CH-01

Materials For Concrete.

Concrete = Cement + Sand (F.A) + Aggregates (C.A) + Water + Admixtures

Note

→ The mixture of cement and water is called paste.

→ The function of paste is to bind sand and aggregates particles by the chemical process of hydration.

→ It also fills the voids between sand and aggregate particles.

* Cement :-

Raw materials for cement

- Calcareous materials
  - e.g. – Lime stone
  - – Chalk
  - – marl.
- Argillaceous materials
  - eg – clay
  - – shale.

→ Three processes of cement manufacturing.

① Wet process

② Dry process

③ Semi-dry process

→ These process are involved three distict operation

→ mixing of raw materials

→ Buning

→ Grinding.

Mixing of Raw Materials

↓

Rotary kiln = upper end

↓ temperature rise

convert small lumps (Noduls)

↓

temperature upto 1500°C to 1700°C
noduls converted into small hard balls (clinkers).
(size - 3mm to 20mm)

↓

put at ball mills and tube mills.
at griding time 2 to 3% gypsum added.
to prevent flash-setting of the cement.

↓

finely stored in silos.
and manually packed by machine in bage.

→ Each bag of cement contains 50kg or $0.035 m^3$

* Oxide Composition of OPC.

Oxide	content %
Lime, CaO	60 – 67%
Silica, SiO_2	17 - 25%
Alumina, Al_2O_3	3 - 8%
Iron Oxide, Fe_2O_3	0.5 — 6%
Magnesia, MgO	0.5 — 4%
Alkalies, K_2O, Na_2O	0.3 – 1.2
Sulphates, SO_3	1.0 – 3.0

* Bogue's compounds.

Abbreviation	Name	per % by mass in cement
C_3S	Tricalcium silicate	30 – 50
C_2S	Dicalcium silicate	20 – 45
C_3A	Tricalcium aluminate	8 – 12
C_4AF	Tetracalcium aluminoferrite	6 – 10

* Properties of Bogue's compounds.

C_3S:
- It is responsible for early strength.
- First 7 days strength is due to C_3S.
- It produces more heat of hydration.
- A cement with more C_3S content is better for cold weather concreting.

C_2S:
- The hydration of C_2S start after 7 days.
- It gives strength after 7 days.
- C_2S hydrates and hardens slowly and provides much of the ultimate strength.
- It is responsible for the later strength of concrete.
- It produces less heat of hydration.

C_3A:
- The reaction of C_3A with water is very fast may lead to an immediate stiffening of paste, and this process is termed as flash set.
- To prevent this flash set, 2 to 3% gypsum is added at the time of grinding the cement clinkers.
- The hydrated C_3A do not contribute to the strength of concrete.

C_4AF :- C_4AF hydrates rapidly.

- It does not contribute to the strength of concrete.
- The hydrates of C_4AF show a comparatively higher resistance to the sulphate attack than the hydrates of C_3A.

* Hydration of Cement

→ When water is added to cement, ingredients of cement react chemically with water and form various complicated chemical compounds. The chemical reaction that take place between cement and water is reffered as hydration of cement.

→ An hydrous cement does not bind fine and coarse aggregate.

→ It acquires adhesive (attraction betn different molecules) property only when mix with water.

→ The silicates (C_3S, C_2S) and aluminate (C_3A) of cement react with water and form hydrosilicates and hydroaluminate.

→ These products are thick and sticky. It is called gel.

→ Gel possess adhesive property and binds aggregates and sand together.

→ It also fill the voids between sand & aggregate.

* Water requrements For hydration

→ 23% for C3S and C2S

→ 15% for bound water

→ Total 38% of water by weight of cement is requird For complete hydration.

→ If less than 38% of water is used than strength of concrete will be reduced.

→ If more than 38% of water used, the more will be the undesirable capillary cavities.

* Heat of Hydration

→ The reaction of cement with water is exothermic. The reaction librates a considerable quantity of heat

*

Setting of cement	Hardening of cement
① Setting is the term used to describe the stiffening of the cement paste	① Hardening refers to the gain of strength of set cement paste
② It refers to change from a fluid to a rigid state	② It refers to formation of solid mass possessing good compressive strength

* **False set** :- cement and water को जब हम mix करते हैं उसकी कुछ ही समय में stiff हो जाता है उसी को false set कहते हैं।

* Types of cement

① Ordinary portland cement (OPC)

(i) 33 grade OPC - IS 269: 1989
(ii) 43 " " - IS 8112: 1989
(iii) 53 " " - IS 12269: 1987

② Rapid Hardening cement
③ Extra Rapid Hardening of cement
④ Quik setting cement
⑤ Low heat cement
⑥ Sulphate Resisting cement
⑦ Super Sulphate cement
⑧ Portland Pozzolona Cement
⑨ Portland slag cement
⑩ coloured cement (white cement)
⑪ Hydrophobic cement
⑫ Air Entraining cement
⑬ Masonary cement
⑭ Oil well cement

(15) Expansive cement

(16) High Alumina Cement

(17) Concrete sleeper Grade cement

(18) Waterproof cement

(19) Rediset cement

(20) Very high strength cement

① Ordanary port land cement

28 days minimum compresive stn.

