DIPLOMA IN CIVIL ENGINEERING

CONCRETE TECHNOLOGY – STUDY NOTES

MODULE I

1. **What is cement? What are its important properties?**

   Any material that can acts as a binding agent for materials.

   - Have good Adhesive and cohesive property
   - On adding water → Hydration takes place
   - Initial setting time for OPC = 30 minutes
   - Final setting time for OPC = 10 hours/600 minutes
   - Normal consistency = 26 -33 %

2. **List types of cement and explain briefly?**

   Various types of cement used are:

   1. Ordinary Portland Cement (OPC)
      - 33 Grade, 43 Grade, and 53 Grade – 33 = f_{ck}
   2. Rapid Hardening cement (RHC)
      - Develop early strength – 3 days (OPC – 7 days)
      - High C_3S content, Low C_2S content.
      - Higher fineness
      - Uses: **Prefabricated constructions, road repair works, cold weather**
   3. Extra Rapid Hardening Cement
      - RHC + $CaCl_2$ (by 2 % weight of RHC)
      - Mixing, placing, compaction and finishing within 20 minutes
      - Storage time – 1 month
      - Not discussed in IS Code
      - Uses: Cold weather, **under water concreting**
   4. Sulphate Resisting Cement
      - To resist sulphate attack
      - Volume of concrete increases due to reaction of cement with sulphate containing solution.
      - Ca(OH)2 + CaSO4 → Volume increases by 227 %
      - Uses: **Marine structures, foundations, sewage treatment units, hydraulic structures**
   5. Portland Slag cement
      - Slag = OPC clinker + Blast furnace slag + Gypsum
      - Resistant to chemical attacks:
        Sulphate attack, Acid attack, Alkali attack, Chlorides attack
      - Reduced permeability
      - Uses: Mass concreting, dams, etc
   6. Quick setting cement
      - Quick setting property

7. Super Sulphated cement
8. Low heat cement
9. Portland Pozzolano Cement (PPC)
    - OPC Clinker + Pozzolanic material (15-35%)+ Gypsum → PPC
    - OPC + $Ca(OH)_2$ + Water → C-S-H gel (Calcium-Silicate-Hydrate)
    - PPC gives increased volume than OPC
    - Pozzolanic material is cheaper
    - Long term strength higher than OPC
    - Disadvantage - Reduced alkalinity leads to corrosion
    - Disadvantage – Initial development of strength is slower than OPC
10. Air Entraining cement
11. Coloured cement/White cement
12. Hydrophobic cement
13. Masonry Cement
14. Expansive cement
15. High Alumina Cement
16. Very High Strength Cement
    - Used in prestressed concrete works

3. What are the functions of cement ingredients? Explain.

Ingredients in concrete and functions:

1	Lime	CaO	60-67 %	• Controls strength and soundness
2	Silica	SiO_2	17-25 %	• Excess cause low setting time
3	Alumina	Al_2O_3	3-8 %	• Imparts quick setting property
4	Iron Oxide	Fe_2O_3	0.5-0.6	• Colour
5	Calcium Suplhate	$CaSO_4$	1-3 %	• Regulate setting time
6	Magnesia	MgO	0.1-4 %	• Imparts hardness and colour
7	Sulphur	SO_3	1.3 - 3 %	• Excess makes the cement unsound
8	Alkalies	K_2O Na_2O	0.4-1.3 %	• Excess cause efflorescence

4. Explain the methods of storing cement.

Methods of storing cement:

1. Jute or gunny bags
2. Storage period = 3 months
3. Stacked in 10 bag piles
4. Care to maintain quality – no moisture content
5. Remove cement bags in order
6. Label – date of receipt – to find age of cement
7. Use waterproof shed/polyethylene during monsoon.

5. What are the functions of alumina in cement?

- Imparts quick setting property to the cement.
- It acts as a flux and it lowers the clinkering temperature.
- Excess alumina weakens the cement.

6. **What is heat of hydration? How the heat of hydration affects in mass concreting?**
   - Chemical reaction between cement and water → HYDRATION
   - **Stages of hydration:**
     1. Loss of workability
     2. Setting (Solid → Concrete)
     3. Hardening (Strength gain)
   - EXOTHERMIC REACTION → Liberates considerable quantity of heat.
   - The heat produced during the chemical reaction of cement with water is termed as HEAT OF HYDRATION.

   Mass concreting and heat of hydration:

   - Large amount of heat is produced during first few days of mass concrete works. Eg: Dam.
   - Max temperature within 1-3 days.
   - Heat is trapped and cannot escape quickly.
   - Results in thermal cracking.
   - Concrete mix becomes too hot.

7. **Explain the chemistry of hydration of cement**

   Cement + Water → C-S-H gel + Heat

   Bougue's compounds:

Compund	Compound Name	Chemical formula
C_3S	Tri-Calcium Silicate	$3\ CaO.SiO_2$
C_2S	Di-Calcium Silicate	$2\ CaO.SiO_2$
C_3A	Tri-Calcium Aluminate	3 CaO.Al2O3
C_4AF	Tetra-Calcium Alumino Ferrite	$3\ CaO.Al_2O_3.Fe_2O_3$

Reaction of Bougue's compounds:

$$2\ C_3S + 6\ H \rightarrow C_3S_2H_3 + 3\ Ca(OH)_2 + \Delta_{(heat)}$$

$$2\ C_2S + 4\ H \rightarrow C_3S_2H_3 + Ca(OH)_2 + \Delta$$

$$2\ C_3A + 21\ H \rightarrow C_4AH_{13} + C_3AH_8 + 2C_3AH_6 + 9\ H + \Delta$$

$$C_4AF + 7\ H \rightarrow C_3AH_6 + CFH + 9\ H + \Delta$$

Reaction with gypsum:

$$C_3A + 32\,H + 3CaSO_4 \rightarrow \underset{\text{(Ettringe)}}{C_6AS_3H_2}$$

$$C_3A + 18\,H + CaSO_4 \rightarrow C_4ASH_{18}$$

8. **Write the functions of hydrated compounds such as C_3S, C_2S and $Ca(OH)_2$.**

$2\,C_3S + 6\,H \rightarrow C_3S_2H_3 + 3\,Ca(OH)_2 + \Delta(\boldsymbol{heat})$

$2\,C_2S + 4\,H \rightarrow C_3S_2H_3 + Ca(OH)_2 + \Delta$

C_3S → Early strength contribution

C_2S → Final strength contribution

$Ca(OH)_2$ → Breakdown of Portland cement

9. **Explain the field tests for cement?**

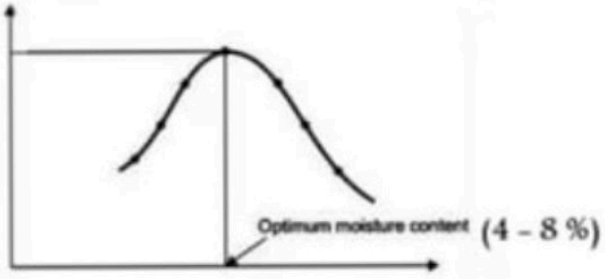
Field tests of cement:

- Open the bag and take a good look at the cement - no visible lumps.
- Colour = Greenish grey
- Should get a cool feeling when thrusted
- When we throw the cement on a bucket full of water, before it sinks the particle should flow

10. **What is mean by bulking of sand?**

Increase in volume of fine aggregates due to presence of water (moisture content)

- Fine sand bulks more than coarse sand.
- Coarse aggregate does not bulk



$$\%\ \text{bulking} = \frac{V - Va}{V_a}$$

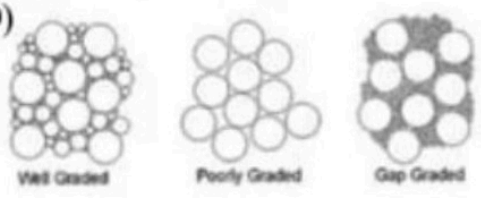
When water is added to dry sand, a film forms around each sand particle. Thus volume increases. When more water is added, the water films break and thus volume decreases. The volume of dry sand increases due to absorption of moisture. This is called as bulking of sand.

