14. Assignment topics with materials

UNIT-I

CEMENT

1. **Define mortar and its types**
2. **Explain about hydration of cement**
3. **What are the basic testing of cement**
4. **Determine the compressive strength of cement**.

TOPIC 1: Mortar and its types

The mortar is a paste like substance prepared by adding required amount of water to a dry mixture of sand or fine aggregate with some binding material like clay, lime or cement.

Lime mortar:

If lime is used as a binding material, the resulting mortar is known as lime mortar.

Mud mortar:

When clay is used as a binding material, the resulting mortar is known as mud mortar

TOPIC 2:Hydration

The setting and hardening of concrete are the result of chemical and physical processes that take place between Portland cement and water, i.e. hydration. To understand the properties and behaviour of cement and concrete some knowledge of the chemistry of hydration is necessary.

A) Hydration reactions of pure cement compounds

The chemical reactions describing the hydration of the cement are complex. One approach is to study the hydration of the individual compounds separately. This assumes that the hydration of each compound takes place independently of the others.

I. Calcium silicates

Hydration of the two calcium silicates gives similar chemical products, differing only in the amount of calcium hydroxide formed, the heat released, and reaction rate.

$2\,C_3S + 7\,H \rightarrow C_3S_2H_4 + 3\,CH$ $2\,C_2S + 5\,H \rightarrow C_3S_2H_4 + CH$

The principal hydration product is $C_3S_2H_4$, calcium silicate hydrate, or C-S-H (non-stoichiometric). This product is not a well-defined compound. The formula $C_3S_2H_4$is only an approximate description. It has amorphous structure making up of poorly organized layers and is called glue gel binder. C-S-H is believed to be the material governing concrete strength. Another product is CH - $Ca(OH)_2$, calcium hydroxide. This product is a hexagonal crystal often forming stacks of plates. CH can bring the pH value to over 12 and it is good for corrosion protection ofsteel.

II. Tri-calcium aluminate

Without gypsum, C_3A reacts very rapidly with water:

$C_3A + 6H \rightarrow C_3AH_6$

The reaction is so fast that it results in flash set, which is the immediate stiffening after mixing, making proper placing, compacting and finishing impossible.

With gypsum, the primary initial reaction of C_3A with water is

$C_3A + 3(C\bar{S}H_2) + 26H \rightarrow C_6A\bar{S}_3H_{32}$

The 6-calcium aluminate trisulfate-32-hydrate is usually called ettringite. The formation of ettringite slows down the hydration of C_3A by creating a diffusion barrier around C_3A. Flash set is thus avoided. Even with gypsum, the formation of ettringite occurs faster than the hydration of the calcium silicates. It therefore contributes to the initial stiffening, setting and early strength development. In normal cement mixes,theettringite is not stable and will further react to form monosulphate ($C_4A\bar{S}H_{18}$)

B) Kinetics and Reactivity's

The rate of hydration during the first few days is in the order of $C_3A > C_3S > C_4AF > C_2S$.

C) Calorimetric curve of Portland cement

A typical calorimetric curve of Portland cement is shown in the following figure. The second heat peaks of both C_3S and C_3A can generally be distinguished, although their order of occurrence can be reversed.

D) Setting and Hydration

Initial set of cement corresponds closely to the end of the induction period, 2-4 hours after mixing. Initial set indicates the beginning of forming of gel or beginning of solidification. It represents approximately the time at which fresh concrete can no longer be properly mixed, placed or compacted. The final set occurs 5-10 hours after mixing, within the acceleration period. It represents approximately the time after which strength develops at a significant rate.

In practice, initial and final set are determined in a rather arbitrary manner with the penetration test.

TOPIC 3: Basic test of cement

Fineness (= surface area / weight):

This test determines the average size ofcement grains. The typical value of fineness is 350 m^2 / kg.Fineness controls the rate and completeness of hydration. The finer a cement,the more rapidly it reacts, the higher the rate of heat evolution and the higher the early strength.

Normal consistency test:

This test is to determine the water required to achievea desired plasticity state (called normal consistency) of cement paste. It is obtained with the Vicat apparatus by measuring the penetration of a loaded needle.

Time of setting:

This test is to determine the time required for cement paste to harden. Initial set cannot be too early due to the requirement of mixing, conveying, placing and casting. Final set cannot be too late owing to the requirement of strength development. Time of setting is measured by Vicat apparatus. Initial setting time is defined as the time at which the needle penetrates 25 mm into cement paste. Final setting time is the time at which the needle does not sink visibly into the cement paste.

