B.Tech.

(SEM. V) ODD SEMESTER THEORY EXAMINATION, 2018-19

CONCRETE TECHNOLOGY

Time : 3 Hours **Max. Marks : 70**

Note : Attempt **all** sections. If any missing data required, then choose suitably.

SECTION – A

1. Attempt **all** questions in brief. **(2 × 7 = 14)**

a. What is bulking of sand ?

Ans. Refer Q. 1.15, Page 1–17D, Unit-1.

b. What are the thermal properties of aggregate ?

Ans. Refer Q. 1.24, 2 Marks Questions, Page SQ–4D, Unit-1.

c. Define Plastic concrete.

Ans. If recycled waste plastic were mixed with cement concrete, then it is called as plastic concrete.

d. What is the impact of W/C ratio on durability ?

Ans. Refer Q. 4.33, Page 4–29D, Unit-4.

e. Write the concept of mix design.

Ans. Refer Concept Outline-1, Page 3–2D, Unit-3.

f. Define standard deviation.

Ans. Refer Q. 3.6, Page 3–6D, Unit-3.

g. What is the Rheological representation of creep ?

Ans. Rheological representation of creep is rheological models consisting of springs and dashpots that represent the time-dependent behaviour of materials like concrete and masonry.

SECTION-B

2. Attempt any **three** of the following : **(7 × 3 = 21)**

a. What are the roles of various ingredients of cement ? What are the harmful compounds likely to be present in cements ?

Ans.

A. **Roles of Various Ingredients of Cement :** Refer Q. 1.2, Page 1–3D, Unit-1.

B. **Harmful Compounds :** The presence of the following two oxides adversely affects the quality of cement :

1. Alkali oxides K_2O and Na_2O
2. Magnesium oxide MgO

Effects :

i. If the amount of alkali oxide exceeds 1 percent, it leads to the failure of concrete.

ii. Similarly, if the content of magnesium oxide exceeds 5 percent, it causes cracks after mortar or concrete hardens.

iii. It is due to the fact that magnesium oxide, burned at a temperature of about 1500 °C slakes very slowly, when mixed with water.

b. Describe the mechanism of action of plasticizers with neat sketch. Mention any three super plasticizers.

Ans.

A. **Mechanism of Action of Plasticizers :** The action of plasticizers is mainly to fluidify the mix and improve the workability of concrete, mortar or grout. The mechanisms involved are :

1. Dispersion :

i. Portland cement being in fine state will have a tendency to flocculate in wet concrete, these flocculation entraps certain amount of water used in the mix.

ii. When plasticizers are used, they get adsorbed on the cement particles, creates particle to particle repulsive forces which overcome the attractive forces.

iii. This repulsive force is called Zeta Potential, which depends on the base, solid content, quantity of plasticizer used.

iv. When cement particles are deflocculated, the water trapped inside the flocs gets released and is now available to fluidify the mix.

2. Lubricating : The agents are organic by nature, thus they lubricate the mix reducing the friction and increasing the workability.

3. Retarding Effect :

i. Plasticizers get adsorbed on the surface of the cement particles and form a thin sheath.

ii. This sheath inhibits the surface hydration reaction between water and cement as long as sufficient plasticizers molecules are available.

iii. Quantity of plasticizers will decrease as the polymers become entrapped in hydration products.

The following mechanisms may take place simultaneously :

a. Reduction in the surface tension of water.

b. Induced electrostatic repulsion between particles of cement.

c. Lubricating film between cement particles.

d. Dispersion of cement grains, releasing water trapped within cement flocs.

e. Inhibition of the surface hydration reaction of the hydration cement particles, leaving more water to fluidify the mix.

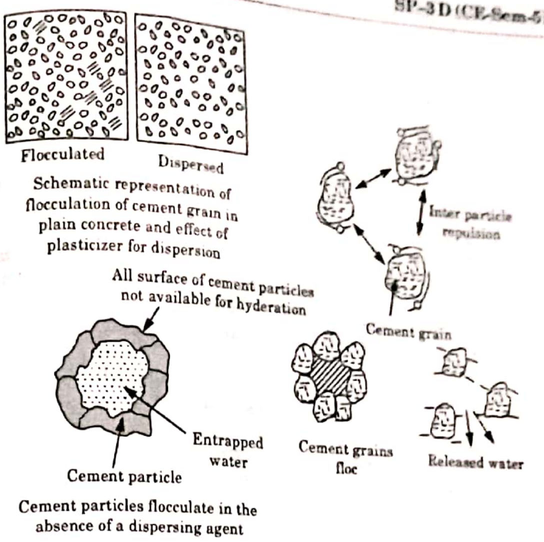

Fig. 5. Mechanism of action of plasticizers.