33 grade → 33 N/mm²

43 " → 43 N/mm²

53 " → 53 N/mm²

uses

→ For general concrete construction when there is no exposure to sulphate in the soil or in the ground water.

② Rapid Hardening cement

→ In pre-fabricated concrete construction

→ For road repair works

→ where formwork is required to be removed early for re-use elsewhere.

→ In cold weathering concreting.

→ wall sealing etc.

③ Extra Rapid Hardening cement

→ In cold weathering concreting

→ It is suitable where a very high early strength is required.

④ Quick setting cement

→ Under water construction

→ Grouting operation.

⑤ Low heat cement

→ Mass concrete construction

→ Resisting to sulphate attack

→ Hot weathering concreting

⑥ Sulphate Resisting cement

→ It is used in marine conditions.

→ sewage treatment plant

→ chemical factory.

⑦ Super Sulphate cement

→ marine condition

→ RCC pipes

→ Mass concreting

⑧ Portland Pozzolona cement

→ For hydraulic structure.

→ For marine structure

→ For sewers and sewage disposal work

⑨ Portland Slag cement

→ For mass concrete

→ For marine structure.

⑩ Coloured cement (white cement)

→ To fill joints of glazed tiles in W.C, bathrooms, kitchen etc.

→ To fill joints in flooring.

(11) Hydrophobic cement

→ It will improve the workability of concrete.

(12) Air Entraing Cement

→ It produce light weight concrete

(13) Masonary cement

→ This cement used as ordinary Portland cement.

(14) Oil well cement

→

(15) Expansive cement

→ Grouting Anchor bolts
→ Grouting machine foundation.

(16) High Alumina Cement

→ Foundation of furnace, coke ovens boiler setting.

(17) Concrete sleeper grade cement

→ To make concrete sleeper.

(18) Waterproof cement

→ It is used for waterproofing of terraces, water tanks, W.C, bathroom etc.

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* Field test of cement

→ Open the bag of cement and take a good look at the cement.
There should not be any visible lumps

→ The coloured of the cement should be greenish gray.

→ When hand is inserted in cement bag. it should give cool feeling.

→ Take a pinch of cement and feel between the finger. It should give a smooth feeling and not a greddy feeling.

→

* Storage of Cement

→ (1) waterproof shed with nonporous wall & flooring.

(2) The plinth level should well above ground level.

(3) No. of opening area (doors, windows, ventilation) is very less.

(4) Cement bags should be kept 30 cm away from wall.

(5)

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* Physical properties of cement

1) Fineness → (1) By sieve test
   (2) By Air permeability test

2) Standard consistency

3) Initial & final setting

4) Compressive strength.

5) Soundness test

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* Aggregate:

→ The aggregates occupy about 75% of the volume of concrete and hence their influence on various properties of concrete is considerable.

* Classification of Aggregate

① Classification of Aggregate Based on Unit Weight.

1. Normal weight aggregate
2. Light weight aggregate
3. Heavy weight Aggregate

② Classification based on size.

1. Fine Aggregate → size ≤ 4.75mm
   → Bulking is more, ex- natural sand.
2. Coarse Aggregate
   → size > 4.75
   → Bulking is very small and neglected.
   → Normal size → 40mm, 20mm, 16mm and 12.5mm.
3. Max. size of Aggregate

③ Classification based on shape.

1. Rounded aggregate
2. Irregular "
3. Angular "
4. Flaky "
5. Elongated "

① Rounded aggregate

→ contains minimum voids ranging from 32 to 33%.
→ It gives better workability.
→ The interlocking between the particles is less and hence the development of bond is poor making.
→ It is unsuitable for high strength concrete.

② Irregular Aggregate

→ voids range · 35 to 38%.
→ bonding is better
→ For giving workability more paste required.

③ Angular Aggregate

→ voids range 38 – 40%.
→ Good bonding between aggregate particles in concrete.
→ It gives high strength of concrete

④ Flaky aggregate

→ The aggregate whose least dimension (thickness gauge) is less than 3/5 of its mean dimension. is termed as flaky aggregate.
→ They reduce workability of concrete.

③ Elongated Aggregate

→ The aggregate whose greater dimension is greater than 9/5 of its mean dimension is called elongated aggregate.

→ They reduce workability in concrete.

④ Classification based surface texture.

Surface texture	Example
→ Glassy	Black flint
→ Smooth surface	chert, slate, marble
→ Granular	Sand stone
→ Crystalline	Basalt, trachyte.

* Laboratory test of aggregate

→ Abrasion value test
→ Impact value test
→ Crushing value test
→ Flaky & Elongation.