Soundness:

Unsoundness in cement paste refers to excessive volume change after setting. Unsoundness in cement is caused by the slow hydration of MgO or freelime.

Their reactions are $MgO + H_2O = Mg(OH)_2$ and $CaO + H_2O = Ca(OH)_2$. Another factor that can cause unsoundness is the delayed formation of ettringite after cement and concrete have hardened. The pressure from crystal growth will lead to cracking and damage. The soundness of the cement must be tested by accelerated methods. An example is the Le Chatelier test (BS 4550). This test is to measure the potential for volumetric change of cement paste. Another method is called Autoclave Expansion test (ASTM C151) which use an autoclave to increase the temperature to accelerate the process.

Strength:

The strength of cement is measured on mortar specimens made of cement and standard sand (silica). Compression test is carried out on a 2" cube with S/C ratio of 2.75:1 and w/cratio of 0.485 for Portland cements. The specimens are tested wet, using a loading rate at which the specimen will fail in 20 to 80 s. The direct tensile test is carried out on a specimen shaped like a dumbbell. The load is applied through specifically designed grips. Flexural strength is measured on a 40 x 40 x 160 mm prism beam test under a centre-pointbending.

TOPIC 4: Compressive Strength of Cement

This test is carried out to determine the **compressive strength of cement**.

Test Procedure for compressive strength of cement:

(i) The mortar of cement and sand is prepared. The proportion is 1:3 which means that (X) gm of cement is mixed with 3(X) gm of sand.

(ii) The water is added to the mortar. The water cement ratio is kept as 0.4 which means that (X) gm of water is added to dry mortar.

(iii) The mortar is placed in moulds. The test specimens are in the form of cubes with side as 70.6 mm or 76 mm. The moulds are of metal and they are constructed in such a way that the specimens can be easily taken out without being damaged. For 70.6 mm and 76 mm cubes, the cement required is 185 gm and 235 gm respectively.

The mortar, after being placed in the moulds, is compacted in vibrating machine for 2 minutes.

(iv) Themoulds are placed in a damp cabin for 24 hours.

(vi) The specimens are removed from the moulds and they are submerged in clean water for curing.

(vii) The cubes are then tested in **compression testing machine** at the end of 3 days and 7 days. The testing of cubes is carried out on their three sides without packing. Thus three cubes are tested each time to find out the compressive strength at the end of 3 days and 7 days. The average value is then worked out. During the test, the load is to be applied uniformly at the rate of 350 kg/cm2 or 35 N/mm2.

(viii) The **compressive strength of cement** at the end of 3 days should not be less than 115 kg/cm2 or 11.50 N/mm2 and that at the end of 7 days should no be less than 175 kg/cm2 or 17.50 N/mm2.

UNIT-II

AGGREGATES & ADMIXTURES

1. **Define aggregate and its classification**
2. **Explain the admixtures classification and functions**

TOPIC 1:Define aggregate and its classification

Aggregates are defined as inert, granular, and inorganic materials that normally consist of stone or stone- like solids. Aggregates can be used alone (in road bases and various types of fill) or can be used with cementing materials (such as Portland cement or asphalt cement) to form composite materials or concrete. The most popular use of aggregates is to form Portland cement concrete. Approximately three-fourths of the volume of Portland cement concrete is occupied by aggregate. It is inevitable that a constituent occupying such a large percentage of the mass should have an important effect on the properties of both the fresh and hardened products. As another important application, aggregates are used in asphalt cement concrete in which they occupy 90% or more of the total volume. Once again, aggregates can largely influence the composite properties due to its large volume fraction.

Classification ofAggregate

Aggregates can be divided into several categories according to different criteria.

In accordance withsize:

Coarse aggregate: Aggregates predominately retained on the No. 4 (4.75 mm) sieve. For mass concrete, the maximum size can be as large as 150 mm.

Fine aggregate (sand): Aggregates passing No.4 (4.75 mm) sieve and predominately retained on the No. 200(75 μm) sieve.

In accordance withsources:

Natural aggregates: This kind of aggregate is taken from natural deposits without changing their nature during the process of production such as crushing and grinding. Some examples in this category are sand, crushed limestone, and gravel.

Manufactured (synthetic) aggregates: This is a kind of man-made materials produced as a main product or an industrial by-product. Some examples are blast furnace slag, lightweight aggregate (e.g. expanded perlite), and heavy weight aggregates (e.g. iron ore or crushed steel).

