Concreting Opertions

Storage of Cement – Precautions, Duration and Place of Storage

Proper precautions for the storage of cement such as duration and place of storage, arrangement, atmospheric moisture content etc. is necessary after the process of manufacturing and before using it in the construction site.

Because the cement hygroscopic nature, the cement absorbs moisture from the atmosphere very actively and hardens like stone which cannot be used for constructional purpose. So, storage of cement should be done with care.

Precautions for Proper Storage of Cement

Cement should not be stored normally. There are some precautions to be considered in the storage of cement. Following are the different situations against which precautions are to be taken:

1. Atmospheric moisture content
2. Duration of cement storage
3. Place of storage
4. Arranging cement bags
5. Withdrawal of cement bags

1. Moisture Content at Place of Storage

Moisture content or dampness is the main hazard for the cement. The moisture present in the atmosphere is enough for the cement to become useless material. The cement should be stored in such a way that it cannot expose to the atmosphere. So, air tight bags are used to pack the cement.

2. Duration of Cement Storage

Time of storing is also a factor that affects the cement especially its strength. Longer the time reduces the strength of cement. It is preferred that the cement should not be stored for more than 3 months. However, if it is stored more than 3 months the strength of cement should be tested before using it.

The following table gives us the percentage reduction of strength of cement for different time periods.

Period of storage	**Fresh stage**	**3 months**	**6 months**	**1 year**	**5 years**
% Reduction in strength at 28 days	0%	20%	30%	40%	50%

If the cement is stored for longer time and strength is found to be reduced, then it is not good for construction. But however, it can be reactivated by different methods like vibro grinding etc. vibro grinding improves fineness quality of long period stored cement and make it fit for the constructional purpose.

3. Place of Cement Storage

The bags of cement should not be stored in open places. Preferably specially designed storage sheds are good for cement storage. They can be used for longer periods.

The main purpose of special design is to provide waterproof floors, roofs and walls. The floor of shed should be well above the ground level. Small windows with air tight doors should be provided. Proper drainage should be provided inside and outside the shed to drain water in any case.

In general, one bag of cement contains 50 kilograms of cement, 20 bags of cement will require 1 cubic meter to store. Based on this the dimensions of storage shed are designed.

4. Arrangement of Cement Bags

A wooden platform of height 150 to 200 mm is prepared above the floor of storage shed to avoid the direct contact between the floors and cement bags.

On the prepared wooden platform, the cement bags should be arranged one above the other which forms stack of cement bags. Each stack should not consist not more than 10 bags of cement. The stack should not touch the walls of shed and it should be considerably 300 mm away from the external walls. Each stack should be closely connected to avoid the circulation of air.

To prevent collapsing of high stacks, cross arrangement of bags one above the other is preferable. All the stacks are covered with water proof layer for long term protection. Passage width of 900mm to 1000mm is provided between the stacks. The stack should consist same type of cement and for each stack date of placing should be noted to know their period of storage.

5. Withdrawal of Cement Bags

When the time of using arrives, Withdrawal of cement bags from stacks happens. The cement bags should be taken out in such a way that the bag first placed in storage shed should be withdrawal first.

Cement Storage Godown or Warehouse Requirements

Storage of cement is predominate for constructional works. Hence, correct arrangements for storing the cement for constructions come are needed. It preserves its quality and fitness of cement to be used.

Cement may be an absorbent construction material. It reacts with wetness either in liquid or in vapor forms quickly. In the presence of wetness, cement undergoes a chemical process termed as hydration. Cement becomes useless once the hydration method has taken place. Cement will stay in shape as long because it encounters wetness. Moisture may be a huge enemy of cement and thus cements luggage never keep for an extended amount.

Requirements of a Godown or Warehouse Used for Cement Storage

For the sake of the building materials' higher quality, each material ought to have a godown or warehouse for storage. Below are the subsequent characteristics of a godown or warehouse to stored cement at work sites. Such as:

- A godown would not allow dampness to urge to cement.
- Godown or warehouse itself ought to be sited in a very strategic purpose that will create it simple for providers to urge to get the good condition of cement. This implies the storeroom ought to be sited solely wherever it will not be tough for trucks to urge merchandise to employees.
- Space ought to be created accessible so, throughout stocking, loaders will simply drop off bags with ease.
- Lighting ought to be created accessible also.
- Godown or warehouse should not be specified moisture would emerge from the ground to satisfy the equipped products.
- The warehouse should have enough workforces to facilitate the movement of products in and out of the warehouse.

Methods for Mixing of Concrete Their Procedure & Precautions!

Concrete is a composite material made up of cement, sand, coarse aggregates, water and chemical admixtures (if required). It is the primary construction material. It plays a significant role in the structure's serviceability and durability. Not only the concrete but the process of concreting such as batching, mixing, transporting, compacting and finishing etc. also plays a significant role. Though making concrete is very easy, the proper concreting process is quite difficult and requires extra care specially the process of mixing of concrete ingredients.

Importance of Mixing of Concrete

Proper mixing of concrete ingredients is of utmost importance in order to produce good quality of fresh concrete. During the process of mixing the surface of all the aggregate particles is coated with cement paste. Well mixed concrete is required for the desired workability and performance of concrete in both the fresh as well as the hardened state. If the concrete is not well mixed, then it tends to segregation and bleeding.

Characteristics of Well Mixed Concrete

- Concrete should be of uniform colour.
- All concrete materials like cement, fine aggregates, coarse aggregates and water should be homogeneously mixed.
- Cement paste should cover all the surface of the aggregate.
- Segregation or bleeding of concrete should not occur after the concrete mixing.

Also Read: Tips to Avoid or Reduce Segregation in Concrete

Methods for Mixing Concrete

When it comes to mixing concrete, following three mixing methods are used for the production of effective and good quality concrete.

01. Hand Mixing of Concrete (Mixing concrete manually without a mixer machine)

02. Machine Mixing of Concrete (Mixing concrete with a mixer machine)

03. Ready Mix Concrete (Mixing in automatic or semi-automatic batching plant)

Several factors affect the method of concrete mixing such as,

- Location of the construction site with sufficient land for construction activities e.g. highly congested urban areas
- Available space for concrete batching and mixing and storage of aggregates
- Volume of concrete needed
- The construction schedule like the volume of concrete required per hour or per day
- Height at which concrete is to be placed
- Cost

01. Hand Mixing of Concrete (Mixing of Concrete Without a Mixer Machine)

Hand mixing is the process of mixing the ingredients of the concrete manually without a mixer machine. Mixing concrete without a mixer is used only for small works where the concrete requirement is less and quality control is less important. In the hand mixing of concrete, uniformity of mixing is difficult to achieve and requires special care and efforts.

Process of Hand Mixing of Concrete:

- Hand mixing of concrete is done on a hard, clean and non-porous base made of masonry or flat iron sheet plates.
- The measured quantity of sand is spread on the platform and then the cement is dropped over the sand.
- The sand and cement are mixed thoroughly for several times with the help of shovels in the dry state until the mixture attains an even colour throughout and is free from streaks.
- Next, the measured amount of coarse aggregates is spread out in uniform layer on the above mixture and mixed properly. Remember to use measurement boxes for batching of aggregates, i.e. to determine how much aggregates are to be used. Never use or allow the use of ‘Ghamelas’ for batching, i.e. measuring quality of aggregates.
- Later, the whole mixture is blended properly like turning over by twist from the center to the side, then back to the center and again to the sides several times.
- After that, depression is made at the center of the mixed materials.
- And, 75% of the required quantity of water is added in the depression and mixed with the help of shovels.
- Lastly, the remaining amount of water is added and the mixing process is continued till a uniform colour and consistency of concrete is obtained. The total time taken for mixing of concrete should not exceed 3 minutes.

Precaution to be Taken Care While Hand Mixing of Concrete:

- Base platform must be clean, dirt free and watertight.
- Use a good and clean shovel for the mixing procedure.
- If there are any dirt or debris in the aggregates, wash them before use.

- The personal protective equipment like hand gloves, mask etc. are must to be worn by the labours and masons while mixing and handling the concrete.
- The mixing platform should be cleaned at the end of the day's work.

