BT- 204 (Basic Civil Engineering and Engineering Mechanics)

Unit-I

Topic- Concrete

Plain concrete, commonly known as concrete, is an intimate mixture of binding material, fine aggregate, coarse aggregate and water. This can be easily moulded to desired shape and size before it looses plasticity an hardens. Plain concrete is strong in compression but very weak in tension. The tensile property is introduced in concrete by inducting different materials and this attempt has given rise to RCC, RBC, PSC, FRC, cellular concrete and Ferro cement.

Major ingredients of concrete are:

1.Binding material (like cement, lime, polymer)
2.Fine aggregate (sand)
3.Coarse aggregates (crushed stone, jelly)
4.Water.

A small quantity of admixtures like air entraining agents, water proofing agents, workability agents etc. may also be added to impart special properties to the plain concrete mixture. Depending upon the proportion of ingredient, strength of concrete varies. It is possible to determine the proportion of the ingredients for a particular strength by mix design procedure. In the absence of mix design the ingredients are proportioned as

1:1:2, 1:1$\frac{1}{2}$:3, 1:2:4, 1:3:6 and 1:4:8

This is the ratio of weights of cement to sand to coarse aggregate. In proportioning of concrete it is kept in mind that voids in coarse aggregates are filled with sand and the voids in sand are filled with cement paste. Proportion of ingredients usually adopted for various works are shown in Table below-

Proportion of cement, sand and coarse aggregates in concrete

S. No.	*Proportion*	*Nature of Work*
1	1:1:2	For machine foundation, footings for steel columns and concreting under water.
2	1:1$\frac{1}{2}$:3	Water tanks, shells and folded plates, for other water retaining structures.
3	1:2:4	Commonly used for reinforced concrete works like beams, slabs, tunnel lining, bridges
4	1:3:6	Piers, abutments, concrete walls, sill of windows, floors.
5	1:4:8	Mass concretes like dam, foundation course for walls, for making concrete blocks.

Preparing and Placing of Concrete:-

The following steps are involved in the concreting:

1.Batching
2.Mixing
3.Transporting and placing and
4.Compacting.

1. Batching: The measurement of materials for making concrete is known as batching. The following two methods of batching is practiced:

(a)Volume batching
(b)Weight batching.

(a) Volume Batching: In this method cement, sand and concrete are batched by volume. A gauge box is made with wooden plates, its volume being equal to that of one bag of cement. One bag of cement has volume of 35 litres. The required amount of sand and coarse aggregate is added by measuring on to the gauge box. The

quantity of water required for making concrete is found after deciding water cement ratio. For example, if water cement ratio is 0.5, for one bag of cement (50 kg), water required is 0.5 × 50 = 25 kg, which is equal to 25 litres. Suitable measure is used to select required quantity of water. Volume batching is not ideal method of batching. Wet sand has higher volume for the same weight of dry sand. It is called bulking of sand. Hence it upsets the calculated volume required.

(b) Weight Batching: This is the recommended method of batching. A weighing platform is used in the field to pick up correct proportion of sand and coarse aggregates. Large weigh batching plants have automatic weighing equipments.

2. Mixing: To produce uniform and good concrete, it is necessary to mix cement, sand and coarse aggregate, first in dry condition and then in wet condition after adding water. The following methods are practiced:

(a)Hand Mixing

(b)Machine Mixing.

(a) Hand Mixing:- Required amount of coarse aggregate for a batch is weighed and is spread on an impervious platform. Then the sand required for the batch is spread over coarse aggregate. They are mixed in dry condition by overturning the mix with shovels. Then the cement required for the batch is spread over the dry mix and mixed by shovels. After uniform texture is observed water is added gradually and mixing is continued. Full amount of water is added and mixing is completed when uniform colour and consistency is observed. The process of mixing is completed in 6–8 minutes of adding water. This method of mixing is not very good but for small works it is commonly adopted.

(b) Machine Mixing: In large and important works machine mixing is preferred. Figure shows a typical concrete mixer. Required quantities if sand and coarse aggregates are placed in the drum of the mixer. 4 to 5 rotations are made for dry mixing and then required quantity of cement is added and dry mixing is made with another 4 to 5 rotations. Water is gradually added and drum is rotated for 2 to 3 minutes during which period it makes about 50 rotations. At this stage uniform and homogeneous mix is obtained.