B. **Super Plasticizers :** Refer Q. 2.7, Page 2–6D, Unit-2.

c. Design a concrete mix of M 30 grade. Take standard deviation 5 MPa. The specific gravities of coarse aggregate and fine aggregate are 2.75 and 2.62 respectively. The bulk density of coarse aggregate is 1610 kg/m³ and fineness modulus of aggregate is 2.70. A slump of 60 mm is necessary. The water absorption of coarse aggregate is 1 % and free moisture in fine aggregate is 2 %. Design the concrete mix using IS code method. Assume any missing data.

Ans.

Given : Standard deviation, σ = 5 MPa, Specific gravity of CA = 2.75, Specific gravity of FA = 2.62, Bulk density of CA = 1610 kg/m^3, Fineness modulus of aggregate = 2.70, Slump value = 60 mm, Water absorption of CA = 1 %, Free moisture in FA = 2 %.

To Find : Design mix M30 grade concrete.

1. Assuming 5 percent of results are allowed to fall below specified design strength. The mean strength,

$$f_m = f_{min} + k\sigma$$
$$= 30 + 1.64 \times 5 = 38.2 \text{ MPa}$$

2. Assume estimated w/c ratio is 0.47.

i. This w/c ratio from strength point of view is to be checked against maximum w/c ratio given for special exposure condition given in IS 456 : 2000 and minimum of the two is to be adopted.

ii. From IS 456 : 2000 the maximum w/c ratio is 0.60.

Therefore, adopt w/c ratio of 0.47.

3. From IS 456 : 2000, for a slump of 60 mm, 20 mm maximum size of aggregate, for non-air-entrained concrete, the mixing water content is 185 kg/m^3 of concrete. Also the approximate entrapped air content is 2 %.

The required cement content = 185 / 0.47 = 394 kg/m^3

4. From IS 456 : 2000, for 20 mm coarse aggregate, for fineness modulus of 2.60, the dry rodded bulk volume of coarse aggregate is 0.62 per unit volume of concrete.

5. Therefore the weight of coarse aggregate = 0.62 × 1610 = 998.2 kg/m^3.

6. From IS code, the first estimate of density of fresh concrete for 20 mm maximum size of aggregate and for non-air-entrained concrete = 2355 kg/m^3.

7. The weight of all the known ingredient of concrete are :

Weight of water = 185 kg/m^3

Weight of cement = 394 kg/m^3

Weight of CA = 998.2 kg/m^3

Weight of FA = 2355 – (185 + 394 + 998.2) = 777.8 kg/m^3

8. Alternatively the weight of FA can also be found out by absolute volume method which is more accurate, as follows :

Item Number	Ingredients	Weight kg/m^3	Absolute Volume cm^3
1.	Cement	394	$\frac{394}{3.15} \times 10^3 = 125 \times 10^3$
2.	Water	185	$\frac{185}{1} \times 10^3 = 185 \times 10^3$
3.	Coarse aggregate	998.2	$\frac{998.2}{2.75} \times 10^3 = 363 \times 10^3$
4.	Air		$\frac{2}{100} \times 10^6 = 20 \times 10^3$

Total absolute volume = 693 × 10^3 cm^3

Henceabsolute volume of FA = (1000 – 693) × 10^3 = 307 × 10^3 cm^3

Weight of FA = 307 × 2.62 = 804.34 kg/m^3

9. Estimated quantities of materials per cubic meter of concrete are :

Cement = 394 kg

FA = 804.34 kg

CA = 998.2 kg

Water = 185 kg

Density of fresh concrete = 2381.54 kg/m^3.

10. Proportions :

Cement	Fine Aggregate	Coarse Aggregate	Water
394	804.34	998.2	185
1	2.04	2.52	0.47

Weight of materials for one bag mix in kg = 50 : 102 : 126.5 : 23.5

The above quantity is on the basis that both FA and CA are in saturated and surface dry condition.