11. **Differentiate between uniform grading and gap grading.**

Poorly graded → All particles of aggregate have same size – more voids

Well graded → Contains particles of all sizes (GOOD)

Gap graded → Some big, some small particles.



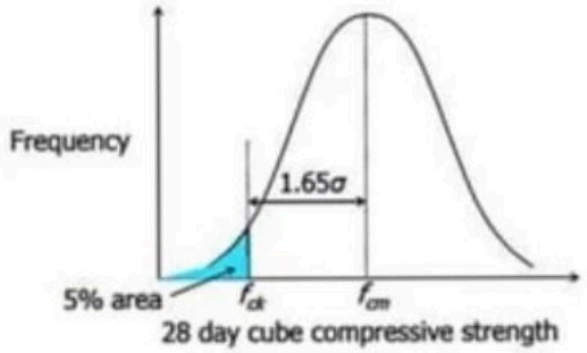
12. What is characteristic compressive strength?

Compressive strength is imp property of hardened concrete.

Compressive strength is given in terms of characteristic compressive strength of 150 mm size cubes tested at 28 days.

Defined as strength of concrete below which not more than 5 % of test results are expected to fall [IS 456:2000].

Follows NORMAL DISTRIBUTION



13. Write a note on sulphate resisting Portland cement and low heat Portland cement?

Sulphate Resisting Portland Cement:

- Resistant to sulphate attack
- low C3A content (5 % only)
- Has high silicate content □ High sulphate resisting ability

Uses: Sewage treatment works, marine structures

Low heat cement:

- Low C3S and C3A
- Slow rate of gain of strength
- Same ultimate strength of OPC

Uses: Dams, mass concrete works

14. Name any four mineral admixtures using for blended concrete?

- Blended concrete = OPC + Mineral admixtures
- Mineral admixtures – Hydraulic/ pozzolanic activity
- To make concrete economical

Examples for Mineral admixtures

- Fly ash
- Silica fume
- Rice Husk Ash
- Metakaolin
- Ground granulated blast furnace slag (GGBFS)

15. Name any four admixtures using for concrete mixes?

Chemicals added to concrete before or during mixing of concrete to modify some specific property of fresh or hardened concrete.

Examples are :-

1. Super plasticizer
2. Accelerators
3. Retarders
4. Air entraining admixtures
5. Water-reducers

16. Write a note on (i) Admixtures (ii) Accelerators (iii) Retarders

Admixtures:

- Chemicals added to concrete before or during mixing of concrete to modify specific property of fresh or hardened concrete.
- Available in powder and liquid form.
    1. Accelerating admixtures
    2. Retarding admixtures
    3. Water reducing admixtures
    4. Air Entraining admixtures

Functions of admixtures:

- Speed up rate of development of strength at early days
- To keep the concrete workable for longer time
- To enhance the workability
- To improve penetration and pump ability of concrete
- To reduce segregation
- To increase strength
- To decrease capillary flow of water
- To control alkali aggregate reaction
- To reduce the heat of hydration
- To enhance bond between concrete and steel
- To reduce weight of concrete, etc.

Accelerators:

- A type of admixture
- Increase rate of hydration of cement
- Reduce setting time
- Increase rate of strength development. Eg:- Na_2SO_4, NaCl, K_2SO_4, $CaCl_2$

Retarders:

- To delay or reduces the setting time
- Slow rate of hydration
- Helpful – concrete transporting to long distance
- Eg:- Derivatives of Sugar and carbohydrates, gypsum, plaster of paris, etc

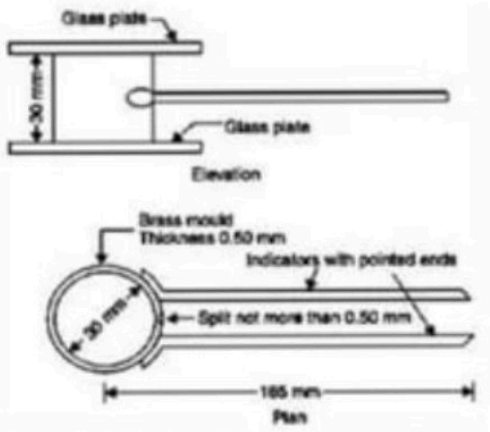
17. What is soundness of cement? How is it tested?

Soundness test: Ability of hardened cement paste to retain its volume after setting without expansion.

Reason: insufficiency in grinding, burning, etc.

Ensures: Cement does not undergo any large expansion and To detect the presence of excess lime in cement.

Take a sample of 100 grams. → Paste 0.78 x P → Cover with glass sheet →



Fill in Le chatelier apparatus

↓

Immerse in water, 24 hrs, 27°C

↓

Note the distance b/w pointers before boiling – d1

← Boil 3 hrs – reach boiling point within 25-30 minutes

← Cool Note the distance b/w pointers after boiling – d2

↑

$$\text{Expansion} = d_2 - d_1$$

- Expansion should be less than 10 mm
- OPC – Ordinary Portland Cement
- RHC – Rapid Hardening Cement
- Low Heat Portland Cement
- If expansion of cement > 10 mm
  - Unsound
  - Excess lime → Cracks

18. Explain the classification of aggregates?

classification of aggregates

Geological origin	Size	Shape	Unit weight
1.Natural aggregates • Igneous • Sedimentary • Metamorphic 2.Artificial aggregates • Blast furnace slag	1.Coarse > 4.75 mm 2.Fine < 4.75 mm	1.Rounded 2.Irregular 3.Flaky 4.Angular	1.Normal weight 2.Heavy weight 3.Light weight

19. Write any six tests for coarse aggregates which determine the properties required for mix design.

1. Aggregate crushing strength
2. Aggregate impact test
3. Abrasion test
4. Flakiness test
5. Elongation test
6. Sieve Analysis

MODULE II

1. Define concrete and write down its properties?

- Concrete is a composite mixture of CA + FA + water + Cement + Admixtures
- Unit weight = 25 kN/m^3.
- Compressive strength: M20 : M→Mix, 20→ Compressive strength
- Flexural strength, $f_{cr} = 0.7\sqrt{fck}$
- Elastic deformation, $E_c = 5000\sqrt{fck}$

2. What are the ingredients of concrete and their fucntions?

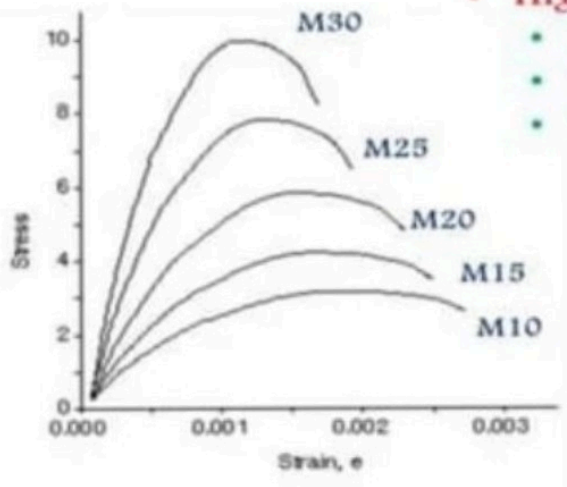
Cement	- Binding material
Coarse aggregate	- Strength contribution
Fine aggregate	- Void filler
Water	- Hydration, workability, curing
Admixtures	- to modify any specific properties.