02. Machine Mixing of Concrete (Mixing Concrete with a Mixer Machine)

Machine mixing is the process of mixing the ingredients of the concrete with a concrete mixer machine. It is highly effective for fulfilling the demands of short mixing time, optimum consistency and homogeneous quality of concrete.

The Process of Machine Mixing of Concrete:

1.First of all, wet the inner surfaces of the drum of concrete mixer.
2.Coarse aggregates are placed in the mixer first followed by sand and then cement.
3.Mix the materials in the dry state in the mixing machine. Normally it should be 1.5 to 3 minutes.
4.After proper mixing of dry materials, gradually add the correct quantity of water while the machine is in motion. Do not add more water than required. It is not advisable as it reduces strength.
5.After adding the water, you must mix concrete for a minimum of two minutes in the drum.
6.If there is any segregation of concrete after unloading from the mixer, then remix the concrete.

Precautions to be Taken While Machine Mixing of Concrete:

1.Concrete mixer machine must be wet before use.
2.Take care of mixing time, speed and numbers of revolution of mixer drum as per the recommendation of the manufacturers of the mixer machine.
3.Concrete should be used within 30 minutes after mixing and discharged by the concrete mixer.
4.If your mixing is batch type then, after discharging one batch of concrete, the interior surface of the mixer drum should be cleaned thoroughly. If not, lumps of hardened concrete from the mix of previous batch may form a part of the subsequent batch and deteriorate the quality of concrete.
5.If your mixing is of a continuous type, it is necessary to clean the concrete mixer after fixed intervals.
5.The inner portion of the concrete mixer should be carefully inspected at regular intervals to check for damages, shatter or corrosion.

Proper Methods for Placing Concrete

Concrete placement is an important process in the construction that determine the success of the structure and its life. Technical and environmental conditions are taken into strict consideration while placing the concrete.

The concrete is allowed to pass through different phase from the point it come out of the mixer till it complete as a finished concrete. The concrete is transported, poured, vibrated, matured, form removed and cured. Each of these phases must follow techniques that will come under good construction practice.

Here we will discuss the special considerations and procedures followed to achieve good concrete placement.

Procedure for Placing Concrete

1.Planning for Concrete Placement

Before any concrete is placed the entire placing, programme consisting of equipment, layout, proposed procedures and methods is planned and no concrete is placed until formwork is inspected and found suitable for placement.

Equipment for conveying concrete should be of such size and design as to ensure a practically continuous flow of concrete during depositing without segregation of materials considering the size of the job and placement location.

Concrete is placed in its final position before the cement reaches its initial set and concrete is compacted in its final position within 30 minutes of leaving the mixer and once compacted it should not be disturbed.

In all cases the concrete is deposited as nearly as practicable directly in its final position and should not be re-handled or caused to flow in a manner which may cause segregation, loss of materials, displacement of reinforcement, shuttering or embedded inserts or impair its strength.

2. Formwork Requirements for Concrete Placement

The formwork must be **rigid** so that it does not get deformed under the pressure of placement of fresh concrete and **water tight** so the concrete does not leak out. For every new use of formwork, the surfaces have to cleaned and brushed.

The concrete reinforcement must be held properly in the formwork. Special care is taken where concrete is dropped from a height especially if reinforcement is in the way particularly in columns and thin walls.

Concrete should be placed in the shuttering by shovels or other methods and should not be dropped from a height more than one metre or handled in a manner which will cause segregation.

It is recommended to maintain the rate of concreting as constant as possible.

3.Concrete Placement in Special Conditions

Concrete placed in restricted forms by borrows, buggies, cars, sort chutes or hand shoveling should be subjected to the requirement for vertical delivery of limited height to avoid segregation   and should be deposited as nearly as practicable in it's final position.

For locations where, direct placement is not possible and in narrow forms suitable drop and Elephant Trunks to confine the movement of concrete is provided.

For hot or cold weather concreting the temperature of the concrete must be kept accordingly to undergo effective placement. So that the concrete does not dry out or freeze out before completing the placement and related procedures.

4.Considerations in Concrete Placement Layers

Concreting once started should be continuous until the pour is completed. Concrete should be placed in successive horizontal layers of uniform thickness ranging from 150 mm to 900 mm.

The thickness of each layer should be such that it can be deposited before the previous layer has stiffened.

Before placing the next concrete layer, it is necessary to properly compact the below layer. Every underlying layer will be responsive to the vibrations above. These layers hence will Knits together.

Concrete placement has to be done rapidly as practicable to prevent the formation of cold joints or planes of weakness between each succeeding layer within the pour. Cold joints are prominent in large pouring sessions. These types of pouring will require proper planning.

The bucket loads or other units of deposit should be spotted progressively along the face of the layer with such overlap as will facilitate spreading the layer to uniform depth and texture with a minimum of shovelling.

Fig.2: Fast and Mass Concreting of a large floor Slab To avoid Cold Joints (Image Courtesy: www.lib.berkeley.edu)

5.Consideration for Segregation during Concrete Placement

Any tendency to segregation should be corrected by shovelling stones into mortar rather than mortar onto stones. Such a condition should be corrected by redesign of mix or other suitable means.

The top surface of each pour and bedding planes should be approximately horizontal unless otherwise specified in drawings.

Fig.3: Segregation of Concrete

Methods of Compaction of Concrete

Concrete consolidation can be carried out either by hand or machines. There are many factors that should be considered to choose compaction methods such as reinforcement quantities and spacing, concrete paste consistency and formwork complexity.

Hand Compaction Method

Reasonably workable and flowable concrete mixtures are consolidated by hand employing a rod. The bar should adequately reach the bottom of the form work and rode diameter need to compact concrete between reinforcement spacing and formworks.

The concrete is tamped by the rod tool repeatedly to consolidate it. Mixtures with low slump value could be consolidated by hand if superplasticizers are added to decrease slump and make the concrete workable.

Furthermore, tools such as spade is used to provide good surface appearance and hitting formwork sides make way to repel entrapped air out of the concrete.

Compaction of concrete with vibrators is divided into the following types:

a) Internal Vibrators

Internal vibrators which sometimes called spude or poker vibrators are usually applied to compact concrete in beams, walls, columns, and slabs. Not only does vibrators performance is influenced by concrete workability but also by frequency, amplitude, and head dimensions of vibrators.

Generally, vibrator head diameter is between 2-18 cm and the shape of the head is cylindrical. As the head diameter of vibrators is increased the effective action area is rose for instance radius action of vibrators with 4 cm head diameter is 15 cm while 45 cm is the radius action of vibrators with 8 cm head diameter.

Moreover, it is considerably significant to utilize internal vibrators correctly to achieve the best compaction. Horizontal movement of vibrators should be avoided to prevent concrete segregation and lowering head of vibrators to the bottom of considered concrete layer and it should over lab previous layer by about 15 cm. Compacted concrete layer thickness is about the head length or 50 cm.

Regarding using vibrators for compacting slabs, the vibrator must be kept submerged in concrete and this can be done by using it horizontally or at specific angle in addition to use 1.5 times the radius action as the distance to guarantee overlap previously adjacent vibrated layer. Not only does the vibrator should be held steady but also keep in specific station for 5-15 seconds to obtain desirable consolidation.