11. The proportions are required to be adjusted for the field conditions. FA has moisture of 2 per cent.

i. Total free surface moisture in FA = (2/100) × 804.34 = 16.08 kg/m^3

ii. Weight of FA in field condition

= 804.34 +16.08 = 820.42 kg/m^3 ≈ 821 kg/m^3

iii. CA absorbs 1 % water

Quantity of water absorbed by CA = (1/100) × 998.2 = 9.981 kg/m^3

iv. Weight of CA in field condition

= 998.2 – 9.982 = 989.2 kg/m^3

v. With regard to water, 16.08 kg of water is contributed by FA and 9.982 kg of water is absorbed by CA.

Therefore 16.08 – 9.982 = 6.1 kg of extra water is contributed by aggregates. This quantity of water is deducted from total water

185.00 – 6.1 = 178.9 kg/m^3 ≈ 179 kg/m^3

12. Quantities of materials to be used in the field duly corrected for free surface moisture in FA and absorption characteristic of CA

Cement = 394 kg/m^3

FA = 821 kg/m^3

CA = 989 kg/m^3

Water = 179 kg/m^3

Field density of fresh concrete = 2388 kg/m^3

d. What is the relation between creep and time ? What is the effect of creep on concrete ?

Ans.

A. Relation between Creep and Time :

1. The rate of creep decreases with time and the creep strains at five years are taken as terminal values.
2. Creep increases rapidly with the stress, loading at an early age of concrete, broken ballast, soft and porous aggregate, poorly graded and improperly compacted concrete.

B. Effect of Creep on Concrete : Refer Q. 4.27, Page 4–25D, Unit-4.

e. Explain the following :

A. Light weight aggregate concrete.

B. SIFCON.

C. **Types of polymer concrete.**

Ans.

A. Light Weight Concrete : Concrete of substantially lower density than that made using aggregates of normal density; consists entirely of light weight aggregate or a combination of light weight aggregate and normal-density aggregate; its equilibrium densities are generally between 1120 to 1920 kg/m^3.

B. SIFCON :

1. SIFCON is the slurry infiltrated fiber concrete.
2. It is one such high performance material that possesses excellent mechanical properties coupled with greater energy absorption characteristics.
3. It contains 6-20 % of fibres.
4. The coarse aggregate is omitted.
5. The strength of the concrete is high with the flexural strength and is suitable for earthquake prone areas.
6. It possesses high flow ability and passing ability.
7. It is fabricated by infiltrating a bed of pre-placed fibres with cement slurry.
8. It is unsuitable and uneconomical for hydraulic structures.

C. Types of Polymer Concrete : Following are the various types of polymer concrete :

1. Polymer impregnated concrete (PIC).
2. Polymer cement concrete (PCC).
3. Partially impregnated and surface coated polymer concrete.
4. Polymer concrete (PC).

SECTION-C

3. Attempt any **one** part of the following : **(7 × 1 = 7)**

a. **What are the sources of aggregate ? And also classify the particles on the basis of aggregate in tabular form.**

Ans.

A. Source of Aggregate :

1. Natural Aggregate :

i. Almost all natural aggregate materials originate from bed rocks.
ii. There are three kinds of rocks, namely, igneous, sedimentary and metamorphic.
iii. The igneous rocks are formed by the cooling of molten magma or lava at the surface of the crest (trap and basalt) or deep beneath the crest (granite).
iv. The sedimentary rocks are formed originally below the sea bed and subsequently lifted up.
v. Metamorphic rocks are originally either igneous or sedimentary rocks which are subsequently metamorphosed due to extreme heat and pressure.

2. Artificial Aggregates : They are obtained either as a by-product or by a special manufacturing process such as heating. (*e.g.* blast furnace slag, expanded perlite).

B. Classification of Particles on the basis of shape of the Aggregate :

Classification	Description	Examples
Rounded	Fully water worn or completely shaped by attrition	River or seashore gravels ; desert, seashore and wind-blown sands
Irregular or partly rounded	Naturally irregular or partly shaped by attrition, having rounded edges	Pit sands and gravels ; land or dug flints ; cuboid rock
Angular	Possessing well-defined edges formed at the intersection of roughly planar faces	Crushed rocks of all types ; talus ; screes
Flaky	Material, usually angular, of which the thickness is small relative to the width and/or length	Laminated rocks

b. **How is water used in making concrete and what is its role in the foundation and properties of concrete ?**

Ans.