3. Write the functions of sand in mortar.

Functions of sand in mortar:

- Void filler
- Bulking – Sand bulks → volume of mortar increases → Thus cost reduced.
- Setting – setting of fat lime occurs effectively due to sand.
- Shrinkage – sand prevents excessive shrinkage of mortar and prevent cracking.
- Strength – helps in adjustment of strength by varying its proportion.

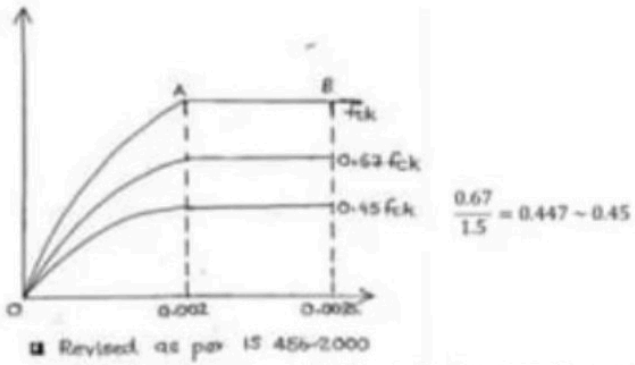
4. Explain the stress strain characteristics of concrete?



- Higher the concrete grade
  - Steeper is the initial portion
  - Sharper the peak of curve
  - Less failure strain

Max compressive stress = 0.67 x characteristic cube strength

Design stress-strain curve of concrete:



Revised as per IS 456-2000

5. **What is segregation in concrete? How it is prevented?**

Separation of constituent materials of concrete mix so that the mix is no longer in homogenous condition. Types:

- CA separating out / settling down from mix
- Paste separating out away from CA

Prevention:

- Concrete mix should be properly designed with optimum quantity of water
- Field quality control must be maintained while handling, transporting, placing & compacting and finishing concrete.
- If at any stage segregation is observed, then remixing should be done to make the concrete again homogeneous.
- Admixtures, such as pozzolanic materials or air entraining agent should be used to avoid segregation
- Concrete should not be allowed to fall from greater heights. It should be placed as near its final position as possible.

6. **What is curing? What is the necessity of curing?**

Process of preventing the loss of moisture from the concrete whilst maintaining a satisfactory temperature.

Reasons to cure concrete

- Gain of strength in concrete by hydration
- Improved durability of concrete
- Improved serviceability and to improvement in microstructure of concrete
- To avoid loss of moisture, curing is required
- Prevents concrete from cracking

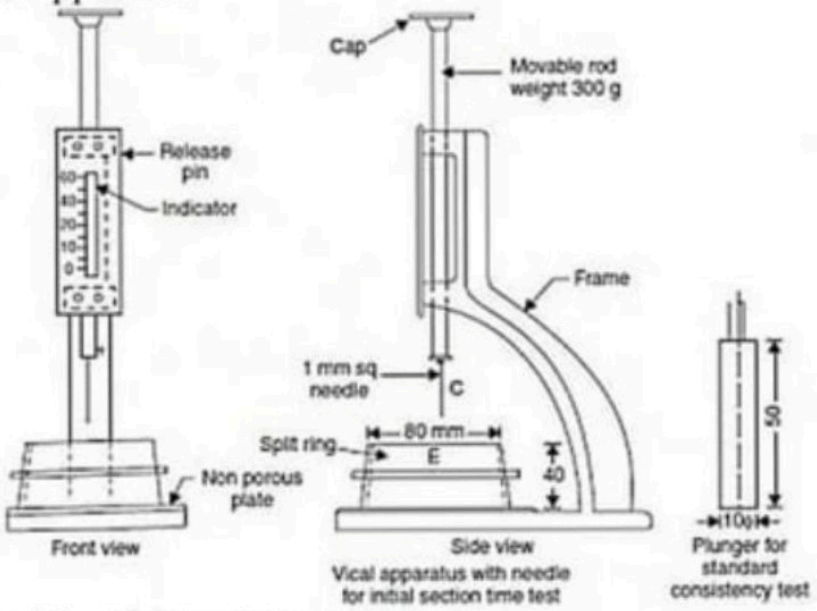
Methods of curing

- Ponding
- Sprinkling
- Wet coverings
- Membrane/Plastic sheet curing
- Steam curing

- Water based curing

7. How is the consistency of cement paste tested?

- Consistency refers to the relative mobility of a freshly mixed cement paste or mortar or its ability to flow.
- The property of holding together and retaining shape.
- Consistency which will permit a vicat plunger to penetrate a depth of 33-35 mm from top of the mould.
- Measured using Vicat Apparatus.



Procedure:

- Take 400 g cement
- Add 25 % water by weight of dry cement
- Make a paste and fill in the vicat mould.
- Release the vicat needle and measure penetration.
- Note the water content added when vacat penetrates 33-35 mm.
- Generally normal consistency for OPC ranges from 26 to 33%.

8. What is super plasticizer? When and where super plasticizers are used?

- A type of water reducing admixture.
- Also called as High range water reducer.
- Increased fluidity : flowing, self levelling, etc.
- Reduced water cement ratio: High early strength.

Commonly used superplasticizers are:

- ✓ Sulphonated melamine formaldehyde condensates (SMF)
- ✓ Sulphonated naphthalene formaldehyde condensates (SNF)
- ✓ Polycarboxylate ether superplasticizers (PCE)

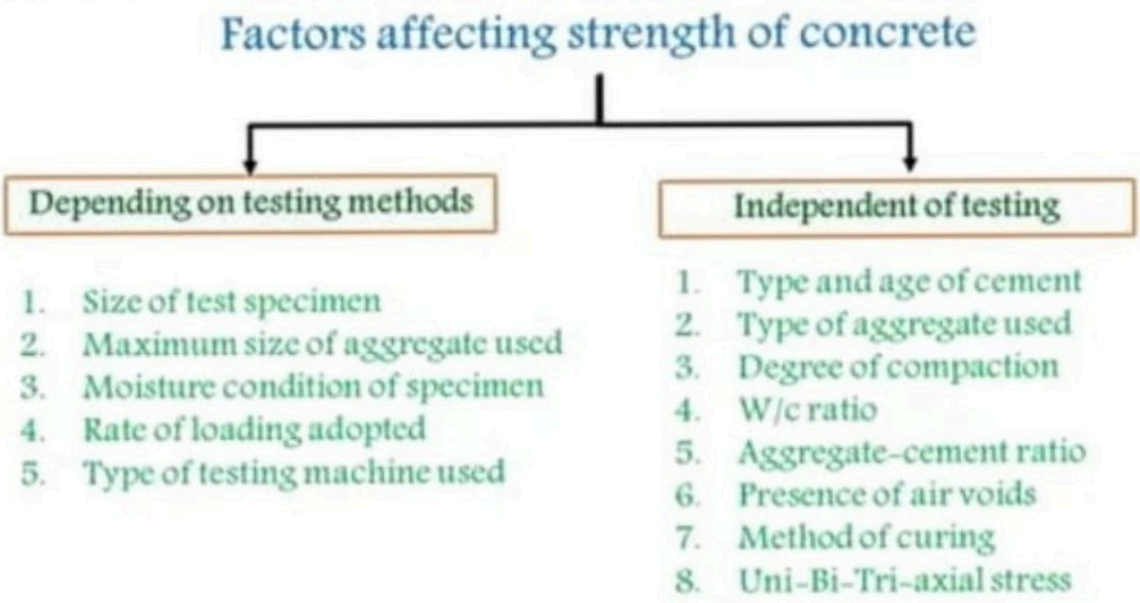
9. What are the methods of transporting concrete?

Transporting and placing is done using:

- Mortar pan
- Wheelbarrows and Buggies
- Belt Conveyors, Cranes and Buckets
- Pumps and Transit Mixer
- Truck mixer and dumper

- Chutes, Pumps and pipelines
- Helicopter.