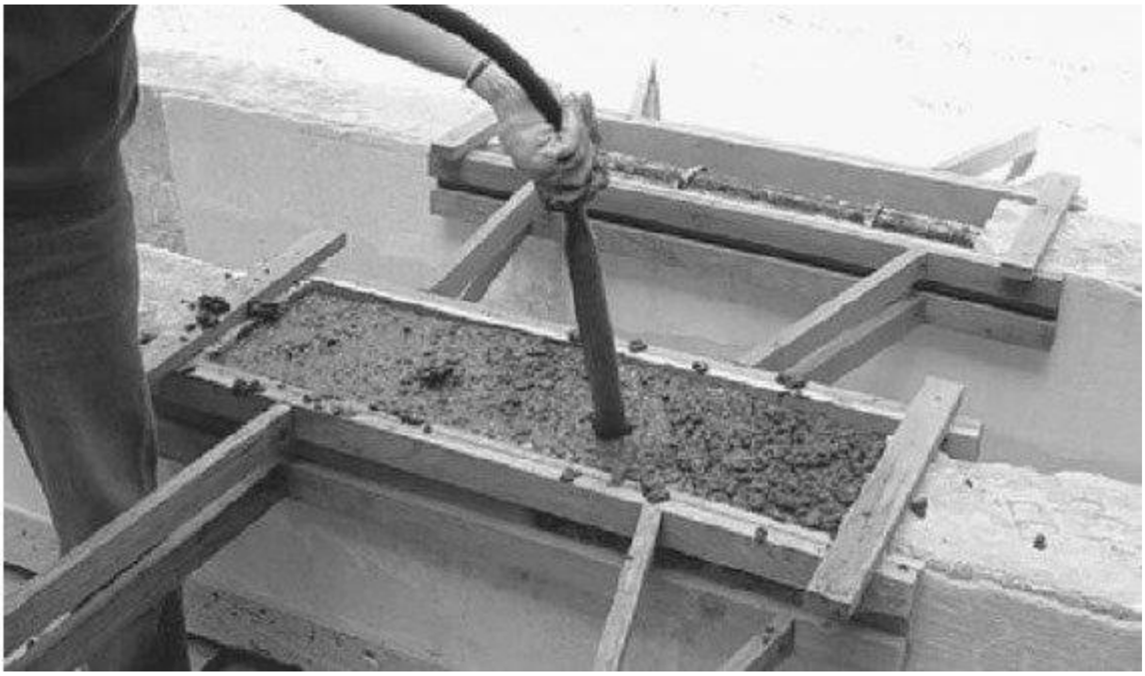


Figure-2: Internal Vibrators for Concrete Compaction

b) External Vibrators

There are two major types of external vibrators which are

- Table or surface vibrator, and
- Form vibrator.

The Table vibrator is widely suitable for compacting concrete surfaces such as floors and slabs. It adequately consolidates slabs up to 20 cm thickness; internal vibration is required for higher slab thicknesses.

The form vibrator is attached to the exterior face of mold or forms properly otherwise energy will be lost because of improper attachments. Moreover, form vibrator is the proper choice for compacting concrete in thin and heavily congested forms, consolidating stiff mixtures, and supplementing external vibrators.

Additionally, form vibrators can be advantageous for constructing pipes, masonry units, and other types of precast concrete. However, it is not recommended to employ form vibration at the top of vertical forms such as columns because it could cause gaps between concrete the molds as a consequent of in and out movements, so internal vibration is better to use in this case.

Curing of concrete is the term used for the job of keeping the fresh concrete wet till the desired purpose is achieved.

Cement concrete has to be kept wet for several days after its placing to ensure complete setting and hardening of the cement.

Concrete derives its strength by the hydration of cement particles.

The quality of the product of hydration and consequently, the amount of gel formed depend on the extent of hydration.

Theoretically, the water-cement ratio of 0.38 is required to hydrate all the particles of the cement and to occupy the space in the gel pores.

In the field, even though the higher water-cement ratio is used, since the concrete is open to atmosphere, the water used in the concrete evaporates, and the water available in the concrete will not be sufficient for adequate hydration to take place, particularly in the top layer.

Curing can be considered as the creation of a favorable environment during the early period for uninterrupted hydration.

Objects of Curing of Concrete.

It is known that all the properties of good concrete are related to the perfect setting of cement.

It is also known that the process of setting involves complex hydration reactions which require a lot of water.

A good quantity of water is added to the concrete ingredients while making the mix. After placing the concrete, some water from concrete may be lost due to evaporation.

Hence, the first and foremost object of curing of concrete is to provide enough quantity of water for the cement to hydrate and set completely.

Another object of curing concrete is to maintain a proper temperature in and around the concrete during the setting process.

This is because both freezing and drying temperatures hamper the process of setting of cement in a normal manner.

The third and most important object of concrete curing is to ensure a concrete of good quality, when set, strong enough to stresses, hard enough to abrasion and resistant to chemical attacks.

Such concrete is quite durable.

Methods of Curing of Concrete.

Different methods or procedures have been adopted for curing of concrete.

FOLLOWING ARE SOME IMPORTANT POINTS FOR SELECTING METHODS OF CONCRETE CURING.

(i) The type of construction such as those involving large horizontal surface areas as in roads, floors, and airfields, or, those involving formed concrete in walls, columns, beams, cantilevers, and arches, etc.

(ii) The place of construction, whether indoors and damp situations (as inside a building) or outdoor.

(iii) The weather conditions where concrete is being laid in cold climates or at the dry and hot weather.

Depending on the above factors, one or more of the following methods are used for curing of concrete.

1. Water Curing.

Water Curing is considered as the best method of curing of concrete as it satisfies all the requirements of curing, namely; absorption of the heat of hydration, promotion of hydration, and elimination of shrinkage.

Water curing can be done in the following ways:

i. Spraying or Fogging.

ii. Ponding.

iii. Wet covering.

iv. Immersion.

i. Spraying of Water:

Vertical retaining walls or plastered surfaces or concrete columns, etc. are cured by spraying water.

This method is ideally suited for almost all types of construction in most conditions. It involves spraying water with the help of house pipes connected to the main water supply lines.

Its disadvantage lies that in tall structures, water spraying at top levels may hamper work on the lower floors.

ii. Ponding of Water:

In this method, pavement slabs, roof slabs, etc., are covered under water by making small ponds.

It is the next common method of curing of concrete suited best for horizontal surface areas such as roads, floors, and slabs.

Small ponds, not more than 5 cm deep, are made over the surface by raising temporary barriers.

These ponds are kept filled with water for several days. In hot weather, ponding is the ideal method of curing of concrete.

iii. Wet Coverings:

In some cases, wet coverings such as wet gunny bags, jute matting, and straw are wrapped to the vertical surface for keeping the concrete wet.

For horizontal surfaces, sawdust, earth or sand are used as wet coverings to keep the concrete in a damp condition for a longer time.

It is another method of concrete curing suitable for flat surfaces and also for columnar and vertical surfaces after the formwork is removed from them.

In this method, coverings made of straw, burlap, hessian, and jute are soaked in water and placed over the concrete.

These are kept moist for the entire period of curing.

They are thought to be double-action; they prevent the evaporation from within the concrete and supply the additional water required for hydration.

iv. Immersion:

The precast concrete items are usually immersed in curing tanks for a specific duration.

2. Use of Curing Compounds (Membrane Method).

This may be broadly described as the chemical method of curing of concrete.

In this method, some suitable chemical compounds dissolved in solvents are sprayed over the fresh concrete to be cured.

The solvent evaporates, leaving behind a thin film of the chemical compound spread over the concrete surface.

This film has the characteristic property that it allows little or no evaporation from the concrete.

Thus, if a sufficient quantity of water has already been added at the time of preparation of concrete, it will hydrate and set and harden satisfactorily without much additional water.

The thick film of chemical compound starts peeling off after some time (2-4 weeks) leaving behind the properly cured concrete. Most curing compounds consist of different types of resins.

A major disadvantage of this method of curing of concrete is that continuous concreting is not possible.

The cured surface will not make a firm band with the new layer or thickness unless it is completely peeled off or removed from it.

Still, on flat surfaces of single thickness, the membrane method is used extensively in concrete constructions.

3. Application of Heat.

The development of the strength of concrete is a function of not only time but also of temperature.

When concrete is subjected to a higher temperature, it accelerates the hydration process resulting in faster development of strength.

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

i. Steam curing at ordinary temperature

ii. Steam curing at high temperature

iii. Curing by infrared radiation

iv. Electrical curing

i. Steam curing at ordinary temperature:

This method is often adopted for prefabricated concrete elements. Application of steam to in-situ-construction will be a difficult task.

For steam curing, the concrete elements are stored in a chamber. The chamber should be large enough to hold a day's production.

The door is closed, and steam is applied.

The steam may be applied either continuously or intermittently.

Accelerated hydration takes place at this higher temperature and concrete attains the 28-day strength in about 3 days.

In large prefabricated factories, they have tunnel curing arrangements. However, concrete subjected to a higher temperature at the early period of hydration is found to lose some of the strength gained at a later stage.

It has been emphasized that very fresh concrete should not be subjected suddenly to high temperature. A certain delay period after casting the concrete is desirable.

Steam curing is often adopted for precast elements, especially precast concrete sleepers.

iii. Curing by infrared radiation:

Curing of concrete by infrared radiations has been practiced in very cold climatic regions of Russia.