* CH-02 * Fresh concrete *.

- → Introduction.
- → Workability
- → segregation
- → Bleeding
- → Relation betn workability & strength.
- → w/c ratio
- → Gel/space ratio
- → Admixture used to improve workability
- → Production of concrete
- → Joints in concrete.

Introduction

→ In previous chapter we studied the properties of different types of cement, properties of coarse and fine aggregate and quality of mixing water.

→ In this chapter we will study one more aspect for deciding the water/cement ratio i.e. workability of concrete.

* Workability

→ It is defined as the ease with which it can be mixed, transported and placed in position in a homogeneous state.

* Factor affecting workability

- → water content
- → Mix proportions
- → size of aggregates
- → shape of aggregates
- → Surface texture of aggregate
- → Grading of aggregate.
- → Use of admixtures
- → Time
- → Temperature.

* Measuring of workability.

→ The following tests are commonly used to measure workability.

1. Slump test
2. Compacting factor test
3. Flow test
4. Vee bee consistometer test
5. kelly ball test.

* **Segregation** :- It can be defined as separating out of the ingredients of concrete mix, so that the mix is no longer in a homogeneous and stable condition.

→ It results in honey combing, decrease in density, and ultimate loss of strength of hardened concrete.

* Types of segregation

→ The coarse aggregate seperating out from the mix, in case of dry mix.

→ The paste seperating out from the mix, in case of wet mix.

→ Water seperating out from the mix, being a material of lowest specific gravity, in case of excess water in the mix.

* Causes of segregation.

(I) Badly proportioned mix where sufficient matrix (paste) is not available to bind and contain the aggregates.

(II) Insufficient mixing of concrete with excess water content.

(III) Dropping of concrete from heights as in the case of placing concrete in column.

(IV) Discharging concrete against an obstacles like reinforcing bars, formwork etc.

(V) Passing concrete along a chute, particularly with changes of direction.

* Precautions

1. Using correctly proportioned mix
2. Use of certain workability agents, pozzolanic materials makes the mix cohesive and greatly help in reducing segregation.
3. The use of air-entraining agents appreciably reduces segregation.
4. Reducing the height of drop of concrete.
5. Concrete should not be caused to flow horizontally or discharged against an obstruction.
6. Vibration should not be used as a means of spreading a heap of concrete into a level mass over a large area.

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* **Bleeding:-** It is defined as the separation of water or water-cement mixture from the freshly mixed concrete.

→ The main causes of bleeding
1. Highly wet mix.
2. Badly proportioned mix.
3. Insufficient mixed mix.

* Remedies to bleeding.

→ Using rich mixes

→ Using finer cement or cement with low alkali content

→ Proper proportioning the mix

→ Uniform and sufficient mixing of concrete.

→ Use of finely divided pozzolanic materials creates a longer path for the water to traverse and reduces bleeding.

→ Use of air entraining agents is also effecting in reducing the bleeding.

* **Relation between workability and strength.**

→ Workability of concrete is directly proportional to the w/c ratio, but inversly proportional to the strength of concrete.

→ As discussed earlier, 23% water is required for chemical reaction and 15% water is required to fill up the gel pores.

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→ Total 38%, workability of concrete reduces. But, concrete with low w/c ratio will give higher strength.

→ If, w/c ratio is higher, workability of concrete will be higher, but strength of concrete will be lesser. In concrete with high w/c ratio, the water in excess of 38%, will create undesirable capillary cavities. hence concrete becomes porous and strength of concrete is reduced.

* Water / cement Ratio.

→ In 1918, as a result of extensive testing at the Lewis Institute, university of Illinois, Duff Abrams found that a relation existed between w/c ratio and concrete strength and Presented this classic law

$$S = \frac{K_1}{(K_2)^x}$$

where, S = strength of concrete
x = w/c ratio
K_1 = 14000 lbs/sq.in.
K_2 = 7.

→ Abram's law, Although eastablished independently, is similar to a general rule formulated by Feret in 1896.

→ Feret defined the strength of concrete paste and concrete in terms of volume factions of cement, water and air.

$$S = K\left(\frac{c}{c+w+a}\right)^2$$

where, S = strength of concrete
c, w, a = vol. of cement, water and air
K = constant.

* Gel/space ratio

→ The influence of the w/c ratio on strength of concrete does not truly constitute a law as the w/c ratio rule propounded by Duff Abrams, does not include many qualifications for its validity.

Hence, Abrams w/c ratio law can only be called a rule and not a law.

* Some of the limitations of Abrams law are:

① The strength at any w/c ratio depends on the degree of hydration of cement and its chemical and physical properties.

② The temperature at which hydration takes place.

③ The air content of concrete in case of air-entrained concrete.

④ change in effective w/c ratio.