1. The water used for the mixing and curing of concrete should be free from injurious amounts of deleterious materials.
2. The unwanted situations, leading to the distress of concrete, have been found to be a result of, among others, the mixing and curing water being of inappropriate quality.
3. Potable water is generally considered satisfactory for mixing concrete.
4. In the case of doubt about the suitability of water, particularly in remote areas or where water is derived from sources not normally utilized for domestic purposes, water should be tested.

Also Refer Q. 1.24(Table), Page 1–25D, Unit-1.

Role of Water :

1. Water is the most important and least expensive ingredient of concrete.
2. It plays an important role in mixing, laying, compaction, setting and hardening of concrete.
3. The strength of concrete depends on the quality and quantity of water used in the mix.
4. The functions of water in the concrete mix are given below :

i. It acts as lubricant for the fine and coarse aggregate and makes the mixture workable.
ii. It acts chemically with cement to form the binding paste.
iii. It is employed to damp the aggregate surface in order to prevent them from absorbing water vitally necessary for chemical action.
iv. It facilitates the spreading of aggregate.
v. It helps to flux the cementing material over the surface of the aggregate.
vi. It enables the concrete mix to flow into moulds.

4. Attempt any **one** part of the following : **(7 × 1 = 7)**

a. Describe gas forming agents ? Give an example of a material in powder form used as a gas forming agent.

Ans. Gas Forming Agent :

1. These admixtures when added to mortar or concrete mixture react chemically with hydroxides present in the cement and form minute bubbles of hydrogen gas of size ranging from 0.1 to 1 mm throughout the cement-water matrix.
2. This action, when properly controlled, causes a slight expansion in plastic concrete or mortar and thus reduces or eliminates voids caused by normal settlement that occur during the placement of concrete.
3. Water films around the gas bubbles prevent bleeding.
4. The gas is beneficial in improving the effectiveness of grout for filling joints, in improving the homogeneity of grouted concrete, and in filling block outs and openings in concrete structures.
5. Larger amounts of powder increase the expansion appreciably resulting in a gas-filled lightweight low strength concrete. These are also called foamed concrete or aerated concrete or cellular concrete.

   Example : Aluminium powder, Hydrogen peroxide, Activated carbon, etc.

b. Write a note on workability agents. Give examples.

Ans. Workability Agents :

1. The workability of concrete is governed by the amount of aggregate in the mix. Where reduction of aggregate (or increase in cement) is impractical, workability is increased by adding a plasticizer.
2. Air-entraining agents, when used, are plasticizers. Other substances include calcium chloride, lime, fly ash, and other pozzolans.
3. Lime increases the cementing properties of cement, as do pozzolans combined with lime.
4. Fly ash is inexpensive compared to cement and is used as a partial replacement (up to as much as 50 percent) of the cement.
5. It changes both the plastic and the hardened properties of concrete.
6. Fly ash improves workability and reduces segregation, bleeding, and the heat of hydration.

Example : Bentonite clay, Diatomaceous earth, Fly ash, Finely divided silica, Hydrated lime, etc.

5. Attempt any **one** part of the following : **(7 × 1 = 7)**

a. Explain how you would determine the various elastic moduli for concrete.

Ans. Refer Q. 4.24 and Q. 4.25, Page 4–23D; Unit-4.

b. What do you understand by carbonation of concrete ? How is it tested ?

Ans.

1. Carbonation occurs in concrete because the calcium bearing phases present are attacked by carbon dioxide of the air and converted to calcium carbonate.
2. Cement paste contains 25-50 % calcium hydroxide ($Ca(OH)_2$) by weight, which mean that the pH of the fresh cement paste is at least 12.5.
3. The pH of a fully carbonated paste is about 7.
4. The concrete will carbonate if CO_2 from air or from water enters the concrete according to:

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

5. When $Ca(OH)_2$ is removed from the paste hydrated CSH will liberate CaO which will also carbonate.
6. The rate of carbonation depends on porosity and moisture content of the concrete.
7. The carbonation process requires the presence of water because CO_2 dissolves in water forming H_2CO_3.
8. If the concrete is too dry (RH < 40 %) CO_2 cannot dissolve and no carbonation occurs.
9. If on the other hand it is too wet (RH > 90 %) CO_2 cannot enter the concrete and the concrete will not carbonate. Optimal conditions for carbonation occur at a RH of 50% (range 40-90 %).