3. Transporting and Placing of Concrete: After mixing concrete should be transported to the final position. In small works it is transported in iron pans from hand to hand of a set of workers. Wheel barrow and hand carts also may be employed. In large scale concreting chutes and belt conveyors or pipes with pumps are employed. In transporting care should be taken to see that segregation of aggregate from matrix of cement do not take place. Concrete is placed on form works. The form works should be cleaned and properly oiled. If concrete is to be placed for foundation, the soil bed should be compacted well and is made free from loose soil. Concrete should be dropped on its final position as closely as possible. If it is dropped from a height, the coarse aggregates fall early and then mortar matrix. This segregation results into weaker concrete.

4. Compaction of Concrete: In the process of placing concrete, air is entrapped. The entrapped air reduces the strength of concrete up to 30%. Hence it is necessary to remove this entrapped air. This is achieved by compacting the concrete after placing it in its final position. Compaction can be carried out either by hand or with the help of vibrators.

(a) Hand Compaction: In this method concrete is compacted by ramming, tamping, spading or by slicing with tools. In intricate portions a pointed steel rod of 16 mm diameter and about a meter long is used for poking the concrete.

(b) Compaction by Vibrators: Concrete can be compacted by using high frequency vibrators. Vibration reduces the friction between the particles and set the motion of particles. As a result entrapped air is removed and the concrete is compacted. The use of vibrators reduces the compaction time. When vibrators are used for compaction, water cement ratio can be less, which also helps in improving the strength of concrete. Vibration should be stopped as soon as cement paste is seen on the surface of concrete. Over vibration is not good for the concrete.

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Girish Patidar

Curing of Concrete

Curing may be defined as the process of maintaining satisfactory moisture and temperature conditions for freshly placed concrete for some specified time for proper hardening of concrete. Curing in the early ages of concrete is more important. Curing for 14 days is very important. Better to continue it for 7 to 14 days more. If curing is not done properly, the strength of concrete reduces. Cracks develop due shrinkage. The durability of concrete structure reduces. The following curing methods are employed:

(a)Spraying of water
(b)Covering the surface with wet gunny bags, straw etc.
(c)Ponding
(d)Steam curing and
(e)Application of curing compounds.
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(a) Spraying of water: Walls, columns, plastered surfaces are cured by sprinkling water.

(b) Wet covering the surface: Columns and other vertical surfaces may be cured by covering the surfaces with wet gunny bags or straw.

(c) Ponding: The horizontal surfaces like slab and floors are cured by stagnating the water to a height of 25 to 50 mm by providing temporary small hunds with mortar.

(d) Steam curing: In the manufacture of pre-fabricated concrete units steam is passed over the units kept in closed chambers. It accelerates curing process, resulting into the reduction of curing period.

(e) Application of curing compounds: Compounds like calcium chloride may be applied on the curing surface. The compound shows affinity to the moisture and retains it on the surface. It keeps the concrete surface wet for a long time.

Properties of Concrete

Concrete has completely different properties when it is the plastic stage and when hardened. Concrete in the plastic stage is also known as green concrete. The properties of green concrete include:

1. Workability 2.Segregation 3.Bleeding 4.Harshness.

The properties of hardened concrete are:

1. Strength 2.Resistance to wear 3.Durability 4.Impermeability.

1. Workability: This is defined as the ease with which concrete can be compacted fully without segregating and bleeding. It can also be defined as the amount of internal work required to fully compact the concrete to optimum density. The workability depends upon the quantity of water, grading, shape and the percentage of the aggregates present in the concrete.

Workability is measured by

(a)The slump observed when the frustum of the standard cone filled with concrete is lifted and removed.
(b)The compaction factor determined after allowing the concrete to fall through the compaction testing machine.
(c)The time taken in seconds for the shape of the concrete to change from cone to cylinder when tested in Vee Bee consistometer.