⑤ Formation of fissures and cracks due to bleeding and shrinkage.

$$\text{Gel/space ratio} = \frac{\text{Volume of hydrated cement paste}}{(\text{Vol. of hydrated cement} + \text{Vol. of capillary pores})}$$

* Admixtures Used to improve workability

① Air entraining agents ② Water reducing agents

③ Finely divided material

* Air entraining agents

<u>materials</u> → Natural wood resins, e.g. vinsol resin.

→ Animal and vegetable fats and oil.

→ Water soluable soaps of resin acids

→ Wetting agents like alkali salts.

→ Aluminium powder, hydrogen peroxide.

<u>Effects</u> → Improvement in workability.

→ Increase resistance to freezing and thawing.

→ Reduction in strength.

→ Reduction in Permeability

→ Reduces tendency of segregation and bleeding.

→ Reduces alkali-aggregate reaction.

* Water reducing agents (Plasticizers)

→ <u>materials</u> → Calcium chloride

→ Sodium ligno-sulphonate

→ ~~Aluminium~~ Amonium ligno-sulphonate

* → The use of plasticizers reduces the water/cement ratio for the given workability which naturally increase the strength of concrete.

→ The action of plasticizer is to fluidify the mix and to improve the workability of mix.

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* Finely divided material :

materials : → Bentonite clay
→ Fine silica
→ Diatomaceous earth
→ Fly ash

effects : → Improve the workability.
→ Reduce rate of bleeding
→ Increase strength of lean concrete.

* Production of concrete

→ The various stages of manufacture of good quality concrete are :

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

* Batching or measurement of materials

→ The proper and accurate measurement of all the materials used in the manufacturer of concrete is essential to ensure uniformity of proportions and aggregate grading in successive batches.

→ There are two methods of batching.

① Volume batching ② Weigh batching.

* Volume batching

→ Volume batching is not a good method for proportioning the material.

→ Volume of moist sand in a loose condition weighs much less than the same volume of dry compacted sand.

→ Volume batching is normally adopted for unimportant concrete or for small jobs, even though measurement by weight is preferable wherever possible.

→ Guage boxes are used for measuring the fine and coarse aggregates.

→ Gauge boxes are also called farmas.

*** Weigh batching :-** Batching by weight is preferable to volume batching as it is more accurate and leads to more uniform proportioning and quality of concrete.

→ It does not have the uncertainities associated with bulking and the non-uniform filling of the guage boxes associated with volume batching.

→ For all important works, only weight batching should be adopted.

② Mixing of concrete

The main aim of mixing of concrete is to produce a homogenous, consistent and uniform coloured concrete.

→ There are two methods of mixing concrete.

① Hand mixing ② Machine mixing.

③ Transporting concrete.

→ The process of carrying the concrete from the place of its mixing to the place of deposition is termed as transportation of concrete.

* The requirements to be fullfilled during transportation of concrete.

① Concrete delivered at the point of placing should be uniform and of proper consistency.

② No segregation in the concrete.

③ No excessive drying and stiffening of the concrete.

④ The process of mixing, transporting, placing and compacting concrete should not take more than 90 minutes in any case.

⑤ Transportation cost should be as low as possible.

* Principal methods adopted for transportation of concrete.

ⓐ Mortar pan ⓑ wheel barrow and hand carts.

ⓒ Truck mixer and Dumpers

ⓓ Crane, bucket and rope way.

ⓔ Belt conveyors

ⓕ chute

ⓖ Transit mixer

ⓗ skip and Hoist

ⓘ pumps and pipeline.

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* Placing of concrete

The process of depositing the concrete in its required position is termed as placing of concrete.

* Placing concrete in the following ~~situ~~ situations.

① Placing concrete within small earth mould.
   For example: Foundation concrete for a column or wall

② Placing concrete within large earth mould.
   For example: Road slab and airfield pavements.

③ Placing concrete in layers within steel or timber shutters
   For example: mass concrete in dam construction,
   concrete abutements and piers.
   concrete raft for high-rise building.

④ Placing concrete within normal formwork.
   For example: slabs, beams, column.

⑤ Placing concrete under water.

* Precaution to be taken while placing concrete.

(i) Placing concrete within small earth mould.

→ Before placing the concrete in the foundation, all the loose earth must be removed from the bed.

→ Any root of tree passing through the foundation trench must be cut charred or tarred effectively.

→ The surface of the earth, if dry must be made wet by sprinkling water.

② Placing concrete within large earth mould.

→ The ground surface on which concrete is placed must be free from loose earth, pool of water and other organic matters like grass, leaves, roots etc.

③ Placing concrete in layers within steel or timber shutters

→ In case of massive concrete works, concrete is laid in thick layers.

→ while placing concrete in layers, it is better to leave the top of the layer rough, so that the succeeding layer can have a good bond with the previous layer.

④ Placing concrete within normal formwork:

→ It must be checked that the reinforcement is properly tied, placed and having appropriate cover.