It is claimed that much more rapid gain of strength can be obtained than with steam curing and does not cause a decrease in the ultimate strength as in the case of steam curing at ordinary pressure.

iv. Electrical curing:

Another method of curing concrete, which applies mostly to very cold climatic regions, is by the use of electricity.

This method is not likely to find much use in ordinary temperatures due to economic reasons.

Concrete Finishing Techniques

Concrete is well-known as a versatile construction material, used worldwide a myriad number of residential commercial and industrial applications. Concrete carries its strength on the inside, but its beauty on the outside: this exterior appearance can be modified by use of various materials and techniques which will be described below.

Concrete Finishes

The most basic type of concrete finish is a smooth surface created through the use of screeds and trowels. Immediately after concrete has been placed in forms, concrete finishers utilize a screed to level out the concrete surface. Screeds often consist of long pieces of metal or wood that are pulled and pushed across the concrete surface to remove excess concrete and fill in gaps in the concrete surface.

Troweling or Floating

Once the concrete has been tooled with a screed, concrete finishers utilize trowels to smooth and fine-level the surface of the concrete. This can be accomplished through manual or mechanical means. To smooth concrete manually a hand trowel, which is typically composed of a flat steel blade with attached handle, is pushed and pulled across the concrete surface. Power trowels are available and are typically used on large commercial and industrial projects where using hand trowels is not feasible. Power trowels resemble large fans with the blades sitting directly against the concrete. These power trowels are available in both walk behind and riding versions.

The image below shows an operator riding a power trowel, which is working to smooth the concrete floor surface.

Edging

Edging of the concrete is conducted to provide rounded or beveled edges on the finished concrete as well as to create joints where needed in the surface to help minimize cracking. A specific edging tool is used to accomplish this task, and requires quite a bit of practice to master.

Broom Finish

In order to make concrete surfaces slip resistant, a broom finish can be applied. This is done after placement, leveling, and troweling of concrete. Once a smooth surface has been created, a broom is dragged across the surface of the concrete to create small ridges that provide for traction control, particularly when the concrete surface is wet. Concrete surfaces without a broom finish tend to be slippery and dangerous when liquids are present on the surface.

Concrete Texture

Aside from broom finishing, there are several other means of creating textures on the surface of concrete, some of which are listed below.

Exposed Aggregate Finish

An exposed finish, once commonly found in sidewalks of old cities, is created by washing the top layer of concrete away, which exposes the edges of the natural stone aggregates that are mixed into the concrete. This provides an attractive and slip resistant finish.

In addition to the use of the normal concrete materials (cement, sand, gravel and water), other materials may be added into the mix to provide exposed finishes with unique looks. Examples are rose quartz, limestone, dark gray or black basalt, red or blue granite and even colored glass or seashells. The key with any of these additives is to avoid materials containing iron, which can stain the concrete. Also, it’s important to provide a high-quality seal after concrete curing in order to protect the surface.

Salt Finish

A salt finish is a type of finish used mainly for swimming pool decks. Salt finishes are created by applying rock salt to the top of the wet concrete and then washing it away, which leaves small pits in the finished surface.

Stamped Concrete

A common method of texturing is to use concrete stamps. Concrete stamps are comprised of panels with inlaid designs, which are placed on concrete while it is still curing. Designs may consist of brick, stone or other decorative patterns to provide the desired look, sometimes mimicking other common building materials, but retaining the strength and durability of concrete. Once the forms are removed, the concrete surface may have color applied via staining, as described below.

Concrete Coloring
Concrete have color added to provide a look that fits with the architecture of the associated structure. This can be accomplished through mix-added pigments or post-cure staining, both of which are discussed below.

Pigments
Concrete coloring using pigments is a simple process, accomplished by adding the pigments directly to the concrete mix prior to pouring. Pigments are available in liquid form or in “mix-ready” dissolvable bags. In both cases, the pigments are placed in the mixer with the other concrete ingredients. The range of colors available is typically confined to “earthy” variants of browns and tans, although greens, blues and grays can also be purchased. It is important to keep pigmented concrete well sealed throughout its lifetime in order to prevent water infiltration, which may cause the pigment to fade.

Concrete Stain
The color of concrete can also be manipulated through the use of various staining products. One common method of staining concrete is through the use of acid. Similar to concrete pigments, the range colors is typically confined to non-bright, relatively subtle tones. Water-based (acrylic) staining provides for a much larger number of colors, including black and white. Stains can be applied to concrete of any age, though the colors are typically more vibrant if the stain is applied relatively soon after the concrete has been placed. Application of stain is typically followed up with installation of a seal over the concrete to protect the surface.

Polished Concrete
Cured concrete, whether freshly-placed or well-aged, can be provided with a polished surface for a clean and glossy look, ease of maintenance and a surface that provides

Types of Joints in Concrete Constructions

Types of joints in concrete constructions are:

1. Construction Joints
2. Expansion Joints
3. Contraction Joints
4. Isolation Joints

1. Construction Joints

Construction joints are placed in a concrete slab to define the extent of the individual placements, generally in conformity with a predetermined joint layout.

Construction joints must be designed in order to allow displacements between both sides of the slab but, at the same time, they have to transfer flexural stresses produced in the slab by external loads.

Construction joints must allow horizontal displacement right-angled to the joint surface that is normally caused by thermal and shrinkage movement. At the same time they must not allow vertical or rotational displacements. Fig.1 summarizes which displacement must be allowed or not allowed by a construction joint.

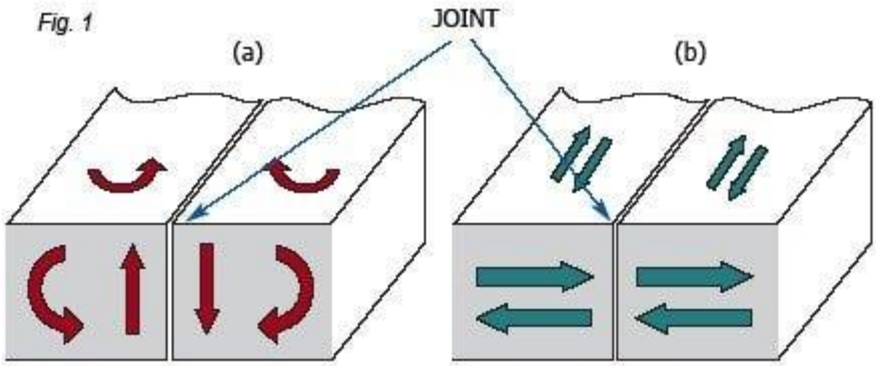
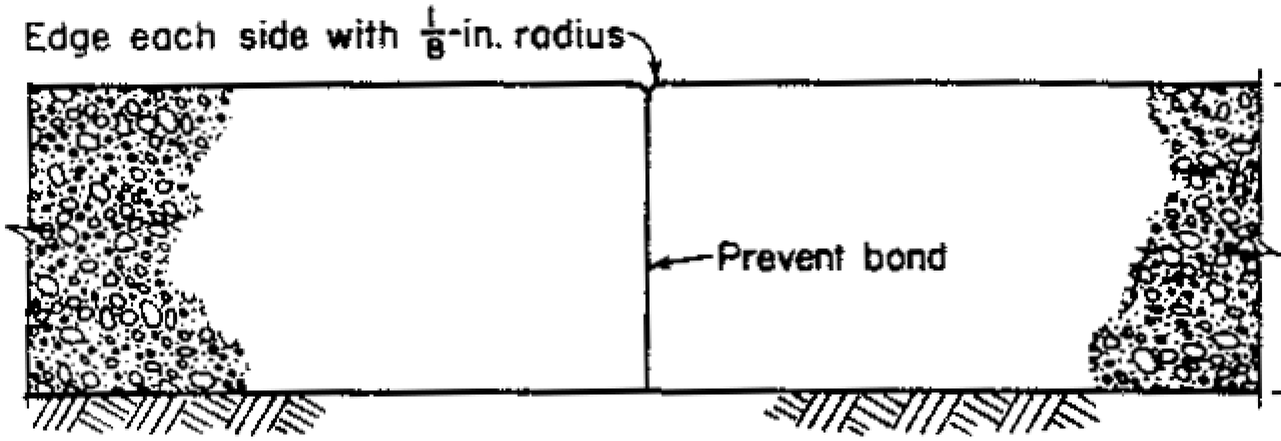
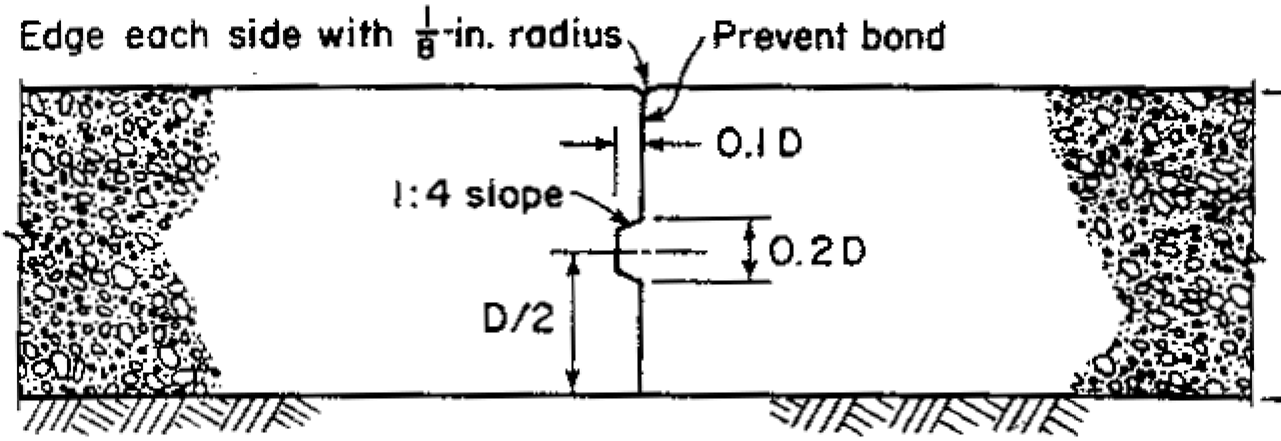


