3.2 Manufacturing Process of concrete:

A good quality concrete is essentially a homogeneous mixture of cement, coarse and fine aggregates and water which consolidates into a hard mass due to chemical action between the cement and water. Each of the four constituents has a specific function. The coarser aggregate acts as a filler. The fine aggregate fills up the voids between the paste and the coarse aggregate. The cement in conjunction with water acts as a binder. The mobility of the mixture is aided by the cement paste, fines and nowadays, increasingly by the use of admixtures.

Most of the properties of the hardened concrete depend on the care exercised at every stage of the manufacture of concrete. A rational proportioning of the ingredients of concrete is the essence of the mix design. However, it may not guarantee of having achieved the objective of the quality concrete work. The aim of quality control is to ensure the production of concrete of uniform strength from batch to batch. This requires some rules to be followed in the various stages of concrete production and is discussed as follows. The stages of concrete production are:

1.Batching or measurement of materials
2.Mixing
3.Transporting
4.Placing
5.Compacting
6.Curing
7.Finishing

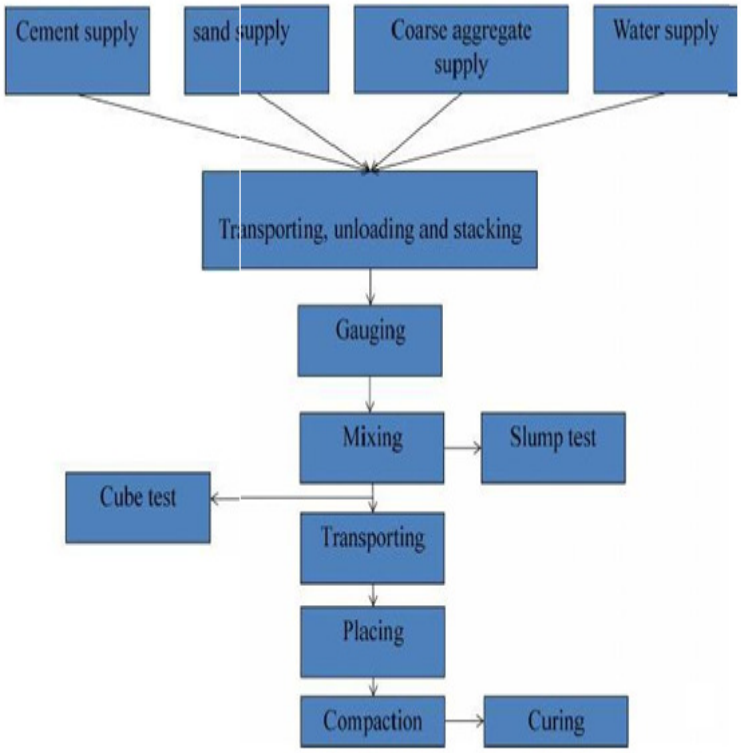


Fig 1 manufacturing process of concrete

1)Baching of Materials

For good quality concrete a proper and accurate quantity of all the ingredients should be used. The aggregates, cement and water should be measured with an accuracy of ± 3 per cent of batch quantity and the admixtures by 5 per cent of the batch quantity. There are two prevalent methods of batching materials, the volume batching and the weigh batching. The factors affecting the choice of batching method are the size of job, required production rate, and required standards of batching performance. For most important works weigh batching is recommended.

a)Volume Batching

b)Weigh Batching

a)Volume batching

- This method is generally adopted for small jobs.
- Gauge boxes are used for measuring the fine and coarse aggregate.
- The volume of gauge box is equal to the volume of one bag of cement.While filling the gauge boxes the material should be filled loosely, no compaction is allowed.
- Bottomless gauge boxes are generally avoided.