→ The formwork must be examined for correct alignment and adequate rigidity to withstand the weight of concrete, impact loads during construction without deformation.

→ Any coating of the hardened mortar on the forms should be removed.

⑤ Placing concrete under water.

→ different methods

1. Bagged concrete
2. Bottom dump bucket
3. Tremie. —— Imp
4. Grouted aggregate
5. Concrete pump.

* Compaction of concrete.

→ Compaction is the process of moulding concrete within the forms and around embedded parts in order to expell the entrapped air from the concrete and to obtain homogeneous dense mass.

* Methods of compaction:

① Hand compaction
② Compaction by vibration.
③ Compaction by pressure and jolting.
④ Compaction by spinning.

* Curing of concrete

→ It is defined as the process of keeping the concrete moist and warm enough, so that hydration of cement may continue until the desired properties are developed.

* Methods of curing

- → water curing
- → Membrane curing.
- → Applications of heat
- → Calcium chloride.

CH-03 Admixtures

→ Admixtures
→ Purposes of using Admixtures
→ Classification of Admixtures
→ Adverse effect of excess use of admixtures.

Admixtures :- It is defined as a material other than the basic ingredients of concrete cement, aggregates and water, added to the concrete mix immediately before or during mixing to modify some properties of concrete in the fresh or hardened state.

→ The use of admixtures like accelerators, retarders, air-entraining agents, pozzolanic materials, water proofing admixtures etc. is being practiced by Indian construction industry since long back.

* Purpose of using Admixtures

→ To increase the strength of concrete.
→ To accelerate the initial setting of concrete.
→ To retard the initial setting of concrete.
→ To improve workability of concrete.
→ To increase durability of concrete.
→ To reduce heat of hydration.
→ To make light weight concrete.
→ To reduce permeability of concrete.
→ To control the alkali-aggregate expansion.

→ To increase the resistance to sulphate attack.
→ To increase the bond between old and new concrete.
→ To increase the bond between concrete and steel reinforcement.
→ To reduce segregation and bleeding of concrete.
→ To produce coloured concrete or mortar.
→ To control the corrosion of concrete.

* Classification of Admixtures.

As per IS: 1903-1999 has covered main five types of admixtures.

1. Accelerating admixture (Accelerators)
2. Retarding admixture (Retarders)
3. Water reducing admixtures (workability admixtures)
4. Air entraining admixtures.
5. Super-plasticizing admixtures.

→ The other types of admixtures are:
→ Pozzolana admixtures.
→ Grouting admixtures
→ Water proofing admixture.
→ Air detraining admixtures
→ Bonding admixtures.
→ Corrosion inhibitting admixtures
→ Gas forming admixture.
→ Colouring admixtures.
→ Alkali-aggregate expansion inhibiting admixturs.
→ Fungicidal, Germicidal, Insecticidal admixturs.

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*① Accelerating Admixtures (Accelerators)

→ Accelerators are added to concrete the setting and hardening of concrete.

→ The most commonly used accelerator is calcium chloride ($CaCl_2$).

→ When it is used under normal conditions, and in regular amounts 2% by weight of cement.

→ It reduces the initial setting time from approximately 3 to 1 hour and final setting time from approximately 6 to 2 hours.

→ At 21°C temperatures, it approximately double the 1 day strength.

Advantages

→ Earlier removal of forms

→ Reduction of required period of curing

→ Earlier placement of structure in services.

→ Early finishing of surface.

→ Offset low-temperature retardation effects during cold weathering concrete.

→ Quick repairs to existing concrete.

② Retarding Admixtures (Retarders)

→ Retarders are added to concrete to slow down the hydration of cement to delay or prolong the setting of the cement in concrete.

→ Retarders keep the concrete plastic and workable for a longer time.

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Purpose

→ To overcome the accelerating effect of high temperature on setting properties of concrete in hot weather concreting.

→ To delay setting of cement, when concrete is to be placed in difficult conditions.

→ When concrete is required to be transported for long distance.

→ In grouting oil wells, where at a depth of about 6000 meter temperatures may be about 200°C and cement grout is required to be in mobile condition for about 3 to 4 hours.

material used as retarder.

→ Calcium sulphate (Gypsum)
→ starches
→ sugars
→ cellulose products.
→

(3) Plasticizers (Water Reducing Admixtures)

→ Use of plasticizers for improving workability without using excess of water is becoming popular practice all over the world.

→ It reduces the w/c ratio for the given workability which naturally increase the strength of concrete.

→ Calcium, sodium and ammonium. ligno-sulphonates are the most commonly used plasticizers.

→ They are used in the amount of 0.1% to 0.4% by weight of cement.

→ The action of plasticizers is to fluidify the mix and to improve the workability of mix.

→ The absorption of charged polymer on the cement particles creats particle to particle repulsive forces, called zeta potential.

④ Super - Plasticizers.