10. What are the factors affecting strength of the concrete?



11. What are the tests for measuring workability of concrete?

Workability of concrete is measured using

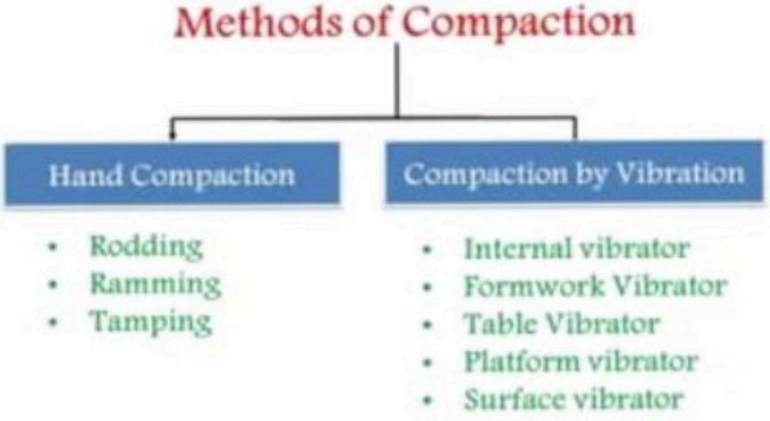
- Slump test
- Compaction factor test
- Vee-bee consistometer test
- Flow test

12. Discuss briefly about various methods of compacting concrete?

To expel entrapped air from the concrete.

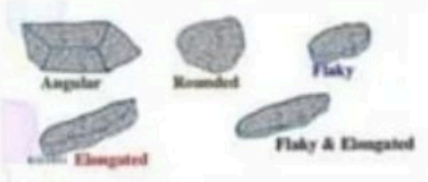
1% air in the concrete approximately reduces the strength by 6%.

If we don't expel this air, it will result into honeycombing and reduced strength.



13. Explain the flakiness index and elongation index.

Flakiness Index: % by weight of particles whose least dimension (thickness) is less than 3/5 (0.6) of their mean dimension.



Elongation Index: % by weight of particles whose greatest dimension (length) is greater than 1.8 times their mean dimension.

The Indian Standard do not specify limits for flakiness index and elongation index but generally flakiness index shall not exceed 40 % and the elongation index shall not exceed 15 %.

14. Explain the role of water cement ratio in the strength of concrete.

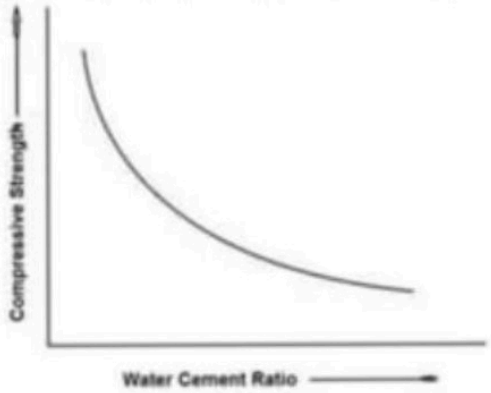
Water-cement ratio: Ratio of mass of 'free water' (excluding that absorbed by aggregates) to cement in a mix.

$$\text{w/c ratio} = \frac{\text{Volume of water}}{\text{Volume of cement}}$$

- Range: 0.35 – 0.65
- Most important indicator of strength.
- Low w/c ratio → Higher strength
- Low w/c ratio is good

Abram's Law :

Water-cement ratio is inversely proportional to compressive strength of concrete.



15. Explain the test for alkali aggregate reaction in concrete.

Alkali-aggregate reaction

- Known as 'Concrete Cancer'.
- Expansion of concrete → Volume increases → Swelling/Bulging → Cracks forms → Strength reduces

Factors affecting Alkali-aggregate reaction:

- High alkali content in cement.
- Reactive silica or carbonate in aggregates.
- Availability of moisture.

- Temperature = 350C.

Remedial measures:

- By using low alkali content cement.
- Selecting non reactive aggregates.
- By controlling moisture and temperature.
- By using pozzolanas, slags, silica fumes, etc.
- By using air entraining agents

16. Explain the factors affecting workability of concrete. Explain

Property of freshly mixed concrete which determines the ease and homogeneity with which it can be mixed, placed, compacted and finished.

It is the ability of concrete to flow and work with concrete.

Property of concrete which determines the amount of useful internal work necessary to produce full compaction.

Factors affecting Workability of concrete

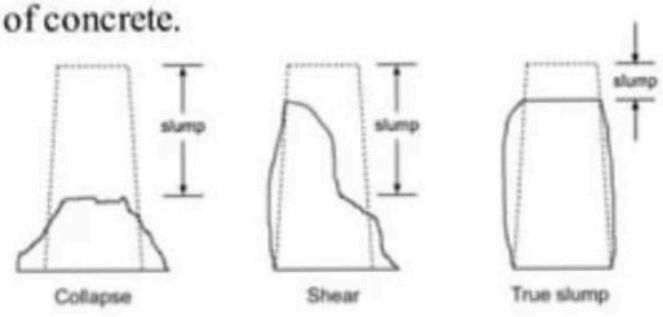
- Influence of mix proportion
  - Amount of water, aggregates, admixtures, etc
- Influence of aggregate properties
  - Specific surface area (SSA), shape and size, etc
- Influence of admixtures
  - Plasticizers, super plasticizers, etc
- Effect of Environmental conditions
  - Temperature, freezing, thawing, etc
- Effect of time – Evaporation

In short, factors affecting are

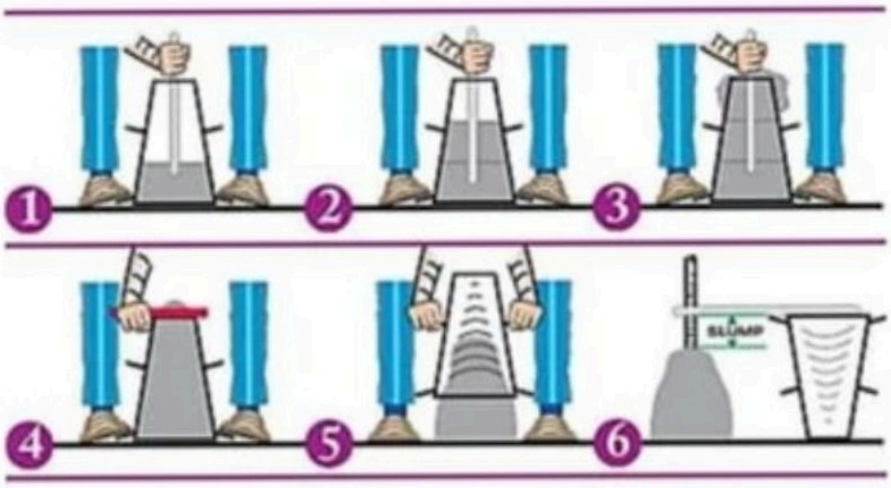
- Cement content
- Water content
- Mix proportions
- Size of aggregates
- Shape of aggregates
- Grading of aggregates
- Surface texture of aggregates
- Use of admixtures in concrete
- Time and environmental conditions

17. Explain slump test? What are the different types of slump?

- Test to determine workability of concrete.
- Field and lab test.
- Types of slump
  - True slump
  - Shear slump



- Collapse slump



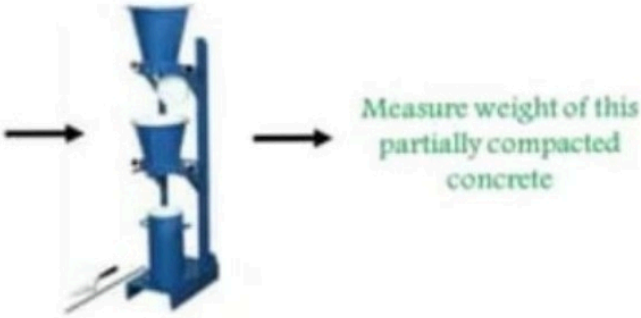
Procedure:

- Prepare mix and fill slump cone.
- Layer 1= 25 tamping
- Layer 2 = 25 tamping
- Layer 3 = 25 tampngs
- Cut the excess concrete and level the top
- Take the slump cone
- Measure the slump : Max = 300 mm

18. How compaction factor test is conducted?

Test to determine workability of concrete.

