operation is 30min.

The strength of concrete is determined within 7 Hours of casting and this accelerated strength shows good relationship with 7 & 28 days strength of normally cured concrete.

One of the main factors that affect the rate of gain of strength is the fineness of cement. It has been estimator that particles of cement over 40µsize contribute to the compressive strength of concrete only over long periods.

Self-Curing Concrete

What is self-curing concrete?

- **TYPES OF COMPOUNDS:**

a) Synthetic resin

b) Wax

c) Acrylic

d) Chlorinated rubber

APPLICATION PROCEDURE

It is applied by brushing or by spraying while the concrete is wet. In the case of beam and column the application is done after removal of formwork In case of road and pavements the curing compound is applied after texturing. In case the concrete surface has dried, the surface should be sprayed with water and thoroughly wetted and made fully damp before curing compound is applied. The container of curing compound should be well stirred before use.

Good and Bad Practices of Making use of Fresh Concrete

Cement: Cement should have easier workability, lower risk of cracking, and higher long term strengths. It should also give a cement mixture with lower porosity, creating concrete that is thicker in texture and therefore less permeable. It should also results in lower emissions of carbon dioxide than the production of Ordinary Portland Cement, primarily through the replacement of a portion of the clinker.

Indeed, the production of Portland- Pozzolan Cement can result in a 20% reduction of the carbon dioxide emissions as compared to the level generated in the production of Ordinary Portland

Cement. Eg: Production of Portland-Pozzolan cement is therefore compatible with a low carbon approach to development.

Cement is the paste that binds the aggregates to make concrete. Since concrete is negatively affected by contaminants, the following guidelines should always be adhered in order to achieve the best out of your concrete

STORAGE OF CEMENT

- Protect your cement from moisture, damp surfaces, draught, water or rain.
- Store cement in a fully enclosed and covered area.
- Do not store cement on bare concrete floor or dirt.
- Always place a moisture barrier such as plastic or a pallet between the floor and the cement.
- Store exposed or opened cement in a plastic garbage bag and seal properly.
- Do not stack cement more than 10 sacks high as this will lead to lumping under pressure.

Sometimes it is also difficult to stack one bag over the other as this may cause them to fall down.

WATER

- You should use only potable water, which is water suitable for drinking and cooking purposes, when mixing concrete
- Water from canals etc. contains contaminants which are not suitable if you want the best concrete.
- Do not use excess water. Excess water reduces the strength of the concrete/ mortar.

MIXING

Use properly proportioned mixes of concreting materials. A minimum recommended mix design for reinforced concrete to be used in domestic building is for M20 Concrete Mix Proportion is 1:2:4;

- One part of Cement
- Two parts fine aggregate (sifting, sand)
- Four parts coarse aggregate (stone)

In mixing, ensure that all ingredients are uniformly distributed, mixed and placed properly. Use mechanical vibrators or poke concrete mixture to remove air bubbles and pockets as excessive air in concrete reduces strength. Vibration reduces the risk of honeycomb formation or "large voids".

- Once properly mixed, placed and compacted concrete will achieve a cube compressive strength will be more than 20N/mm^2 at the age of 28days.
- Remember, always stick to your mix design and do not use excess water.

Placing: Refer Page Number 17, 18 &19

Compaction: There are various methods to vibrate the concrete filled formwork. Compaction of concrete is the process adopted for expelling the entrapped air from the concrete. If this air is not removed fully, the concrete loses strength considerably. 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 effort available in the field.

If the vibration increases then it may lead to the segregation of constituents.

CURING

- Curing is essential for the concrete to continue with the process of hydration to develop its strength.
- Concrete should be properly cured by wetting/misting, covering with plastic or using curing compound.
- Keep your concrete continuously wet for at least seven (7) days.
- Start curing immediately after the concrete has set for as long as practical.

Effect of heat of hydration during mass concreting at project sites:

The heat of hydration in mass concrete structures has an important effect on project sites schedule and safety. The main factor contributing to temperature rise in mass concrete is heat evolution due to an exothermic reaction of cement. Understanding the mechanism of heat generation for cement is the key to controlling the temperature of mass concrete.

Mass concreting like dam constructions is depending on concrete block thickness, the temperature generated from the hydration of cement in mass concrete can reach a true adiabatic condition in the interior if large blocks prevent timely heat dissipation to the surroundings.

At a high temperature, the interior concrete tends to expand, while at a low ambient temperature, the exterior concrete tends to shrink and resist interior concrete to expand, thus causing thermal stress. The high thermal gradient between the centre and the surface may cause thermal cracks when the thermal stress in concrete exceeds its tensile strength. In other words, small concrete blocks and thin construction lift allows rapid heat dissipation, thus reducing thermal cracking. Once cracks take place at the upstream side of a dam under high water pressure especially in flood season, the service life of the structure may be shortened or safety problems may occur in the long run. Normally these types of situation can be observed in Dam construction.

REVIEW QUESTION:

1. Define workability and list & explain the factor influencing workability of concrete?
2. Write note on segregation and bleeding
3. Why curing is needed to concrete? Explain curing methods?
4. Why compaction is required to concrete? Explain compaction methods by vibration?
5. What are the processes of manufacturing of cement concrete? Explain briefly?
6. Define water cement ratio, and How this w/c ratio will have influence on workability of fresh concrete
7. Explain factors effecting consistency and cohesiveness of fresh concrete mixtures, suggest ways to improve
8. Explain any two methods, equipment's and advantages of handling and placing of concrete.
9. Explain the measurement of workability of concrete using
   (i) Compaction factor method (ii) Vee Bee consistometer method (iii) Slump Test
10. Explain factors affecting the workability of concrete by using admixtures