→ Japan was the first country to develop super-plasticizers in 1960 and subsequently Germany in 1970.

→ The use of super-plasticizers permit the reduction of water to the extent of 30% without reducing workability of the mix.

→ They are also called high range water reducers.

→ They are more powerful as dispersing agents.

Advantages

→ Very high workability can be achieved, Hence, self levelling, self compacting, flowing concrete can be produced.

→ For the same workability, it has made possible to use w/c ratio as low as 0.28 to obtain strength of the order of 100 MPa.

→ With low w/c ratio, it also permits a reduction of cement content.

→ The super-plasticizers produce a homogeneous, cohesive concrete generally without any tendency for segregation and bleeding.

(5) Air-Entraining Admixtures.

→ The air entrained concrete is produced by mixing a small amount of air-entraining agent or by using air-entraining cement during mixing of the concrete.

→ Air-entraining agents also modifies the properties of hardened concrete regarding strength, durability, permeability and resistance to frost action.

Air-entraining Agents

(1) Natural wood resins, e.g. vinsol resin.
(2) Animal and vegetable fats and oil.
(3) Animal and vegetable fatty acids, water soluble soaps of resin acids.
(4) Aluminium powder, zinc powder, hydrogen peroxide.

Effects of air-entrainment.

→ Improvement in workability.
→ Increased resistance to freezing and thowing.
→ Reduction in strength.
→ Reduces tendency of segregation and bleeding.
→ Reduces the permeability.
→ Reduces cement content and heat of hydration.
→ Reduction in unit weight of concrete.
→ Reduces alkali-aggregate reaction.
→ Increase in resistance to chemical.

(6) Pozzolanic Admixtures

→ Pozzolans when added to concrete mixes, rather than substituted for a part of the cement, improve workability, impermeability and resistance to chemical attack.

→ The overall effect depends on the aggregate used in concrete.

→ The aggregate deficient in fine material give the best result.

Advantages

→ Improved workability with lesser amount of water.

→ Reduction in heat of hydration.

→ Increase resistance to the action of salt, sulphate or acid water.

→ Prevention of $Ca(OH)_2$ leaching.

→ Reduce alkali-aggregate reaction.

→ Increase watertightness

→ Lower costs.

(7) Grouting Admixtures

→ Sometimes grout mixtures will be required to set quickly and sometime grout mixtures will have to be in fluid form over a long period.

→ Various admixtures used for grouting purpose use.

- Accelerators
- Retarders
- Plasticizers
- Gas forming agents
- Workability agents.

④ Air-Detraining Admixtures -

Used

- Dissipate excess air or other gases from plastic concrete.
- Remove a part of the entrained air from a concrete mixture.

materials

- Tributyl phosphate
- Dibutyl phthalate
- Water soluble alcohols
- Silicons.

⑤ **Bonding Admixtures**

- When fresh concrete is placed over an old concrete surface, the fresh concrete shrinks while setting which makes the new concrete pull away from the old concrete surface.
- The commonly used bonding admixtures are made from natural rubber, synthetic rubber or from any organic polymers.

⑥ Water proofing Admixtures.

- The leakage of roofs, bathroom, toilets, walls, Kitchen, water tanks, basements etc is still a headache for civil engineers.
- Waterproofing depends upon the quality of materials durability of materials, workmanship, environments.
- Water proofing admixtures may be obtained in powder, paste or liquid form.
- There are two type materials available namely, pore filling and water repellent materials.

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CH - 6 Hardened Concrete

→ In quality control of cement concrete works, testing of hardened concrete plays an important role.

→ The main purpose of testing hardened concrete is to confirm that the concrete used at site has developed desired strength.

→ Planned testing of cement, sand, aggregates, fresh concrete and hardened concrete is helpfull in assuring the performance of the concrete with regard to both strength and durability of concrete.

* Purpose of testing hardened concrete.

→ To confirm that the concrete used at site has developed desired strength.

→ To control the quality of concrete.

→ Compression strength test gives compressive strength of concrete.

→ Compressive strength of concrete is required for structural design.

→ Bond between steel and concrete is studied by bond strength test.

→ The efficiency of concrete depends upon it's bond strength.

→ Due to shrinkage, corrosion of reinforcement, temperature changes etc. tensile stresses are developed in concrete. Hence, tensile strength test of concrete is necessary.

* Various tests for hardened concrete.

① Compression test.

② Tensile strength test.

- split cylinder test
- Modulus of rupture test

③ Bond strength test.

* Factors affecting strength of concrete.

① shape and size of specimen.

② End condition of specimen and capping.

③ Rate of application of load.