Field and lab test



Procedure:

- Prepare mix
- Fill in HOPPER A
- Open trap door → Mix falls to HOPPER B
- Open trap door → Mix falls to CYLINDER
- Weight it → Weight of partially compacted concrete.
- Remove all concrete from cylinder – EMPTY IT
- Again fill the cylinder from same sample mix
- Fill in 3 LAYERS – 25 Tampings with tamping rod
- Weight it → Weight of fully compacted concrete

$$\text{Compaction Factor, C.F} = \frac{\text{Weight of partially compacted concrete}}{\text{Weight of fully compacted concrete}}$$

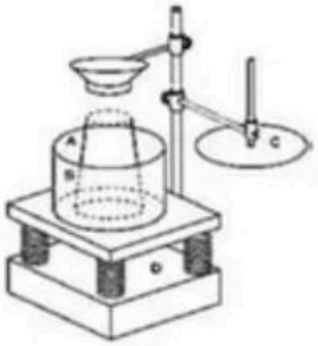
19. Explain vee-bee test?

To determine workability of concrete → Indirectly.

Lab test

Procedure:

- Slump cone placed inside cylinder
- Swivel glass is turned & placed on slump cone
- ON the vibrator + Start stop watch
- Conical shape of slump disappears → Flat
- OFF the stop watch
- The time taken is noted → Vee bee seconds



20. Explain the factors influence the durability of concrete.

Durability:

- Time for which the structure can fulfil its desired objectives.
- Ability to withstand the damaging effects over a long time.
- Resistance to deterioration.
- Deterioration may be due to internal or external factors.
- Internal factors are - b/w constituent materials and contaminants.
- External factors – interaction with environment.

Factors affecting durability:

- Permeability
- Frost action
- Suplhate attack
- Mineral oils
- Organic acids
- Vegetables & animal oils and fats
- Sugar
- Sewage
- Thermal effects on concrete
- cracks

21. What are the advantages and disadvantages of super plasticizer in concrete?

Advantages:

- Significant water reduction.
- Reduced cement contents and Increased workability.
- Reduced effort required for placement.
- More effective use of cement.
- More rapid rate of development of strength.
- Increased long term strength and Reduced permeability.

Disadvantages:

- Additional admixture cost

- Slump loss greater than conventional concrete.
- Modification of air entraining dosage.
- Less responsive with some cement.
- Mild decoloration takes place.

22. Describe the importance of quality of water used for concreting?

Functions of water in concrete:

- Potable water (drinking water can be used) is used in concrete.
- Amount of water controls Workability of concrete.
- Amount of water controls Hydration.
- Amount of water controls Curing.
- Affects strength of concrete.
- Affects shrinkage of concrete.

23. What are tests on hardened concrete?

1. Compression test (cube & cylinder)
2. Flexural strength test
3. Split tensile strength test

24. Compare cylinder test and cube test in concrete compression.

Parameter	Cube Test	Cylinder Test
Size of test specimen	15 cm X 15 cm X 15 cm	15 cm ø X 30 cm height
Test condition	Non uniform tri-axial compression	Mono axial compression
Strength	More – 15 % greater	Less
Tested in	UTM/CTM	UTM/CTM

25. Define shrinkage and creep. What are the factors affecting shrinkage and creep?

Creep:

- Time dependent deformations of concrete under permanent loads.
- Time dependent strain due to self weight.
- Permanent deformation with time at constant loading.
- Plastic deformation (Permanent and non-recoverable).
- Homologous temp – temperature at which creep is uncontrollable.
- Continuous deformation of concrete with time under sustained load.

Shrinkage:

- Shortening of concrete due to drying (loss of moisture).
- Contraction due to loss of moisture.
- Evaporation of water from concrete mixture leads to loss of moisture.
- Plastic deformation (Permanent and non-recoverable).
- Homologous temp – temperature at which creep is uncontrollable.
- Continuous deformation of concrete with time under sustained load.

26. Explain briefly on the properties of hardened concrete?

Properties of concrete in the hardened state:

1. Strength
   - Resistance offered by concrete against failure
   - Primary design parameter
   - Strong in compression, weak in tension.
   - Types of strength: Compressive, tensile, shear, bond, impact and fatigue
   - Tensile strength = 10 % X Compressive stress
   - Bending strength = 15 % X Compressive strength
   - Shear strength = 20 % X Compressive strength
2. Stiffness
   - Resistance of concrete against deformation
   - Secondary design parameter
   - Rigidity of an object
3. Poisson's ratio
   - When a material is stretched in one direction, it tends to get thinner in other two directions.
   - Ratio of lateral strain to longitudinal strain

$$\mu = \frac{-\text{Lateral strain}}{\text{Longitudinal strain}} = \frac{\text{Transverse strain}}{\text{Axial strain}}$$

   - Normal concrete : 0.15 – 0.20
   - Found by:
     - Strain measurements
     - Ultrasonic pulse velocity method
4. Fatigue
   - Weakening of materials due to repeated cyclic loads
   - Due to repeated loading and unloading
   - If total accumulated strain energy exceeds toughness = FAILURE
   - Microscopic cracks develops where stress concentration occurs.
   - Life of the material decreases
5. Impact
   - Sudden loading on a material
   - High force or shock applied for a short time
6. Elasticity
   - When a force is applied, material deforms.
   - The property of a material to regain its original shape even after loading is termed as elasticity.
   - Concrete is not a perfectly elastic material
   - Modulus of elasticity of concrete is determined by cube test
7. Modular ratio

- Ratio of modulus of elasticity of steel to that of concrete
  - $m = \frac{\text{Modulus of elasticity of steel}}{\text{Modulus of elasticity of concrete}} = \frac{E_s}{E_c}$

8. Creep
   - Time dependent deformations of concrete under permanent loads
   - Time dependent strain due to self weight
   - Permanent deformation with time at constant loading
   - Plastic deformation (Permanent and non-recoverable)
   - Continuous deformation of concrete with time under sustained load
9. Shrinkage
   - Shortening of concrete due to drying (loss of moisture)
   - Contraction due to loss of moisture
   - Evaporation of water from concrete mixture leads to loss of moisture
10. Bond strength
    - Strength between rebar and concrete
    - Depends on surface configuration of rebar and concrete
    - Ensures there is no slip of steel bar from concrete
    - Develops primarily due to friction b/w rebar and concrete
    - In general, bond strength proportional to compressive strength
11. Durability
    - Time for which the structure can fulfil its desired objectives
    - Ability to withstand the damaging effects over a long time
    - Resistance to deterioration
    - Deterioration may be due to internal or external factors
    - Internal factors are - b/w constituent materials and contaminants
    - External factors – interaction with environment
12. Brittleness
    - Materials which fails suddenly
    - Opposite of plasticity
    - Breaks before it deforms
    - NOTE: Concrete is brittle

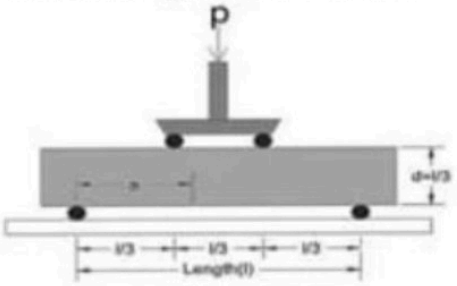
27. Describe compression test?