Figure 1 – Relative movements which must be (b) allowed and (a) not allowed by a con-struction joint for concrete slabs



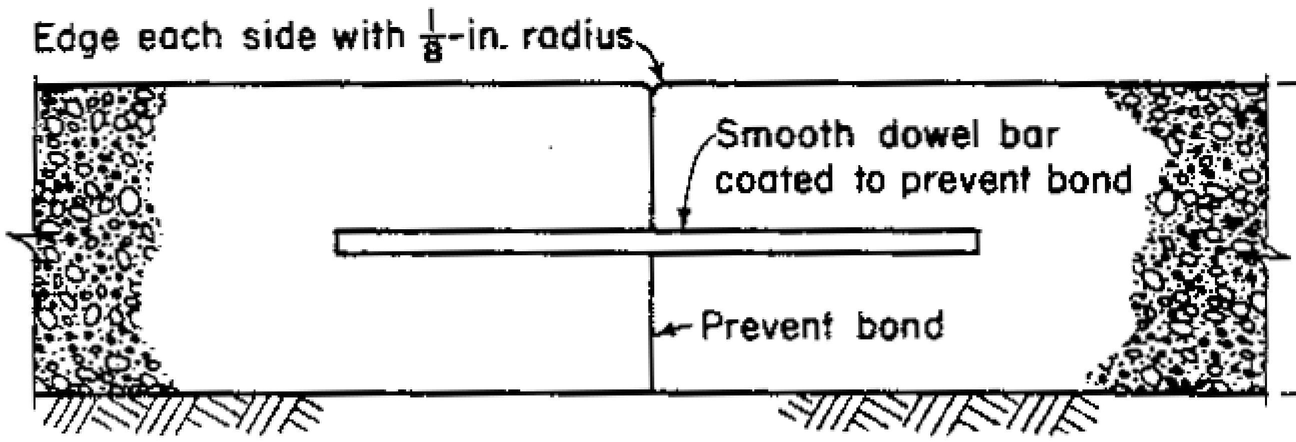
Butt-type construction joint

(a)



Tongue-and-groove construction joint

(b)



Butt-type construction joint with dowels

(c)

Fig.2: Types of Construction Joints in Concrete Structures

2. Expansion joints

The concrete is subjected to volume change due to many reasons. So we have to cater for this by way of joint to relieve the stress. Expansion is a function of length. The building longer than 45m are generally provided with one or more expansion joint. In india recommended c/c spacing is 30m. The joints are formed by providing a gap between the building parts.

3. Contraction Joints

A contraction joint is a sawed, formed, or tooled groove in a concrete slab that creates a weakened vertical plane. It regulates the location of the cracking caused by dimensional changes in the slab.

Unregulated cracks can grow and result in an unacceptably rough surface as well as water infiltration into the base, subbase and subgrade, which can enable other types of pavement distress.

Defects in Concrete Structures – Types Causes, Prevention

Different types of defects in concrete structures can be cracking, crazing, blistering, delamination, dusting, curling, efflorescence, scaling and spalling. These defects can be due to various reasons or causes.

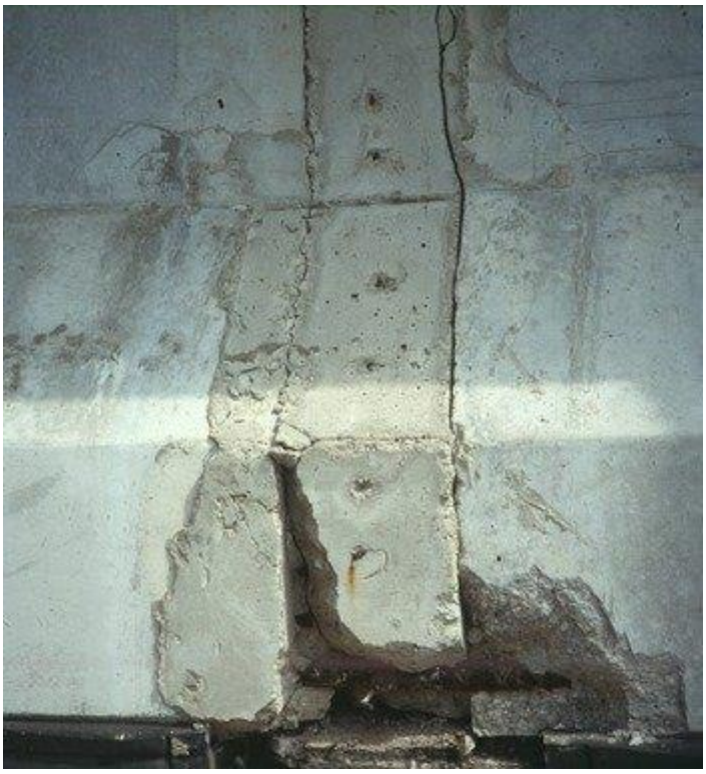
Causes for Defects in Concrete Structures

Causes of defects in concrete structures can be broadly categorized as:

1. Structural deficiency resulting from errors in design, loading criteria, unexpected overloading, etc.
2. Structural deficiency due to construction defects.
3. Damage due to fire, floods, earthquakes, cyclones etc.
4. Damage due to chemical attack.
5. Damage due to marine environments.
6. Damage due to abrasion of granular materials.
7. Movement of concrete due to physical characteristics.

Structural Defects due to Design and Detailing

In such case, the design is required to be reviewed in detail and remedial measures worked out by the design team. Once this is done the methods of carrying out the remedial measures will be similar to those arising out of other defects.



Structural Deficiency due to Construction Defects

Defective construction methods form the largest segment of source of distress to the beams. Such defects can be broadly subdivided as follows:

1. Defects due to the quality of raw materials.
2. Non adoption of designed concrete mix.
3. Use of defective construction plant for producing, transporting, and placing the concrete.
4. Defective workmanship.
5. Inadequate quality detailing.

It is very necessary to choose the right type of cement for the concrete going into the structure under consideration. Ordinary Portland cement is the most common of all cements. Provided the quality of cement conforms to the relevant standard specifications, at the time of use, normally no problem is encountered in respect of ordinary Portland cement.

Where the concrete is exposed to aggressive environment, it may be necessary to use special cements, such as, sulphate resisting Portland cement, blast furnace slag cement, low C3A cement.

The quality of aggregates, particularly in respect of alkali-aggregate reaction, needs to be taken into account, fortunately cases of defects / failures attributed to alkali aggregate reaction in India are very rare.