In accordance with unitweight:

Light weight aggregate: The unit weight of aggregate is less than 1120kg/m^3. The corresponding concrete has a bulk density less than 1800kg/m^3. (cinder, blast-furnace slag, volcanic pumice).

Normal weight aggregate: The aggregate has unit weight of 1520-1680kg/m^3. The concrete made with this type of aggregate has a bulk density of 2300-2400 kg/m^3.

Heavy weight aggregate: The unit weight is greater than 2100 kg/m^3. The bulk density of the corresponding concrete is greater than 3200 kg/m^3. A typical example is magnesite limonite, a heavy iron ore. Heavy weight concrete is used in special structures such as radiation shields.

In accordance withorigin:

Igneous rock Aggregate:

- Hard, tough anddense.
- Massive structures: crystalline, glassy or both depending on the rate at which they are cooledduring formation.
- Acidic or basic: percentage of silicacontent.
- Light or darkcoloured.
- Chemically active: react withalkalis.

Sedimentary rock Aggregate:

- Igneous or metamorphic rocks subjected to weatheringagencies.
- Decompose, fragmentize, transport and deposit deep beneath ocean bed are cementedtogether.
- Range from soft-hard, porous-dense,light-heavy and can beflaky.
- Suitabilitydecidedby:degreeofconsolidation, typeofcementation,thicknessoflayerand contamination.

Metamorphic rock Aggregate:

- Rocks subjected to high temperature andpressure.
- Economic factor intoconsideration.
- Least overallexpense.

TOPIC 2: **Admixtures can be classified by function asfollows:**

1. Air-entrainingadmixtures
2. Water-reducingadmixtures
3. Plasticizers
4. Acceleratingadmixtures
5. Retardingadmixtures
6. Hydration-controladmixtures
7. Corrosioninhibitors
8. Shrinkage reducers
9. Alkali-silica reactivityinhibitors
10. Colouringadmixtures
11. Miscellaneous admixtures such as workability, bonding, dampproofing, permeability reducing,grouting, gas forming, anti-washout, foaming, and pumpingadmixtures.

Concrete should be workable, finish able, strong, durable, watertight, and wear resistant. These qualities can often be obtained easily and economically by the selection of suitable materials rather than by resorting to admixtures (except air-entraining admixtures when needed).

The major reasons for usingadmixtures

1. To reduce the cost of concreteconstruction
2. To achieve certain properties in concrete more effectively than by othermeans
3. Tomaintainthequalityofconcreteduringthestagesofmixing, transporting, placing, andcuringin adverse weatherconditions
4. To overcome certain emergencies during concretingoperations

UNIT-III

FRESH CONCRETE

1. Define workability and factors affecting workability
2. Explain about segregation and bleeding of concrete
3. Explain various methods of measuring workability

TOPIC 1: Workability

All the characteristics above describe many different aspects of concrete behavior. The term workability is used to represent all the qualities mentioned. Workability is often defined in terms of the amount of mechanical energy, or work, required to fully compact concrete without segregation. This is important since the final strength is a function of compaction.

The concept of viscosity is a measure of how a material behaves under stress. For a Newtonian fluid, the relationship may be written as:

$$\tau = \eta D$$

Where ***t***is the shear stress, ***n*** is the viscosity, and ***D*** is the rate of shear or velocity gradient.For a very dilute suspension of solids in liquids, this relationship holds true. However, for large volumes of suspended solids, like concrete, the Newtonian model does not work. Concrete has an initial shear strength that must be exceeded before it will flow. This type of behaviour is described by the Bingham model:

$$\tau - \tau_0 = \eta D$$

Where ***t0*** is the yield shear stress, ***n*** is the plastic viscosity.

Factors AffectingWorkability

Water Content of the Mix:

This is the single most important fact or governing workability of concrete. A group of particles requires a certain amount of water. Water is absorbed on the particle surface, in the volumes between particles, and provides "lubrication" to help the particles move past one another more easily. Therefore, finer particles, necessary for plastic behaviour, require more water. Some side-effects of increased water are loss of strength and possible segregation.

Influence of Aggregate Mix Proportions:

Increasing the proportion of aggregates relative to the cement will decrease the workability of the concrete. Also, any additional fines will require more cement in the mix. An "over sanded" mix will be permeable and less economical. A concrete deficient of fines will be difficult to finish and prone tosegregation.