Procedure:

1. Prepare mix and fill in mould: 3 cubes – 15 X 15 X 15 cm
   or 3 cylinders – dia=30 cm, 60 cm
2. Mould removal – after 1 day
3. Curing – 3, 7, 28 days
4. Tested using UTM (Universal Testin Machine) /
   CTM (Compression Testing Machine)

$$\text{Compressive stress} = \frac{\text{Maximum load}}{\text{Area of cross section}}$$

28. Describe the test carried out to determine the flexural strength of concrete?

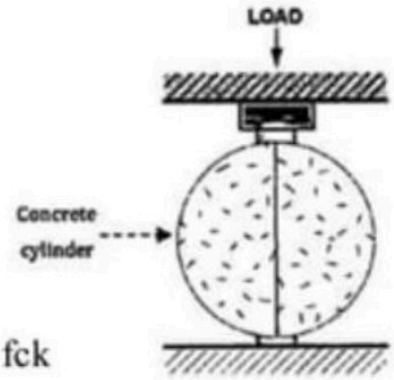


- To determine the tensile strength of concrete
- Flexural strength test procedure:
  - Prepare mix and fill in mould
  - Take Beam mould: 15X15X70 cm
  - Tamp using tamping bar
  - Test in Flexural testing machine
  - Loading rate = 400 kg/min
- Flexural strength or modulus of rupture (f_b)
  - $f_b = \frac{Pl}{bd^2}$ when a > 20 cm
  - $f_b = \frac{3Pa}{bd^2}$ when a < 20 cm and a > 17 cm

a - Distance b/w line of fracture and the nearer support

29. Explain split tensile strength of concrete?

- To determine tensile strength of concrete
- Diameter = 15 cm, Height = 30 cm
- Tested using UTM
  - Draw diametrical lines on two ends
  - Note weight and dimension of specimen
  - UTM → Plywood strips on either sides
  - Align the specimen
  - Apply load (Rate = 14-21 kg/cm2/minute)
  - Note breaking load
- As per IS 456, split tensile strength of concrete.= 0.7 fck



$$\text{Split tensile strength} = \frac{2P}{\pi DL}$$

30. What is bleeding in concrete?

- Appearance of water along with cement particles on the surface of freshly laid concrete.
- Tendency of water to rise to surface of freshly laid concrete.
- Particular form of segregation
- Reason : Water has low specific gravity than other contents
- Source: Over limit of compacting
- Quality and strength affected

31. Explain the methods of curing?

Curing :

- Process of preventing the loss of moisture from the concrete while maintaining a satisfactory temperature.

- Concrete gain strength by hydration.
- To avoid loss of moisture
- Prevents concrete from cracking

Reasons:

- Gain of strength in concrete
- Improved durability of concrete
- Improved serviceability
- Improvement in microstructure of concrete.

Methods:

- Ponding
- Sprinkling
- Wet coverings
- Membrane/plastic sheet
- Steam curing
- Water based

32. Explain the different modulus of elasticity of concrete.

Elasticity:

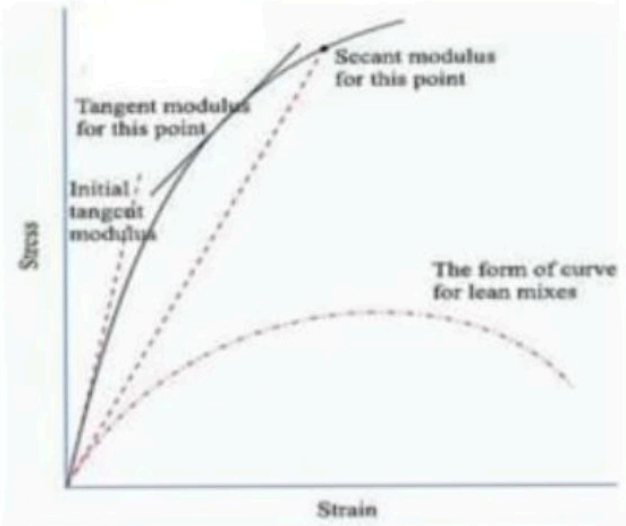
When a force is applied, material deforms.

The property of a material to regain its original shape even after loading is termed as elasticity.

Concrete is not a perfectly elastic material.

Modulus of elasticity of concrete is determined by cube test.

$$E_C = 5000\sqrt{f_{ck}}$$



- **Modulus of elasticity**: Slope of straight line portion of stress-strain diagram.
- **Initial tangent modulus** : Modulus drawn from the first tangent.

- **Secant modulus**: Slope of line connecting a specified point to the origin. Modulus of elasticity commonly used in practice is secant modulus

MODULE III

1. **What is concrete mix design? What are the various methods of mix design?**
   Mix Design is the art and science of determining the relative proportions of the ingredients of concrete to achieve the desired properties in the most economical way. To find a good combination of ingredients for concrete.

   Should satisfy the required specifications
   - Durability
   - Structural Strength
   - Workability – Mixing, placing, compacting and finishing.

   It should be economical.

   Methods of proportioning (Mix design):

   - IS Method
   - ACI Method
   - Road Note-4 Method
   - IRC-44 method
   - Arbitrary method
   - Max density method
   - Fineness modulus method
   - Surface area method
   - Mix design for high strength concrete
   - DOE mix design method

2. **Explain the ideas/choices behind the mix proportioning.**
   Principles of Mix Design (Design requirements):

   1. Grade of concrete
   2. Type of cement
   3. Type and Size of aggregates
   4. Nominal maximum size aggregate (m.s.a)
   5. Max/Min cement content (kg/m^3)
   6. Type of mixing and curing
   7. Max w/c ratio
   8. Degree of workability
   9. Air content
   10. Type of admixtures used
   11. Max/Min density of concrete
   12. Max/Min temperature of fresh concrete.

   } Selected appropriately

3. Define (i) Mean strength (ii) Variance and (iii) Standard Deviation

(1) Mean strength:

$$\text{Mean strength } (\bar{x}) = \frac{\text{sum of strength of all the cubes}}{\text{number of cubes}}$$

$$= \frac{\sum x}{n}$$

(2) Variance: Difference between any single observed data from the mean strength or deviation from mean value.

$$\text{Variance } (\sigma^2) = x - \bar{x}$$

(3) Standard deviation:

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

σ = Standard deviation,
n = number of observations
x = particular value of observations
$\bar{x}$ = arithmetic mean.

(4) Coefficient of variation:

$$v = \frac{\sigma}{\bar{x}} \times 100$$

4. What do you mean by target strength in concrete mix design.

5. Explain the relation between characteristic strength and target strength of concrete.

(Table 1, IS 10262:2009, page – 2)

$$\overline{f_{ck}} = f_{ck} + 1.65\ S$$

S – standard deviation

6. Write the steps involved in the mix design as per IS 10262:2009.

See IS 10262:2009 and write

A-1 Stipulations for proportioning
A-2 Test data for materials
A-3 Target strength for mix proportioning
A-4 Selection of water cement ratio
A-5 Selection of water content
A-6 Calculation of cement content
A-7 Proportion of volume of CA and FA content
A-8 Mix calculations
A-9 Mix proportions for trial no.1

A-10 Do if needed

A-11 Do if needed.

MODULE IV

1. What is special concrete?

Concrete prepared for specific purpose.