- They are made generally deep and narrow
- They can be made of timbers or steel.
- Gauge bow are also called as FARMAS

2. Weigh Batching

- Batching by weight is more preferable to volume batching ,as it is more accurate and leads to more uniform proportioning.
- It does not have uncertainties associated with bulking. It's equipment falls into 3 general categories :

i. Manual,
ii. Semi automatic,
iii. Fully automatic

i)Manual

In case of manual batching all weighing and batching of concrete are done manually. It is used for small jobs.

ii)Semi automatic

In case of semi automatic batching the aggregate bin gates are opened by manually operated switches. And gates are closed automatically when the material has been delivered. This system also contains interlock which prevents charging and discharging.

iii) Fully automatic

In case of automatic batching the material are electrically activates by a single switch and complete autographic record are made of the weight of each material. The batching plant comprises 2,3,4 or 6 compartment bins of several capacitie. Over the conveyer belt the weigh batchers discharging are provided below the bins

2)Mixing

1.Hand Mixing
2.Machine Mixing
a.Tilting Mixers
b.Non-tilting Mixer
c.Reversing Drum Mixer
d.Pan-type or Stirring Mixer
e.Transit Mixer

A poor quality of concrete is obtained if the mixing time is reduced. On the other hand if the mixing time is increased it is uneconomical. However, it is found that if the mixing time is increased to 2 minutes the compressive strength of concrete produced is enhanced and beyond this time the improvement in compressive strength is insignificant. A prolonged mixing may cause segregation. Also, due to longer mixing periods the water may get absorbed by the aggregates or evaporate resulting in loss of workability and strength.

3) Transporting

Concrete should be transported to the place of deposition at the earliest without the loss of homogeneity obtained at the time of mixing. A maximum of 2 hours from the time of mixing is permitted if trucks with agitator and 1 hour if trucks without agitators are used for transporting concrete. Also it should be ensured that segregation does not take place during transportation and placement. The methods adopted for transporting concrete depend upon the size and importance of the job, the distance of the deposition place from the mixing place, and the nature of the terrain. Some of the methods of transporting concrete are as below:

a.Mortar Pan

b.Wheel Barrow

c.Chutes

d.Dumper

e.Bucket and Ropeway

f.Belt conveyor

g.Skip and Hoist

h.Pumping

4) Placing

To achieve quality concrete it should be placed with utmost care securing the homogeneity achieved during mixing and the avoidance of segregation in transporting. Research has shown that a delayed placing of concrete results in a gain in ultimate compressive strength provided the concrete can be adequately compacted. For dry mixes in hot weather delay of half to one hour is allowed whereas for wet mixes in cold

weather it may be several hours. The various situations in which concrete is placed are discussed below.

i)Foundations

Concrete foundations for walls and columns are provided below the ground surface. Before placing the concrete in the foundation all the loose earth, roots of trees etc., are removed. If the surface is found dry it is made wet so that earth does not absorb water from concrete. On the other hand if the foundation bed is wet the water and mud is removed and cement is sprinkled before placing concrete.

ii)Beams, Columns, and Slabs

Before placing the concrete, the forms must be examined for correct alignment. They should be adequately rigid to withstand the weight of concrete and construction loads without undue deformation. Forms should be light enough to avoid any loss of mortar resulting in honeycombed concrete. The insides of the forms should be cleaned and oiled before use to avoid any sticking of concrete with the forms and making their stripping off difficult.

Concrete should not be dropped but placed in position to prevent segregation. It should be dropped vertically from as small height as possible. It should be placed at one point in the formwork and allowed to flow side ways to take care of honeycombing.

Laitance formation should be avoided. It can be checked by restricting thickness of layer of concrete by 150–300 mm for R.C.C work. Laitance, however, if formed must be removed before placing the next layer of concrete. Several such layers form a lift, provided they follow one another quickly enough to avoid cold joints. The surface of the previous lift is kept rough and all the laitance removed before placing the next lift.

The reinforcement should be checked for tightness and clean surface. The loose rust or scales if any, are removed by wire brush. Paint, oil or grease if found should be removed. The minimum cover for reinforcement should be checked before concreting.

iii)Mass Concreting

When the concrete is to be laid in mass as for raft foundation, dam, bridge, pier etc., concrete is placed in layers of 350–450 mm thickness. Several such layers placed in quick succession form a lift. Before placing the concrete in the next lift, the surface of

the previous lift is cleaned thoroughly with water jets and scrubbing by wire brush. In case of dams, sand blasting is done.