The use of water containing salt for making concrete can also contribute to deterioration of the concrete.

The design of concrete mix can be satisfactorily carried out using a wide variety of aggregates. A reasonable continuity of grading of aggregates should be ensured.

Other factors leading to poor design detailings

1. Re-entrant corners.
2. Abrupt changes in section.
3. Inadequate joint detailing.
4. Deflection limits.
5. Poorly detailed drips and scuppers.
6. Inadequate or improper drainage.
7. Poor detailing of expansion joints.

Types of Concrete Defects – Causes, Prevention

Various types of defects which can be observed in hardened concrete surface and their prevention methods are explained below:

1. Cracking

Cracks are formed in concrete due to many reasons but when these cracks are very deep, it is unsafe to use that concrete structure. Various reasons for cracking are improper mix design, insufficient curing, omission of expansion and contraction joints, use of high slump concrete mix, unsuitable sub-grade etc.

To prevent cracking, use low water – cement ratio and maximize the coarse aggregate in concrete mix, admixtures containing calcium chloride must be avoided. Surface should be prevented against rapid evaporation of moisture content. Loads must be applied on the concrete surface only after gaining its maximum strength.

Fig 1: Cracking

2. Crazing

Crazing also called as pattern cracking or map cracking, is the formation of closely spaced shallow cracks in an uneven manner. Crazing occurs due to rapid hardening of top surface of concrete due to high temperatures or if the mix contains excess water content or due to insufficient curing.

Pattern cracking can be avoided by proper curing, by dampening the sub-grade to resist absorption of water from concrete, by providing protection to the surface from rapid temperature changes.

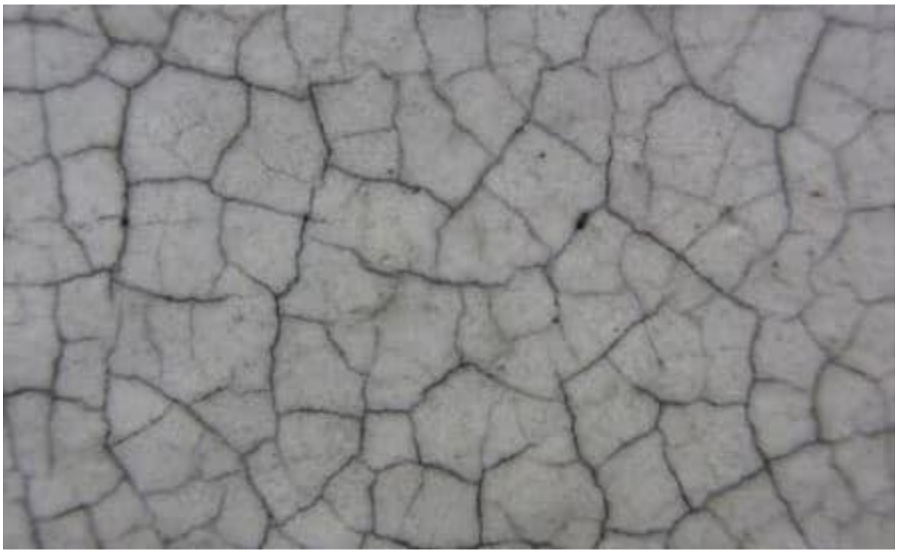


Fig 2: Crazing or Pattern Cracking

3. Blistering

Blistering is the formation of hollow bumps of different sizes on concrete surface due to entrapped air under the finished concrete surface. It may cause due to excessive vibration of concrete mix or presence of excess entrapped air in mix or due to improper finishing. Excessive evaporation of water on the top surface of concrete will also cause blistering.

It can be prevented by using good proportion of ingredients in concrete mix, by covering the top surface which reduces evaporation and using appropriate techniques for placing and finishing.

Fig 3: Concrete Blisters

4. Delamination

Delamination is also similar to blistering. In this case also, top surface of concrete gets separated from underlying concrete. Hardening of top layer of concrete before the hardening of underlying concrete will lead to delamination. It is because the water and air bleeding from underlying concrete are struck between these two surfaces, hence space will be formed.

Like blistering, delamination can also be prevented by using proper finishing techniques. It is better to start the finishing after bleeding process has run its course.

Fig 4: Delamination

5. Dusting

Dusting, also called as chalking is the formation of fine and loose powdered concrete on the hardened concrete by disintegration. This happens due to the presence of excess amount of water in concrete. It causes bleeding of water from concrete, with this fine particles like cement or sand will rise to the top and consequent wear causes dust at the top surface.

To avoid dusting, use low slump concrete mix to obtain hard concrete surface with good wear resistance. Use water reducing admixtures to obtain adequate slump. It is also recommended to use better finishing techniques and finishing should be started after removing the bleed water from concrete surface.

Fig 5: Dusting

6. Curling

When a concrete slab is distorted into curved shape by upward or downward movement of edges or corners, it is called curling. It occurs mainly due to the differences in moisture content or temperature between slab surface (top) and slab base (bottom).

Curling of concrete slab may be upward curling or downward curling. When the top surface is dried and cooled before bottom surface, it begins to shrink and upward curling takes place. When bottom surface is dried and cooled due to high temperature and high moisture content, it will shrink before top surface and downward curling occurs.

To prevent curling, use low shrink concrete mix, provide control joints, provide heavy reinforcement at edges or provide edges with great thickness.

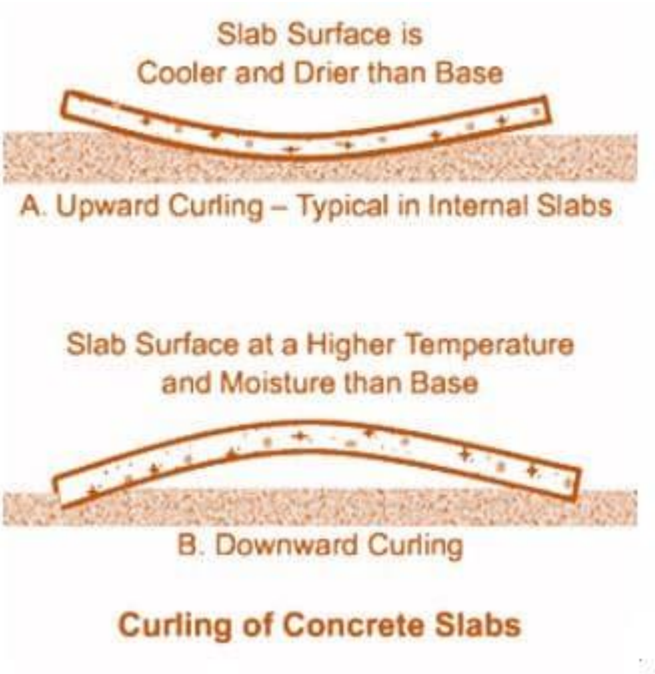


Fig 6: Curling of Concrete Slab

7. Efflorescence

Efflorescence is the formation of deposits of salts on the concrete surface. Formed salts generally white in color. It is due to the presence of soluble salts in the water which is used in making concrete mix.

When concrete is hardening, these soluble salts gets lifted to the top surface by hydro static pressure and after complete drying salt deposits are formed on the surface.

It can be prevented by using clean and pure water for mixing, using chemically ineffective aggregates etc. And make sure that cement should not contain alkalis more than 1% of its weight.

Fig 7: Efflorescence

8. Scaling and Spalling

Scaling and spalling, in both the cases concrete surface gets deteriorated and flaking of concrete occurs. The main cause for this type of cases is penetration of water through concrete surface. This makes steel gets corroded and spalling or scaling may occurs.

Fig 8: Scaling

Some other causes are use of non-air entrained concrete mix, inadequate curing and use of lo strength concrete etc. This type of defects can be prevented by, using well designed concrete mixes, by adding air entrainment admixtures, proper finishing and curing, providing good slope to drain water coming on to the surface etc.

Method of Non -Destructive Test

ULTRASONIC PULSE VELOCITY

This test is done to assess the quality of concrete by ultrasonic pulse velocity method as per IS: 13311 (Part 1) – 1992. The underlying principle of this test is –
The method consists of measuring the time of travel of an ultrasonic pulse passing through the concrete being tested. Comparatively higher velocity is obtained when concrete quality is good in terms of density, uniformity, homogeneity etc.