Eg:-

- Light weight
- High density
- Fire protection
- Radiation shielding

2. Compare ordinary and special concrete.

Characteristics	Ordinary concrete	Special Concrete
Density	2200 – 2600 kg/m³ High	300 - 1850 kg/m³ Low
Self weight	High	Less
Haulage and handling cost	High	Less
Thermal conductivity	High	Low
Uses	Building, bridges, etc	Nuclear reactor, acoustic buildings
Ingredients	C+S+A+W	+ LW aggregates
Cost	Economical	Costly

3. List various types of special concrete.

1) Light weight concrete
2) Air entrained concrete
3) High Strength concrete
4) High performance concrete
5) Polymer concrete
6) Geo Polymer concrete
7) Steel fiber reinforced Concrete
8) Sulpher concrete
9) Self compacting concrete
10) No-fines concrete
11) Pre-packed concrete
12) Guniting or shotcreting

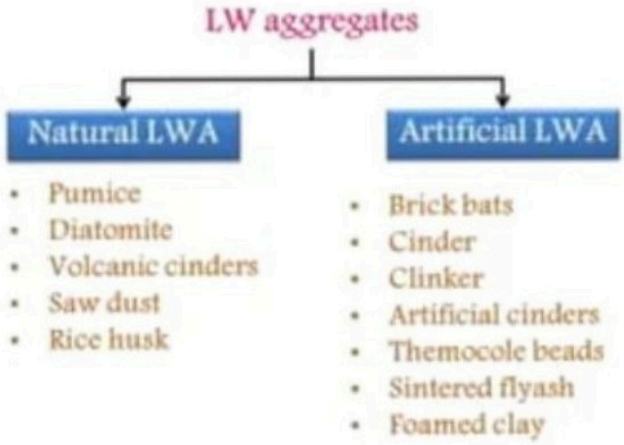
4. What is light weight concrete? Write advantages of light weight concrete?

Making concrete light weight by inclusion of air in concrete.

Three ways:

- Replace aggregate with cellular porous/LWA
  = **Light weight aggregate concrete**

- Introduce gas/air bubbles in concrete
  = **Aerated concrete**
- By omitting sand fraction from aggregates
  = **No fines concrete**



Advantages:

- Reduction of self weight (Dead Load)
- Less haulage and handling costs
- Low thermal conductivity – Comfort – A/C
- Smaller section of structural members can taken
- Increase in the progress of work
- Good fire resistance
- Overall economy

5. **What is air entrained concrete? Write its applications?**
   - Also called as Aerated concrete, gas concrete
   - By introducing gas/air bubbles into a slurry
   - Density 300-800 kg/m3.
   - Self weight is reduced
   - Applications:
     - Insulation purposes
     - Building blocks for load bearing walls
     - Pre fabricated structures
6. **What is high strength concrete (HSC)? What are its advantages?**
   Have higher compressive strength
   High cement content, less w/c ratio
   Methods:
   - Seeding
   - Revibration
   - Using admixtures
   - Sulphur impregnation

   Applications
   - Used mainly in pre-stressed concrete
   - High rise buildings, long span bridges
7. **Differentiate between HPC and HSC?**

HPC	HSC
High Performance Concrete	High Strength Concrete
high abrasion resistance	Strength 70 MPa or more
Good compaction without segregation	A high-strength concrete is always a high-performance concrete, but a high-performance concrete is not always a high-strength concrete.
Sensitive to changes in constituent material	Where architectural considerations are required.
High cementitious content and a water-cementitious material ratio of 0.40 or less	Early high strength
Ease of placement and consolidation without affecting strength	Toughness is good
Long-term mechanical properties	Volume stability is high

8. **Define corrosion in concrete? What are the protective measures taken against corrosion? Explain the causes of corrosion of reinforcement.**

Steel reinforcement inside the concrete get affected due attack of certain reactive liquids and gases. This is termed as corrosion in concrete.

Eg:- Sewage pipelines, bridges, etc.

Causes of corrosion:

- Quality of concrete
- Cover thickness of concrete reinforcement
- Condition of reinforcement
- Effect of environmental and other chemicals
- Porosity of concrete
    - Age of concrete
    - Degree of compactness
    - The size and grading of aggregate
    - Type of cement
- Salt water causes corrosion.
- Effect of high thermal stress
- Freezing and thawing condition

Protective measures:

1. Improving the quality of concrete
    - Adopting the best mix proportion
    - Efficient compaction during casting
    - Leak proof formwork
    - Adopting salt free sand
    - Using plasticizers
    - Using sulphate resisting cement and pozzolana cement
2. Increasing depth of concrete cover to reinforcement
3. Concrete coating and sealers
4. Galvanizing

- Cathodic protection.
- Anodic protection

5. Fusion bonded epoxy coating (fbec)
6. Coating of rebars
   - Paint
   - Chemical compound
   - Metallic epoxy coating
   - Fusion bonded epoxy
7. Proper storage & stacking of reinforcing steel
8. Use of corrosion inhibitors
9. Bio-film coating
10. Surface treatment
11. Selection of proper materials

9. Write short notes on (i) Sulphate attack (ii) Carbonation

Sulphate attack:

- Found in ground water and sub soil.
- Increase in volume of cement paste in concrete due to presence of sulphur containing chemicals.
- In hardened concrete: Calcium-Aluminate-Hydrate (C-A-H) react with sulphur salt to form calcium sulphoaluminate which increases volume of concrete upto 227 %.
- How to control sulphate attack?
  - Use of sulphate resisting cement
  - Addition of pozzolano.
  - Quality of concrete
  - Use of air entrainment
  - High pressure steam curing
  - Use of High-alumina cement

Carbonation:

- Alkalinity of concrete
- Carbon dioxide from the air reacts with $Ca(OH)_2$ in concrete to form $CaCO_3$.
- In the presence of moisture, carbonic acid is formed which reduces the alkalinity of concrete.
- Thus PH value of concrete reduces (13.5 to 8.3).
- So corrosion increases.

10. Write short note on workability test in self-compacting concrete?

- Self compacting concrete should have below properties.
  1. Filling ability
  2. Passing ability and
  3. Segregation resistance

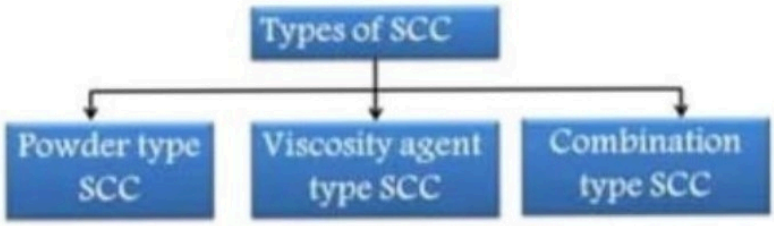
- The self compacting concrete must meet the filling ability and passing ability with uniform composition throughout the process of transport and placing.
- Test methods to determine workability of Self Compacting Concrete are:
    1. Slump flow test
    2. V Funnel Test
    3. L Box Test
    4. U Box Test
    5. Fill Box Test

2. What is mean by permeability of concrete. What are the factors affecting permeability of concrete?

- Rate at which water can penetrate concrete.
- Influence primarily by:
- Nature of hardened cement paste
- Porosity and W/c ratio
- Degree of compaction, Type and quantity of aggregates used

3. Explain the self-compacting concrete.

- No vibration needed
- Self compacted
- Flow around obstructions
- Encapsulate reinforcement and fill up the formwork completely under its own weight.



Requirements of a SCC:

- FILLING ABILITY
    - Ability of concrete to flow into and fill completely all spaces in the formwork, under its own weight.
- PASSING ABILITY
    - To flow through congested reinforcements
- SEGREGATION RESISTANCE
    - To remain in homogenous composition during transport and placing

4. List various special concreting cases.

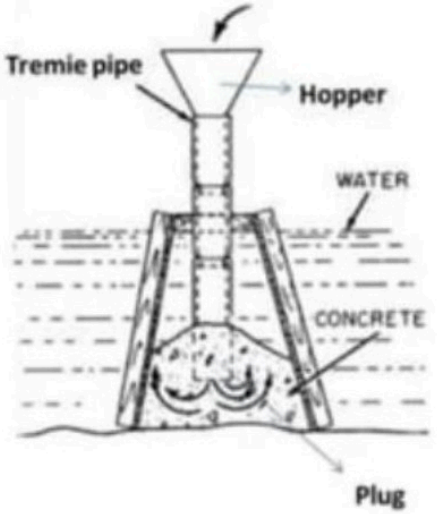
- Underground and underwater concreting
- Concreting in cold weather
- Concreting in hot weather
- Mass concreting
- Concreting in marine environment

5. Write short notes on underground and underwater concreting. What are the precautions to be taken during under water concreting?