Aggregate Properties:

The ratio of coarse/fine aggregate is not the only factor affecting workability. The gradation and particle size of sands are important. Shape and texture of aggregate will also affect workability. Spherical shaped particles will not have the interaction problems associated with more angular particles. Also, spherical shapes have a low surface/volume ratio, therefore, less cement will be required to coat each particle and more will be available to contribute to the workability of the concrete. Aggregate which is porous will absorb more water leaving less to provide workability. It is important to distinguish between total water content, which includes absorbed water, and free water which is available for improvingworkability.

Time and Temperature:

In general, increasing temperature will cause an increase in the rate of hydration and evaporation. Both of these effects lead to a loss ofworkability.

Loss of Workability:

Workability will decrease with time due to several factors; continued slow hydration of C3S and C3A during dormant period, loss of water through evaporation and absorption, increased particle interaction due to the formation of hydration products on the particle surface. Loss of workability is measured as "slump loss" withtime.

Cement Characteristics:

Cement characteristics are less important than aggregate properties in determining workability. However, the increased fineness of rapid-hardening cements will result in rapid hydration and increased water requirements, both of which reduceworkability.

Admixtures:

In general, air-entraining, water-reducing, and set-retarding admixtures will all improve workability. However, some chemical admixtures will react differently with cements and aggregates and may result in reducedworkability.

TOPIC 2: Segregation and Bleeding

Segregation:

Segregationrefers to a separation of the components of fresh concrete, resulting in a non-uniform mix. This can be seen as a separation of coarse aggregate from the mortar, caused from either the settling of heavy aggregate to the bottom or the separation of the aggregate from themix due to improperplacement.

Some factors that increase segregation are:

1. Larger maximum particle size (25mm) and proportion of the largerparticles.
2. High specific gravity of coarseaggregate.
3. Decrease in the amount of fineparticles.
4. Particle shape andtexture.
5. Water/cementratio.

Bleeding:

Bleeding is defined as the appearance of water on the surface of concrete after it has consolidated but before it is set. Since mixing water is the lightest component of the concrete, this is a special form of segregation. Bleeding is generally the result of aggregates settling into the mix and releasing their mixing water. Some bleeding is normal for goodconcrete.

However, if bleeding becomes too localized, channels will form resulting in "craters". The upper layers will become too rich in cement with a high w/c ratio causing a weak, porous structure. Salt may crystalize on the surface which will affect bonding with additional lifts of concrete. This formation should always be removed by brushing and washing the surface. Also, water pockets may form under large aggregates and reinforcing bars reducing the bond.

Bleeding may be reduced by:

- Increasing cementfineness.
- Increasing the rate ofhydration.
- Using air-entrainingadmixtures.
- Reducing the watercontent.

TOPIC 3: Measurement ofWorkability

Workability, a term applied to many concrete properties, can be adequately measured by three characteristics:

1. Compatibility, the ease with which the concrete can be compacted and air voidremoved.
2. Mobility, ease with which concrete can flow into forms and aroundreinforcement.
3. Stability, ability for concrete to remain stable and homogeneous during handling andvibration without excessivesegregation.

Different empirical measurements of workability have been developed over the years. None of these tests measure workability in terms of the fundamental properties of concrete. However, the following tests have been developed:

Slump Test:

The oldest, most widely used test for determining workability. The device is a hollow cone-shaped mould. The mould is filled in three layers of each volume. Each layer is rodded with a 16mm steel rod 25 times. The mouldis then lifted away and the change in the height of the concrete is measured against the mould. The slump test is a measure of the resistance of concrete to flow under its ownweight.

There are three classifications of slump; "true" slump, shear slump, and collapse slump. True slump is a general reduction in height of the mass without any breaking up. Shear slump indicates a lack of cohesion, tends to occur in harsh mixes. This type of result implies the concrete is not suitable for placement. Collapse slump generally indicates a very wet mix. With different aggregates or mix properties, the same slump can be measured for very different concretes.

Compaction Test:

Concrete strength is proportional to its relative density. A test to determine the compaction factor was developed in 1947. It involves dropping a volume of concrete from one hopper to another and measuring the volume of concrete in the finalhopper to that of a fully compacted volume. This test is difficult to run in the field and is not practical for large aggregates (over 1in.).

Flow Test:

Measures a concretes ability to flow under vibration and provides information on its tendency to segregate. There are a number of tests available but none are recognized by ASTM. However, the flow table test described for mortar flows is occasionallyused.

Remoulding Test:

Developed to measure the work required to cause concrete not onlyto flow but also to conform to a newshape.