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Suggested values of workability

Application	*Slump*	*Compaction Factor*	*Time in Vee-Bee*
1. Concreting of shallow sections with vibrations	—	0.75 – 0.80	10 – 20
2. Concreting of light reinforced sections with vibrators	—	0.80 – 0.85	5 – 10
3. Concreting of lightly reinforced sections without vibrations and heavily reinforced sections with vibrations	25 – 75 mm	0.85 – 0.92	2 – 5
4. Concreting of heavily reinforced sections without vibration	75 – 125 mm	More than 0.92	—

2.Segregation: Separation of coarse particles from the green concrete is called segregation. This may happen due to lack of sufficient quantity of finer particles in concrete or due to throwing of the concrete from greater heights at the time of placing the concrete. Because of the segregation, the cohesiveness of the concrete is lost and honey combing results. Ultimately it results in the loss of strength of hardened concrete. Hence utmost care is to be taken to avoid segregation.

3.Bleeding: This refers to the appearance of the water along with cement particles on the surface of the freshly laid concrete. This happens when there is excessive quantity of water in the mix or due to excessive compaction. Bleeding causes the formation of pores and renders the concrete weak. Bleeding can be avoided by suitably controlling the quantity of water in the concrete and by using finer grading of aggregates.

4.Harshness: Harshness is the resistance offered by concrete to its surface finish. Harshness is due to presence of lesser quantity of fine aggregates, lesser cement mortar and due to use of poorly graded aggregates. It may result due to insufficient quantity of water also. With harsh concrete it is difficult to get a smooth surface finish and concrete becomes porous.

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. The factors helping concrete to have more lubricating effect to reduce internal friction for helping easy compaction are given below:

(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:

The higher the water content per cubic meter of concrete, the higher will be the workability of concrete,.

(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 will be the workability. On the other hand, in case of rich concrete with lower aggregate/cement ratio, more will be workability.

(c) Size of Aggregate:

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.

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(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. This explains the reason why river sand and gravel provide greater workability to concrete than crushed sand and aggregate. The importance of shape of the aggregate will be of great significance in the case of present day high strength and high performance concrete when we use very low w/c in the order of about 0.25.

(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. 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.

(g) Use of Admixtures:

Of all the factors mentioned above, the most import factor which affects the workability is the use of admixtures. In Chapter 5, it is amply described that the plasticizers and super-plasticizers greatly improve the workability many folds. 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. One should manipulate other factors to obtain initial slump of 2 to 3 cm in the reference mix. Without initial slump of 2 –3 cm, the workability can be increased to higher level but it requires higher dosage – hence uneconomical.

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. Similarly, the fine glassy pozzolanic materials, inspite of increasing the surface area, offer better lubricating effects for giving better workability.

Tests on Concrete

The following are some of the important tests conducted on concrete:

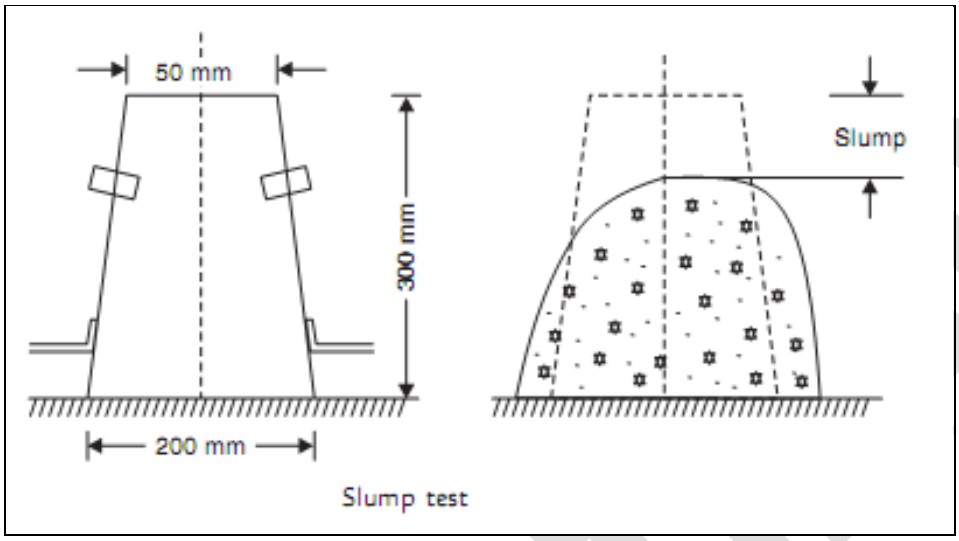
1.Slump test.

2.Compaction factor test.

3.Crushing strength test.