Test of Carbonation of Concrete :

1. Carbonation may be recognized in the field by the presence of a discoloured zone in the surface of the concrete.
2. The colour may vary from light gray and difficult to recognize to strong orange and easy to recognize.
3. Carbonation can be visualized by using phenolphthalein.
4. In the optical microscope carbonation is recognized by the presence of calcite crystals and the absence of calcium hydroxide, ettringite and un-hydrated cement grains.

6. Attempt any **one** part of the following : (7 × 1 = 7)

a. Write a brief note on flexure strength of concrete.

Ans. Flexure Strength of Concrete :

1. The determination of flexural tensile strength is essential to estimate the load at which the concrete members may crack.
2. As it is difficult to determine the tensile strength of concrete by conducting a direct tension test, it is computed by flexure testing.
3. The flexural tensile strength at failure or the modulus of rupture is thus determined and used when necessary.
4. Its knowledge is useful in the design of pavement slabs and airfield runway as flexural tension is critical in these cases.
5. The modulus of rupture is determined by testing standard test specimens of 150 mm × 150 mm × 700 mm over a span of 600 mm or 100 mm × 100 mm × 500 mm over a span of 400 mm, under symmetrical two-point loading.
6. The modulus of rupture is determined from the moment at failures as $f_r = M/Z$.

b. Discuss the influence of mix proportions of concrete on shrinkage.

Ans. Following are the affecting factors of shrinkage :

1. **Type of Coarse Aggregates :** In general, concretes made with high moduli of elasticity non-shrinking aggregates will have low shrinkage.
2. **Shape of Aggregates :** The size and shape of coarse aggregate influence the loss of moisture and it has therefore an indirect effect on the shrinkage of concrete. In general, the smaller the aggregate size, the more surface area, more water is absorbed as a result and, therefore, more shrinkage.
3. **Hardness of Aggregates :** Harder aggregate with higher modulus of elasticity like quartz shrinks much less than softer aggregates such as sandstone.
4. **Effect of Admixtures :** Addition of calcium chloride increases the shrinkage of concrete generally between 10 to 50 %. The plasticizers which reduce the water-cement ratio of the concrete, their net effect on shrinkage is negligible.
5. **Chemical Composition of Cement :** The chemical composition of cement has been observed as not having any effect on the shrinkage of concrete. However cement deficient in gypsum exhibits a greatly increased shrinkage.
6. **Effect of High Alumina Cement :** The shrinkage of concrete made with high alumina cement is of the same magnitude as that of concrete made with Portland cement, but in case of high alumina cement shrinkage takes place much more rapidly than when Portland cement is used.
7. **Water Content :** The water content affects the water-cement ratio hence higher the amount of water, greater the shrinkage as higher the water-cement ratio.
8. **Properties of Cement :** The properties of cement have little effect on the shrinkage of concrete. Fineness of cement has no influence on the shrinkage of concrete. However it increases the shrinkage of cement paste.
9. **Quality of Cement Paste :** The quality of cement paste influences the magnitude of shrinkage. The quality of cement pate is dependent on the water cement ratio. Higher the w/c ratio, greater the shrinkage,

7. Attempt any **one** part of the following : (7 × 1 = 7)

a. What is the need to study fiber reinforced concrete and explain briefly the factors effecting properties of fiber reinforced concrete ?

Ans. Refer Q. 5.8, Page 5–9D, Unit-5.

b. Difference between high performance concrete and high density concrete.

Ans. High Performance Concrete :

1. High performance concrete is a concrete mixture, which possess high durability and high strength when compared to conventional concrete.
2. This concrete contains one or more of cementitious materials such as fly ash, silica fume or ground granulated blast furnace slag and usually a super plasticizer.
3. High performance concrete has high strength and low permeability.
4. High performance concrete is not a special type of concrete. It comprises of the same materials as that of the conventional cement concrete.
5. The use of some mineral and chemical admixtures like silica fume and super plasticizer enhance the strength, durability and workability qualities to a very high extent.
6. It is used in high rise building column, off shore platforms and heavy-duty floors.

High Density Concrete :

1. Concrete having unit weight of 30 kN/m^3 to 64 kN/m^3 is called high density or heavy weight concrete.

2. Thus unit weight of high density concrete is more than about 25 percent higher than that of conventional concrete which is the range of 24 kN/m^3.
3. High density concrete can be produced by using different types of heavy weight aggregates.
4. High density concrete is used for construction of nuclear radiation shields walls, ballast blocks, counterweights, sea walls and other applications where high density is important.

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