④ Height/Diameter ratio

⑤ Moisture condition during test

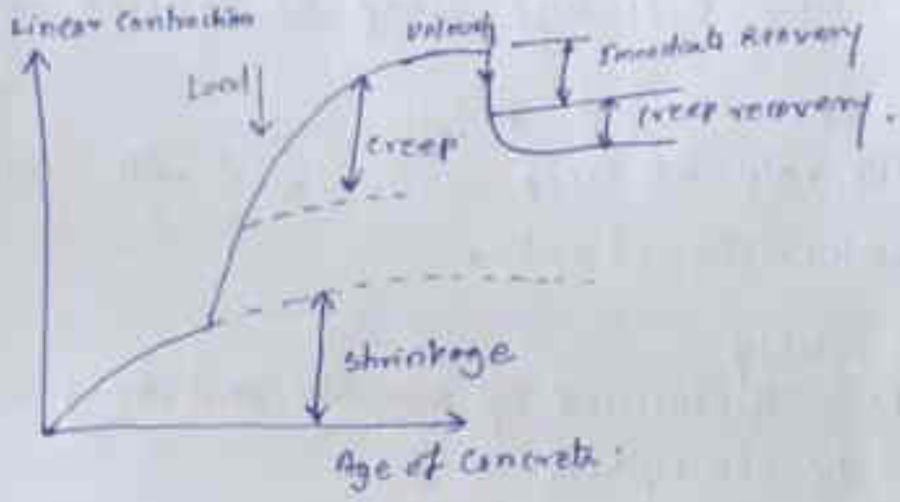
⑥ Largest size of aggregate

⑦ Temperature of the specimen.

* Creep :-

→ The increase of strain in concreti with time under sustained (stable) stress is termed as creep

→ It can be defined as the elastic and long-term deformation of concreti under a continuous load.



→ Generally, ~~a long-term deformation of concreti under a continuous load~~

→ Generally, a long term pressure changes the shape of concreti structure and the deformation occurs along the direction of the applied load.

→ When the continuous load is removed, the strain is decreased immediately.

→ The amount of the decreased strain is equal to the elastic strain at the given age.

→ This quick recovery is then followed by a continuous decrease in strain, known as creep recovery that is a part of total creep strain suffered by the concreti.

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* creep coefficient

:- The ratio of the ultimate creep strain to the elastic strain at the age of loading is termed as creep coefficient.

* Factors affecting creep of concrete:

① water-cement Ration

→ The rate of creep is increased with increasing water-cement ratios

② Humidity

→ It in influenced by humidity and drying condition of the atmosphere.

③ Age of Concrete:

→ The rate of creep rapidly decreases with time. The time taken by a concrete structure to attained creep is 5 years

④ Aggregate:-

→ Aggregates with moisture movement and low elastic modulus cause a large amount of creep.

→ The rate of creep generally decreases with the increase of the size of aggregate.

⑤ Admixtures

→ Some admixtures (mainly accelerators) are also responsible for causing creep in concrete.

* Effects of Creep

→ In reinforced concrete beams, creep increases the deflection with time and may be a critical consideration in design.

→ In reinforced concrete columns, creep results in a gradual transfer of load from the concrete to the reinforcement.

→ In statically indeterminate structures, creep may relieve stress concentrations induced by shrinkage, temperature changes or settlement of supports

→ In mass concrete, creep in itself may be a cause of cracking when restrained concrete mass undergoes a cycle of temperature change due to the developedent of the heat of hydration and subsequent cooling.

→ In case of prestressed concrete, creep reduces prestress and provision is made for the loss of prestress in the design of such structures.

* Quality Control :—

In the design of reinforced concrete, the strength of concrete is specified by the designer.

→ The variation in quality of concrete depends upon the several factors.

* Variation in the quality of constituent materials.
* Variation in the mix proportions due to batching process.
* Variation in the quality of batching and mixing equipmen
* The quality of overall workmanship supervision at si

→ The main aim of quality control is to reduce the variations in quality of concrete to fulfil the needs of serviceability, safety and durability.

* Stages in quality control:

→ The quality control is exercised during the following three stages of construction.

① Preparatory to construction.
② During construction.
③ After construction.

① Preparatory to construction:-

During preparatory stage the quality control involves:

(i) Specification of concrete quality.
(ii) Strength and workability requirements
(iii) Initial and detailed testing of materials for the approval of sources.
(iv) Obtaining mix design data for controlled concrete from a central laboratory.
(v) Aggregate grading and absorption.
(vi) Mix proportion and w/c ratio
(vii) Setting up a field laboratory for controlled concrete.
(viii) Inspection for approval of batching and mixing facilities.

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② During construction

→ During construction, the exercise involves.

(i) Testing of materials for concrete - tests and their frequency.

(ii) controls and adjustments for aggregate grading, moisture content, bulking sand etc.

(iii) control and adjustments for maintaining constant workability and strength.

(iv) control on concreting operations - mixing, transporting, placing, compacting, finishings etc.

③ After construction

(i) controlled curing for specified period.

(ii) Interpretation of cube strength results and the assessments of concrete.

(iii) Non-destructive testing.

* Advantages of Quality control.