1.Slump Test: This test is conducted to determine the workability of concrete. It needs a slump cone for test. Slump cone is a vessel in the shape of a frustum of a cone with diameter at bottom 200 mm and 50 mm at top and 300 mm high. This cone is kept over a impervious platform and is filled with concrete in four layers. Each layer is tamped with a 16 mm pointed rod for 25 times. After filling completely the cone is gently pulled up. The

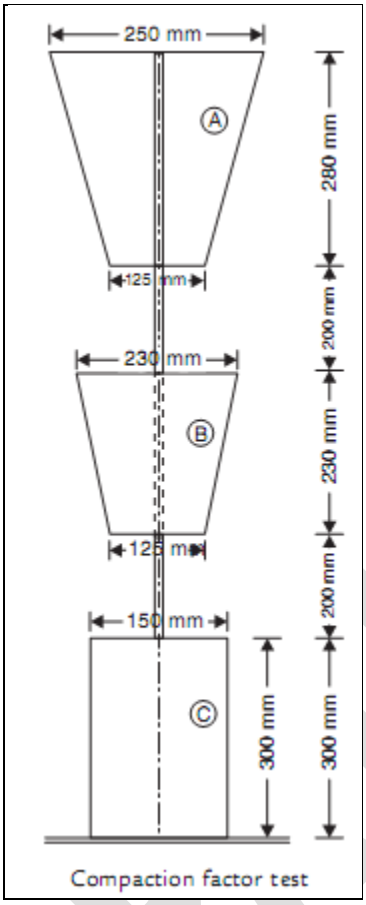
decrease in the height of the concrete is called slump. Higher the slump, more workable is the concrete. The desired values of slumps for various works have been shown in Table below:-



Slump Values for various works

Type of concrete	**Slump Value (mm)**
Road	20-40
Slab, horizontal walls etc.	40-50
Canal lining, arc wall, side walls of tunnels	90-100
Normal RCC	80-150
Mass concrete	25-50
Vibrators	10-25

2. Compaction Factor Test: This is another test to identify the workability of concrete. This test is conducted in the laboratory. The test equipment consists of two hoppers and a cylinder fixed to a stand, the dimensions and the distances between the three vessels being standardized. Vessel A and B are having hinged bottoms whereas cylinder C is having fixed bottom. Top vessel A is filled with the concrete to be tested. As soon as it is filled, the hinged door is opened. Concrete is collected in vessel B. Then the hinged door of B is opened to collect concrete in cylinder C. The concrete in cylinder C is weighted. Let it be W_1. Now cylinder is again filled with the sample of concrete in 50 mm layers, which is compacted by ramming and vibrating. Then the weight of compacted concrete is determined. Let this weight be W_2. The ratio W_1/W_2 is termed as compaction factor. The specified values of compaction factor for different works are listed in Table below:-



Compaction factor test

Compaction factor value for various purposes

Application	Compaction Factor
Concreting of shallow section with vibrators	0.75-0.80
Concrete of light reinforced section with vibrator	0.80-0.85
Concrete of light reinforced section without vibra & heavily reinforced section with vibrators	0.85-0.92
Concrete of heavily reinforced section without vi	More than 0.92

3.Crushing Strength Test: Metallic moulds of size 150 mm × 150 mm × 150 mm are used for casting concrete cubes. Before filling mould, it is properly oiled on its inner surfaces, so that cubes can be easily separated. Fresh cube is filled with concrete to be tested in 3 layers and kept in the room. After 24 hours, cube is removed from the mould and kept under water for curing. After 28 days of curing cubes are tested in the compression testing machine. In this test cubes are placed over the smooth surface which is in contact with side plates of mould. The crushing load is noted and crushing strength is found as load divided by surface area ($150 \times 150\ mm^2$).

Uses of Concrete

1. As bed concrete below column footings, wall footings, on wall at supports to beams
2. As sill concrete

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Girish Patidar

3. Over the parapet walls as coping concrete
4.For flagging the area around buildings
5.For pavements
6.For making building blocks.

However major use of concrete is as a major ingredient of reinforced and prestressed concrete. Many structural elements like footings, columns, beams, chejjas, lintels, roofs are made with R.C.C. Cement concrete is used for making storage structures like water tanks, bins, silos, bunkers etc. Bridges, dams, retaining walls are R.C.C. structures in which concrete are the major ingredient.

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Prepared by
Girish Patidar