- Placing concrete underground or underwater
- Special precautions should be selected
- Slump = 15 – 18 cm
- Methods:
  - Tremie method
  - Bucket placing
  - Placing in bags
  - Pre-packed concrete and Placing in dewatered caissons
- Requirements:
  - Workability and self compaction
  - Cohesion about washout and segregation
  - Low heat of hydration
  - Controlled set time
  - Compressive strength and adequate bond strength

1. Tremie Method:

- Tremie is a water tight pipe – 250 mm dia
- One end of formwork(or pipe) below water and other end above water
- Funnel shape at top and loose plug at bottom
- Supported on a working platform above water level.
- Concrete is poured from top to bottom through this pipe with help of gravity
- Before concreting air and water must be excluded



2. Bucket Placing:

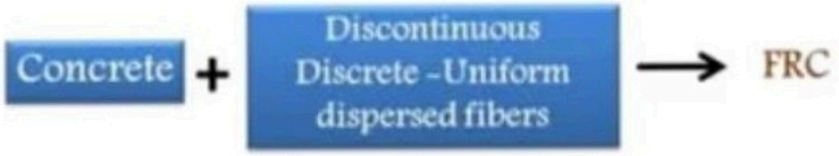
- Large quantity of STIFF/HARD concrete filled in bucket
- Bucket is lowered to required depth using crane
- Top of bucket is suitably covered to avoid disturbances
- The bucket is opened by divers or suitable arrangement from the top
- Early discharge of concrete should be prevented, so as to avoid entry of water into it.

- Only used for shallow depths.

3. Placing in bags:

- Concrete is filled in gunny/cotton bags
- Lowered into water and placed carefully in a header and stretcher fashion by divers.
- Slow and laborious
- Accurate placing is difficult
- Expensive
- For shallow waters only

6. What are the factors affecting properties of fibre reinforced concrete?



- Inclusion of fibers
  - Closely spaced
  - Uniformly dispersed
- Composite material
- Resistance to crack growth
- Improve tensile strength
- Improve durability

7. Write a note Polymer concrete

- Concrete containing polymers

Why Polymer concrete?

- Different drawbacks of concrete are eliminated
- Reducing the drawbacks of ordinary concrete
- Alternative to conventional concrete
- Reduce green house effect
- Reduce energy consumption

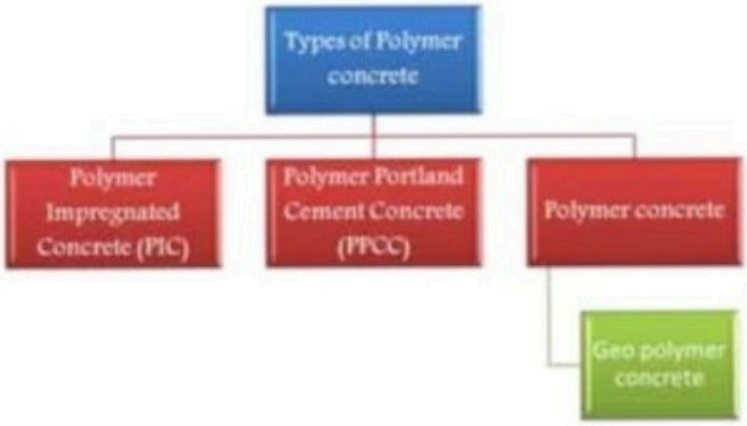
- COMPRESSIVE STRENGTH
  - Tensile strength
  - Impermeability
  - Chemical resistance
  - Initial strength
  - Good adhesion

  Favorable
- THERMAL CHARACTERISTICS
  - Creep
  - Continuous loading
  - Cost

  Unfavorable

- Uses:
  - Precast works
  - Floor and pavements
  - Channel sections

8. What are different types of polymer concrete?



Polymer Impregnated Concrete (PIC):

- Impregnating a hardened Portland cement concrete with a monomer
- Polymerize the monomer in site.
- Improves durability
- Improves surface resistance
- Monomer used for impregnation are
  - Methyl Methacrylate
  - Styrene
  - T-Butyl styrene
  - Epoxy

Polymer Portland Cement Concrete (PPCC)

- Replacing a part of mixing water with LATEX
- Latex means polymer emulsion

9. Write a note on geo-polymer concrete?

- Made from flyash and alkaline solution
- Combines waste products to useful product
- Setting mechanism depends on polmerisation
- Curing temperature is b/w 600-900 C
- Reduce CO2 emissions → Less green house gas
- High fire resistance
- High compressive strength
- Rapid strength gain

- Less shrinkage
- Greater corrosion resistance

10.Write a note on no fines concrete and its applications

- Fine aggregate fraction is omitted
- CA + Cement + Water only.
- Light in weight
- Offers architecturally attractive look
- Bond strength is low- reinforcement - X
- Formworks can be removed earlier – less side thrust
- Low drying shrinkage
- Low thermal conductivity
- Applications:
    - Load bearing walls
    - For temporary structures
    - Heat insulation
    - Good base for plastering
    - Dampness free walls
    - Where sand is not available, no-fines concrete become a popular construction material

11.List the defects in concrete.

- Cracks
    - Excess water – evaporation /freezing – volume changes
    - Alkali aggregate reaction
    - Corrosion of steel bars
    - Freezing and thawing
- Crazing
- Sulphate deterioration
- Effloresence
    - Appearance if fluffy white patches on surface of concrete
- Segregation
- Bleeding
- Laitance
    - Cement and water slurry coming out to top of concrete surface

12.How defects can be reduced?

Defects can be reduced by:

1. Selection of cement as desired quality by IS
2. Selection of aggregates of desired quality as per IS
3. Maintaining accurate water cement ratio
4. Proper batching of ingredients
5. Proper operation in production of concrete
6. Carefulness in finishing items

13.What is mean by pre-packed concrete?

- Also called as GROUNTED CONCRETE
- Special technique of placing concrete under water
- Used where reinforcement is complicated – mass concreting, piers, Pipes, conduits, openings, etc
- Place coarse aggregate only in the form and thoroughly compacting it to form a prepacked concrete
- This prepacked mass is grouted with cement mortar of required proportions.
- Undergoes less drying shrinkage

14.What is mean by guniting or shotcreting?

- Gunite – mortar conveyed through a hose and pumped with a high velocity to the surface
- Force of the jet impacting on the surface compact the material
- Eg: Rediset cement
- Process –
  - Dry mix process
  - Wet mix process

15.Write a note on concreting in cold weather?

- Small cracks → water enters → become ice → volume increases → concrete cracks
- Temperature to be maintained = 50C
- Effects
  - Delayed setting
  - Freezing of concrete at early age
  - Freezing and thawing
  - Temperature stresses
- Recommended practices and precautions
  - Selection of suitable type of cement
  - Temperature control of ingredients
  - Electrical heating of concrete mass
  - Use of insulating formwork
  - Admixtures of anti-freezing materials
  - Use of air entraining agents
  - Delayed removal of form work
  - Placing and curing of concrete

Study this with code book- Module III – Mix design.

1. Design a concrete mix w.r.t following data.

Grade of concrete	: 30 MPa
Type of cement	: OPC 43 Grade
Maximum nominal size of coarse aggregate	Fraction I = 20 mm Fraction II = 10 mm
Maximum water cement ratio	: 0.45
Maximum cement content	: 360 mm
Specific gravity of cement	: 3.15
Specific gravity of sand	: 3.15
Specific gravity of C.A	: 3.15

- Assume all other data suitably.

<<Refer Notebook for details>>