Procedure to determine strength of hardened concrete by Ultrasonic Pulse Velocity.
i) Preparing for use: Before switching on the 'V' meter, the transducers should be connected to the sockets marked "TRAN" and " REC".
The 'V' meter may be operated with either:
a) the internal battery,
b) an external battery or
c) the A.C line.

ii) Set reference: A reference bar is provided to check the instrument zero. The pulse time for the bar is engraved on it. Apply a smear of grease to the transducer faces before placing it on the opposite ends of the bar. Adjust the 'SET REF' control until the reference bar transit time is obtained on the instrument read-out.

iii) Range selection: For maximum accuracy, it is recommended that the 0.1 microsecond range be selected for path length upto 400mm.

iv) Pulse velocity: Having determined the most suitable test points on the material to be tested, make careful measurement of the path length 'L'. Apply couplant to the surfaces of the transducers and press it hard onto the surface of the material. Do not move the transducers while a reading is being taken, as this can generate noise signals and errors in measurements. Continue holding the transducers onto the surface of the material until a consistent reading appears on the display, which is the time in microsecond for the ultrasonic pulse to travel the distance 'L'. The mean value of the display readings should be taken when the units digit hunts between two values.

Pulse velocity=(Path length/Travel time)

v) Separation of transducer leads: It is advisable to prevent the two transducer leads from coming into close contact with each other when the transit time measurements are being taken. If this is not done, the receiver lead might pick-up unwanted signals from the transmitter lead and this would result in an incorrect display of the transit time.

Interpretation of Results

The quality of concrete in terms of uniformity, incidence or absence of internal flaws, cracks and segregation, etc,indicative of the level of workmanship employed, can thus be assessed using the guidelines given below, which have been evolved for characterizing the quality of concrete in structures in terms of the ultrasonic pulse velocity.

Pulse Velocity (km/second)	Concrete Quality (Grading)
Above 4.5	Excellent
3.5 to 4.5	Good
3.0 to 3.5	Medium
Below 3.0	Doubtful

Rebound Hammer Test on Concrete – Principle, Procedure, Advantages & Disadvantages

What is Rebound Hammer Test?

Rebound Hammer test is a Non-destructive testing method of concrete which provide a convenient and rapid indication of the compressive strength of the concrete. The rebound hammer is also called as Schmidt hammer that consist of a spring controlled mass that slides on a plunger within a tubular housing.

The operation of rebound hammer is shown in the fig.1. When the plunger of rebound hammer is pressed against the surface of concrete, a spring controlled mass with a constant energy is made to hit concrete surface to rebound back. The extent of rebound, which is a measure of surface hardness, is measured on a graduated scale. This measured value is designated as Rebound Number (rebound index). A concrete with low strength and low stiffness will absorb more energy to yield in a lower rebound value.

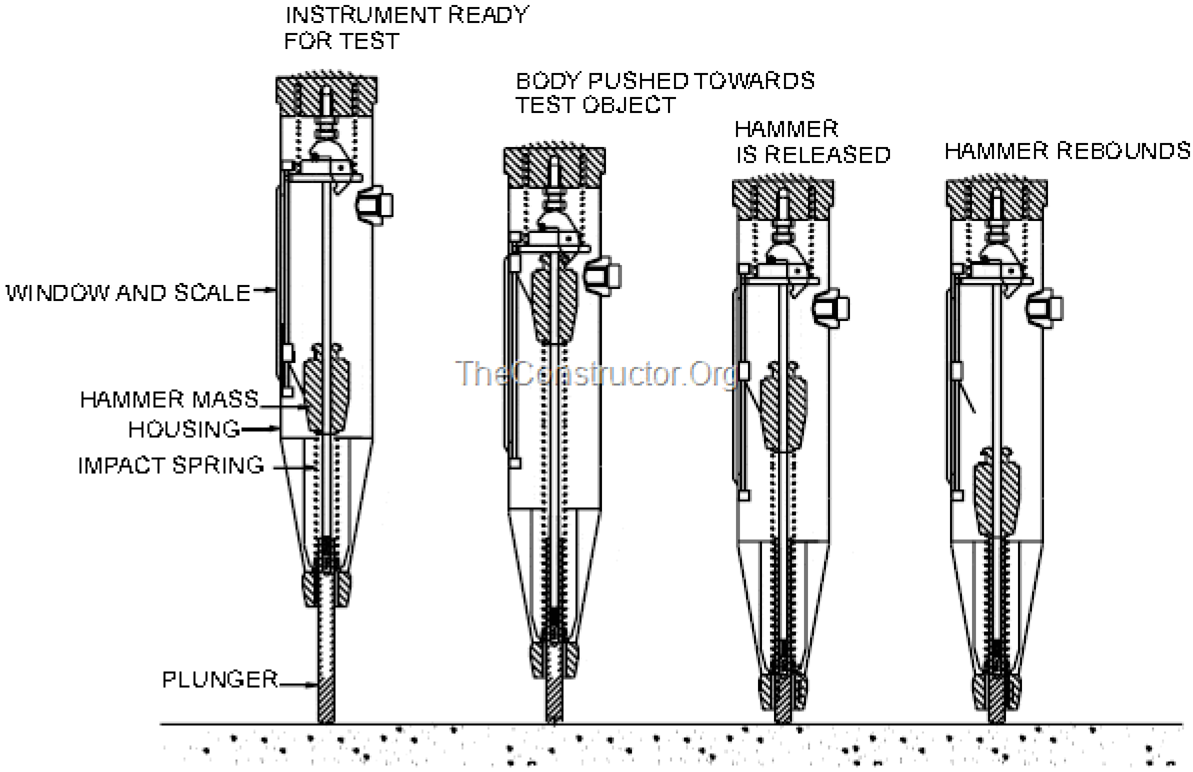


Fig.1.Operation of the rebound hammer

Objective of Rebound Hammer Test

As per the Indian code IS: 13311(2)-1992, the rebound hammer test have the following objectives:

1. To determine the compressive strength of the concrete by relating the rebound index and the compressive strength
2. To assess the uniformity of the concrete
3. To assess the quality of the concrete based on the standard specifications
4. To relate one concrete element with other in terms of quality

Rebound hammer test method can be used to differentiate the acceptable and questionable parts of the structure or to compare two different structures based on strength.

Principle of Rebound Hammer Test

Rebound hammer test method is based on the principle that the rebound of an elastic mass depends on the hardness of the concrete surface against which the mass strikes. The operation of the rebound hammer is shown in figure-1. When the plunger of rebound hammer is pressed against the concrete surface, the spring controlled mass in the hammer rebounds. The amount of rebound of the mass depends on the hardness of concrete surface.

Thus, the hardness of concrete and rebound hammer reading can be correlated with compressive strength of concrete. The rebound value is read off along a graduated scale and is designated as the rebound number or rebound index. The compressive strength can be read directly from the graph provided on the body of the hammer.

Procedure for Rebound Hammer Test

Procedure for rebound hammer test on concrete structure starts with calibration of the rebound hammer. For this, the rebound hammer is tested against the test anvil made of steel having Brinell hardness number of about 5000 N/mm2.

After the rebound hammer is tested for accuracy on the test anvil, the rebound hammer is held at right angles to the surface of the concrete structure for taking the readings. The test thus can be conducted horizontally on vertical surface and vertically upwards or downwards on horizontal surfaces as shown in figure below

If the rebound hammer is held at intermediate angle, the rebound number will be different for the same concrete.