→ Locally available materials and resources are used after testing their characteristics, results in the reduction in the material cost.

→ In the absence of quality control at the site the designer is tempted to overdesign, so as to minimize the risks. This adds to the overall cost.

→ check at every stages of the production of concrete and rectification ~~and~~ of the faults at the right time expedities completion and reduces delay in construction.

→ Quality control reduces the maintenance costs.

→ It provides long term benefits like safety and serviceability.

* Common Terminologies

(1) Mean strength ($\bar{x}$)

$$\bar{x} = \frac{\Sigma x_i}{n}$$

where,

$\bar{x}$ = mean strength

Σx_i = sum of strength of all cubes

n = number of cubes

(2) Variance = $x_i - \bar{x}$

→ This is the measure of variability or difference betn any single observed data from the mean strength.

(3) **Range** :- The range is the difference between the Largest and the smallest values in a set of observations.

(4) Standard deviation (s):

$$s = \sqrt{\frac{\Sigma (x_i - \bar{x})^2}{n-1}}$$

where, s = standard deviation

x_i = particular value of observation

$\bar{x}$ = mean strength

n = no. of cubes.

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(5) Coefficient of variation (V):

$$V = \frac{S}{\bar{X}} \times 100$$

IN-SITU STRENGTH ASSESSMENT

→ The purpose of in-situ testing of concrete are:

1. Assessment of structural integrity following material deterioration by overload, fire, blast, fatigue, earthquake etc.
2. Proposed extension of structure.
3. Change of usage of structure.
4. Acceptability of structure for purchase or insurance.
5. Monitoring long-term changes in material properties.
6. Assessment of cause and extent of deterioration for repair.

In-situ methods of testing

Non-Destructive test (NDT)

1. Surface hardness test
2. Rebound hammer test
3. Ultrasonic pulse velocity test
4. Radioactive methods
5. Nuclear methods
6. Magnetic methods
7. Electrical methods

Partially-destructive tests

1. Pull-out testing
   - (i) Cast-in method (Lok-test)
   - (ii) Drilled-hole method (Capo-test)
2. Pull-off test
3. Penetration resistance test.

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* Rebound - Hammer test.

→ Theory :- The test is based on the principle that the Rebound of an elastic mass depends on the Hardness of the surface upon which is impinges and in this case will provide information about a surface layer of the concrete.

→ The results give a measure of the relative hardness of the corresponding tested zone.

Procedure :→ The reading is very sensitive to local variations of concrete especially aggregate particles near to the surface.

→ It is recommended to take several reading at each test locations by marking grids and to find their average

method of testing :- Rebound hammer will be used on the concrete surface at five different positions for assessment of surface hardness and strength estimation. At site depending on the avalability of exposed surface of concrete.

(a) Horizontal

(b) Vertically upwards

(c) Vertically downwards

(d) Inclined upwards

(e) Inclined downwards

* Factors influencing the test results.

(1) Mix characteristics like cement type, cement content.
(2) Smoothness of the surface under test.
(3) Type of coarse aggregate.
(4) Size, shape and rigidity of the specimen.
(5) Age of concrete
(6) Moisture condition of the concrete
(7) Carbonation of concrete surface
(8) Type of mould.

* (1) Durability :- Durability is defined as its ability to resist weathering action chemical attack, abrasion or any other process of deterioration, that is durable concrete will retain its original form, quality, and serviceability when exposed to its environment

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* Factors affecting Durability:-

The factors affecting durability are broadly divided into two groups, namely external factors and internal factors.

External factors	Internal factors
→ Physical, chemical or mechanical	→ Permeability of concrete.
→ Environmental, such as extreme temperatures, abrasion and	→ Alkali aggregate reaction
→ Attack by natural or industrial liquids and gases.	→ Volume changes due to difference in thermal properties of the aggregate and cement paste.

* Requirement for Durability.

→ Exposure conditions
→ Requirement of concrete cover
→ shape & size of member
→ Type and quality of constituent material
→ compaction, finishing and curing of concrete.

* Permeability of concrete :-

It is defined as the property that governs the rate of flow of a fluid into a porous solid (concrete).

* Importance of permeability.

→ In reinforced concrete, ingress of water and air will result in corrosion of steel leading to expansion, cracking and disruption of concrete.

→ The penetration of deleterious materials in solution may adversely affect the durability of concrete eg- $Ca(OH)_2$ leaches out and aggressive liquids attack ~~of~~ the concrete.

→ If concrete becomes saturated with water due to permeability, it is more vulnerable to frost action.

→ The permeability is very important in case of liquid retaining structures like water ~~[illegible]~~ ~~[illegible]~~ tanks and dams where water-tightness is necessary.

* Factors affecting permeability.

→ Water/cement ratio

→ Properties of cement

→ Aggregate.

→ absorption and homogeneity of concrete

→ Curing

→ Use of admixtures

→ Age of concrete