The laitance and loose materials are removed and cement slurry is applied. When the concrete is subjected to lateral thrust, bond bars or bond stones are provided to form a key between different layers.

iv) Concreting Highways and Runways

Concrete is laid in bays for highway, runway, or floor slabs. First the ground on which concrete is to be laid is prepared and all the loose materials and grass etc., are removed. The earth is wetted and compacted. The subgrades over which concrete is to be laid should be properly compacted and damped to avoid any loss of moisture from concrete. Concrete is then laid in alternate bays. This allows the concrete to undergo sufficient shrinkage and cracks do not develop afterwards. Concrete is not placed in heap at one place and then dragged, instead it is placed in uniform thickness.

v)Concreting Underwater

Concrete may be placed underwater with the help of bottom dump buckets. The concrete is taken through the water in water- tight bucket. On reaching the place of deposition the bottom of the bucket is made to open and the concrete is dumped. In this process certain amount of cement is washed away causing a reduction in strength of concrete. Another way of concreting underwater is by filling cement bag with dry or semi-dry mix of cement and aggregates and lowering them to the place of deposition. The drawback of this method is that the concrete will be full of voids interspersed with purticible gunny bags.

The best method of placing concrete underwater is by the use of termie pipe. The concrete is poured into it through funnel. The bottom end of the pipe is closed with a thick ploythene sheet, with the bottom end of the pipe at the place of deposition. The concrete (slump 150–200 mm) is poured into funnel till the whole pipe is filled with concrete. The pipe is slightly lifted and given a jerk, the polythene sheet cover falls and concrete discharged. It should be ensured that the end of pipe remains inside the concrete so that water does not enter the pipe. The pipe is again filled with concrete through funnel and the process repeated till the concrete level comes above the water level. No compaction is required for underwater concrete as it gets compacted by the

hydrostatic pressure of water. Concrete can also be placed underwater with the help of pipes and pumps.

5) Compaction

After concrete is placed at the desired location, the next step in the process of concrete production is its compaction. Compaction consolidates fresh concrete within the moulds or frameworks and around embedded parts and reinforcement steel. Considerable quantity of air is entrapped in concrete during its production and there is possible partial segregation also. Both of these adversely affect the quality of concrete. Compaction of the concrete is the process to get rid of the entrapped air and voids, elimination of segregation occurred and to form a homogeneous dense mass. It has been found that 5 per cent voids in hardened concrete reduce the strength by over 30 per cent and 10 per cent voids reduce the strength by over 50 per cent. Therefore, the density and consequently the strength and durability of concrete largely depend upon the degree of compaction. For maximum strength driest possible concrete should be compacted 100 per cent.

The voids increase the permeability of concrete. Loss of impermeability creates easy passage of moisture, oxygen, chlorides, and other aggressive chemicals into the concrete. This causes rusting of steel and spalling (disintegration) of concrete i.e., loss of durability. Easy entry of sulphates from the environment causes expansive reaction with the tricalciums aluminates (C3A) present in cement. This causes disintegration of concrete and loss of durability. Entry of carbon dioxide causes carbonation of concrete i.e., loss of alkalinity of concrete or loss of the protective power that concrete gives to the reinforcement or other steel embedded in it. Once the carbonation depth exceeds the thickness of concrete cover to the embedded steel, steel becomes vulnerable to the attack of moisture. This expedites rusting of steel as the protective concrete cover remains no longer alkaline in nature.

Voids also reduce the contact between embedded steel and concrete. This results in loss of bond strength of reinforced concrete member and thus the member loses strength. Voids such as honeycombs and blowholes on the exposed surface produce visual blemish. Concrete surface is not good to look with all such blemishes. Concrete

with smooth and perfect, surface finish not only looks good but is also stronger and more durable.

Compaction is achieved by imparting external work over the concrete to overcome the internal friction between the particles forming the concrete, between concrete and reinforcement and between concrete and forms and by reducing the air voids to a minimum. The compaction of concrete can be achieved by the following methods.