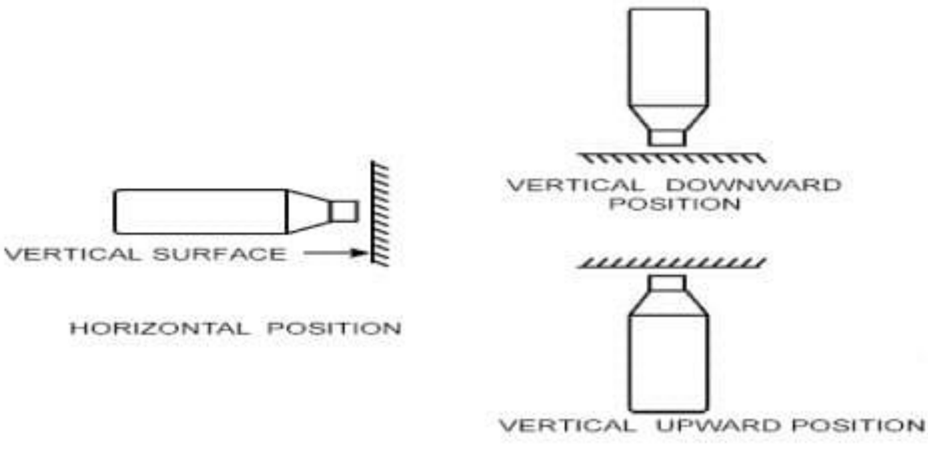


Fig.2.Rebound Hammer Positions for Testing Concrete Structure

The impact energy required for the rebound hammer is different for different applications. Approximate Impact energy levels are mentioned in the table-1 below for different applications.

Table-1: Impact Energy for Rebound Hammers for Different Applications As per IS: 13311(2)-1992

Sl.No	Applications	Approximate Impact Energy for Rebound Hammer in Nm
1	For Normal Weight Concrete	2.25
2	For light weight concrete / For small and impact resistive concrete parts	0.75
3	For mass concrete testing Eg: In roads, hydraulic structures and pavements	30.00

Points to Remember in Rebound Hammer Test

1. The concrete surface should be smooth, clean and dry.
2. Ant loose particles should be rubbed off from the concrete surface with a grinding wheel or stone, before hammer testing.
3. Rebound hammer test should not be conducted on rough surfaces as a result of incomplete compaction, loss of grout, spalled or tooled concrete surface.
4. The point of impact of rebound hammer on concrete surface should be at least 20mm away from edge or shape discontinuity.
5. Six readings of rebound number is taken at each point of testing and an average of value of the readings is taken as rebound index for the corresponding point of observation on concrete surface.

Correlation between compressive strength of concrete and rebound number

The most suitable method of obtaining the correlation between compressive strength of concrete and rebound number is to test the concrete cubes using compression testing machine as well as using rebound hammer simultaneously. First the rebound number of concrete cube is taken and then the compressive strength is tested on compression testing machine. The fixed load required is of the order of 7 N/ mm2 when the impact energy of the hammer is about 2.2 Nm.

The load should be increased for calibrating rebound hammers of greater impact energy and decreased for calibrating rebound hammers of lesser impact energy. The test specimens should be as large a mass as possible in order to minimize the size effect on the test result of a full scale structure. 150mm cube specimens are preferred for calibrating rebound hammers of lower impact energy (2.2Nm), whereas for rebound hammers of higher impact energy, for example 30 Nm, the test cubes should not be smaller than 300mm.

The concrete cube specimens should be kept at room temperature for about 24 hours after taking it out from the curing pond, before testing it with the rebound hammer. To obtain a correlation between rebound numbers and strength of wet cured and wet tested cubes, it is necessary to establish a correlation between the strength of wet tested cubes and the strength of dry tested cubes on which rebound readings are taken.

A direct correlation between rebound numbers on wet cubes and the strength of wet cubes is not recommended. Only the vertical faces of the cubes as cast should be tested. At least nine readings should be taken on each of the two vertical faces accessible in the compression testing machine when using the rebound hammers. The points of impact on the specimen must not be nearer an edge than 20mm and should be not less than 20mm from each other. The same points must not be impacted more than once.

Interpretation of Rebound Hammer Test Results

After obtaining the correlation between compressive strength and rebound number, the strength of structure can be assessed. In general, the rebound number increases as the strength increases and is also affected by a number of parameters i.e. type of cement, type of aggregate, surface condition and moisture content of the concrete, curing and age of concrete, carbonation of concrete surface etc.

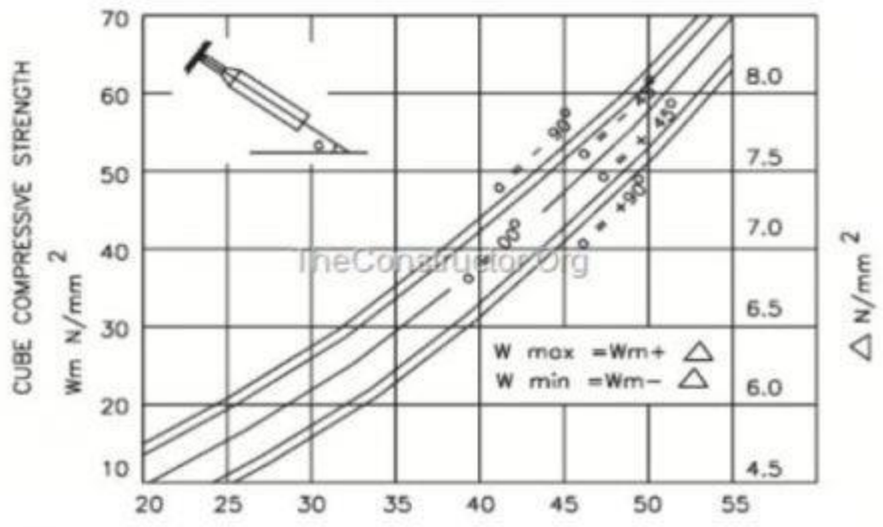


Fig.3.Relationship Between Cube Strength and the Rebound Number

Moreover the rebound index is indicative of compressive strength of concrete up to a limited depth from the surface. The internal cracks, flaws etc. or heterogeneity across the cross section will not be indicated by rebound numbers.

Table-2 below shows the quality of concrete for respective average rebound number.

Table.2. Quality of Concrete for different values of rebound number

Average Rebound Number	Quality of Concrete
>40	Very good hard layer
30 to 40	Good layer
20 to 30	Fair
< 20	Poor concrete
0	Delaminated

As such the estimation of strength of concrete by rebound hammer method cannot be held to be very accurate and probable accuracy of prediction of concrete strength in a structure is ± 25 percent. If the relationship between rebound index and compressive strength can be found by tests on core samples obtained from the structure or standard specimens made with the same concrete materials and mix proportion, then the accuracy of results and confidence thereon gets greatly increased.

Advantages and Disadvantages of Rebound Hammer Test

The advantages of Rebound hammer tests are:

1. Apparatus is easy to use
2. Determines uniformity properties of the surface
3. The equipment used is inexpensive
4. Used for the rehabilitation of old monuments

The disadvantages of Rebound Hammer Test

1. The results obtained is based on a local point
2. The test results are not directly related to the strength and the deformation property of the surface

3. The probe and spring arrangement will require regular cleaning and maintenance
4. Flaws cannot be detected with accuracy

Factors Influencing Rebound Hammer Test

Below mentioned are the important factors that influence rebound hammer test:

1. Type of Aggregate
2. Type of Cement
3. Surface and moisture condition of the concrete
4. Curing and Age of concrete
5. Carbonation of concrete surface

Type of Aggregate

The correlation between compressive strength of concrete and the rebound number will vary with the use of different aggregates. Normal correlations in the results are obtained by the use of normal aggregates like gravels and crushed aggregates. The use of lightweight aggregates in concrete will require special calibration to undergo the test.

Type of Cement

The concrete made of high alumina cement ought to have higher compressive strength compared to Ordinary portland cement. The use of supersulphated cement in concrete decrease the compressive strength by 50% compared to that of OPC.

Type of Surface and Moisture Condition

The rebound hammer test work best for close texture concrete compared with open texture concrete.   Concrete with high honeycombs and no-fines concrete is not suitable to be tested by rebound hammer. The strength is overestimated by the test when testing floated or trowelled surfaces when compared with moulded surfaces.

Wet concrete surface if tested will give a lower strength value. This underestimation of strength can go lower to 20% that of dry concrete.

Type of curing and age of concrete

As time passes, the relation between the strength and hardness of concrete will change. Curing conditions of concrete and their moisture exposure conditions also affects this relationship. For concrete with an age between 3days to 90 days is exempted from the effect of age. For greater aged concrete special calibrated curves is necessary.

Carbonation on Concrete Surface

A higher strength is estimated by the rebound hammer on a concrete that is subjected to carbonation. It is estimated to be 50% higher. So the test have to be conducted by removing the carbonated layer and testing by rebound hammer over non-carbonated layer of concrete.