1.Hand Compaction

2.Compaction by Vibration

a.Needle Vibrator:

b.Formwork Vibrator

3.Compaction by Spinning

4.Compaction by Jolting

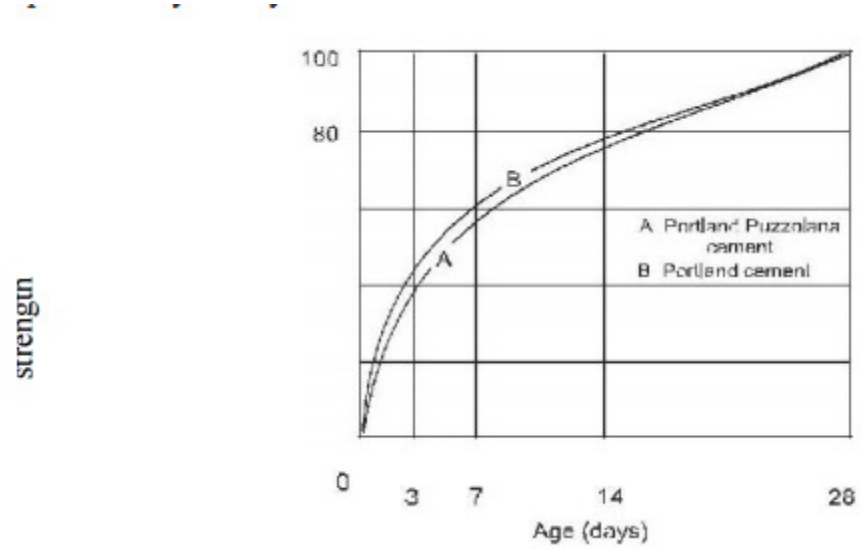
5.Compaction by Rolling

6) Curing

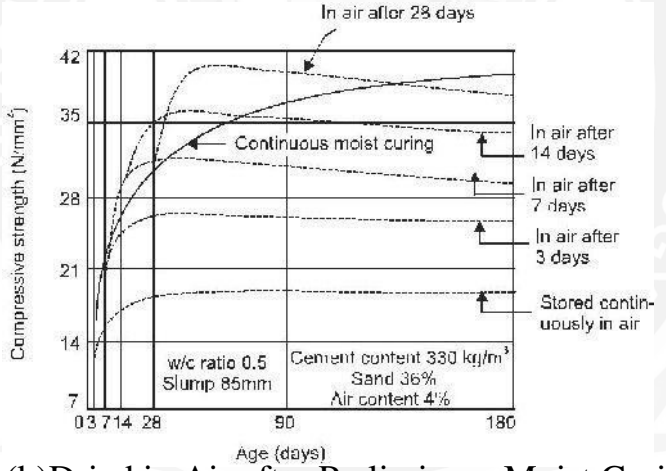
Cement gains strength and hardness because of the chemical action between cement and water. This chemical reaction requires moisture, favourable temperature and time referred to as the curing period. The variation of compressive strength with curing period is shown in Fig.2(a, b). Curing of freshly placed concrete is very important for optimum strength and durability. The major part of the strength in the initial period is contributed by the clinker compound C3S and partly by C2S, and is completed in about three weeks. The later strength contributed by C2S is gradual and takes long time. As such sufficient water should be made available to concrete to allow it to gain full strength. The process of keeping concrete damp for this purpose is known as curing. The object is to prevent the loss of moisture from concrete due to evaporation or any other reason, supply additional moisture or heat and moisture to accelerate the gain of strength. Curing must be done for at least three weeks and in no case for less than ten days.

Approximately 14 litres of water is required to hydrate each bag of cement. Soon after the concrete is placed, the increase in strength is very rapid (3 to 7 days) and continues slowly thereafter for an indefinite period. Concrete moist cured for 7 days is about 50 per cent stronger than that which is exposed to dry air for the entire period. If

the concrete is kept damp for one month, the strength is about double than that of concrete exposed only to dry air.



(a)Development of Strength with Age



(b)Dried in Air after Preliminary Moist Curing

Methods of Curing

Concrete may be kept moist by a number of ways. The methods consist in either supplying additional moisture to concrete during early hardening period by ponding, spraying, sprinkling, etc. or by preventing loss of moisture from concrete by sealing the surface of concrete by membrane formed by curing compounds. Following are some of the prevalent methods of curing.

1.Water Curing

2.Steam Curing

3.Curing by Infra Red Radiation:

4.Electrical Curing

5.Chemical Curing:

7) Finishing

Concrete is basically used because of its high compressive strength. However, the finish of the ultimate product is not that pleasant. In past couple of decades efforts have been made to develop surface finishes to give a better appearance to concrete surfaces and are as follows.

1.Formwork Finishes

2.Surface Treatments

3.Applied Finishes