Vebee Test:

A standard slump cone is cast, the mouldremoved, and a transparent disk placed on top of the cone. The sample is then vibrated till the disk is completely covered with mortar. The time required for this is called the Vebetime.

Thaulow Drop Table - Similar to the Vebe test except a cylinder of concrete is remoulded on a drop table. The number of drops to achieve this remouldingiscounted.

Penetration Test:

A measure of the penetration of some indenter into concrete. Onlythe Kelly ball penetration test is included in the ASTM Standards. The Kelly ball penetration test measures the penetration of a 30 lb. hemisphere into fresh concrete. This test can be performed on concrete in a buggy, open truck, or in form if they are not too narrow. It can be compared to the slump test for a measure of concrete consistency.

TOPIC 4: Setting ofConcrete

Setting is defined as the onset of rigidity in fresh concrete. Hardening is the development of useable and measurable strength; setting precedes hardening. Both are gradual changes controlled by hydration. Fresh concrete will lose measurable slump before initial set and measurable strength will be achieved after final set.

Setting is controlled by the hydration of C_3S. The period of good workability is during the dormant period, (stage 2). Initial set corresponds to the beginning of stage 3, a period of rapid hydration. Final set is the midpoint of this acceleration phase. A rapid increase in temperature is associated with stage 3 hydration, with a maximum rate at final set.

If large amounts of ettringite rapidly form from C_3A hydration, the setting times will be reduced. Cements with high percentages of C_3A, such as expansive or set-regulated cements, are entirely controlled by ettringite formation.

Abnormal Setting Behavior

False Set: Early stiffening of concrete, fluidity may be restored by remixing. Basically, it is a result of hydration of dehydrated gypsum, which forms rigid crystals. Because there are few of these crystals and they are weak, the matrix can be destroyed by remixing.Acceleratedhydration of C3A will cause rapid development of ettringite and falseset.

Flash Set: Stiffening of concrete due to the rapid development of large quantities of C3A hydration products which cannot be returned to a fluid state with mixing. This is generally no longer a problem since the introduction of gypsum to control C3A hydration. However, some admixtures will increase C3A hydration and flash set may be aproblem.

UNIT-IV

HARDENED CONCRETE

1. **Explain about the strength of hardened concrete**
2. **Explain Dimensional stability--Shrinkage andcreep**
3. **What are the factors affecting in creep explain briefly.**

TOPIC 1: Strength of hardened concrete

Strength is defined as the ability of a material to resist stress without failure. The failure of concrete is due to cracking. Under direct tension, concrete failure is due to the propagation of a single major crack. In compression, failure involves the propagation of a large number of cracks, leading to a mode of disintegration commonly referred to as 'crushing'.

The strength is the property generally specified in construction design and quality control, for the following reasons:

(1) It is relatively easy to measure and

(2) Other properties are related to the strength and can be deduced from strength data.

The 28-day compressive strength of concrete determined by a standard uniaxial compression testis accepted universally as a general index of concrete strength.

TOPIC 2: Dimensional stability--Shrinkage and creep

Dimensional stability of a construction material refers to its dimensional change over a long period of time. If the change is so small that it will not cause any structural problems, the material is dimensionally stable. For concrete, drying shrinkage and creep are two phenomena that compromise its dimensional stability.

Shrinkage and creep are often discussed together because they are both governed by the deformation of hydrated cement paste within concrete. The aggregate in concrete does not shrink or creep, and they serve to restrain the deformation.

Drying shrinkage

After concrete has been cured and begins to dry, the excessive water that has not reacted with the cement will begin to migrate from the interior of the concrete mass to the surface. As the moisture evaporates, the concrete volume shrinks. The loss of moisture from the concrete varies with distance from the surface. The shortening per unit length associated with the reduction in volume due to moisture loss is termed the shrinkage. Shrinkage is sensitive to the relative humidity. For higher relative humidity, there is less evaporation and hence reduced shrinkage. When concrete is exposed to 100% relative humidity or submerged in water, it will actually swell slightly.

Shrinkage can create stress inside concrete. Because concrete adjacent to the surface of a member dries more rapidly than the interior, shrinkage strains are initially larger near the surface than in the interior. As a result of the differential shrinkage, a set of internal self-balancing forces, i.e. compression in the interior and tension on the outside, is set up.

In additional to the self-balancing stresses set up by differential shrinkage, the overall shrinkage creates stresses if members are restrained in the direction along which shrinkage occurs. If the tensile stress induced by restrained shrinkage exceeds the tensile strength of concrete, cracking will take place in the restrained structural element. If shrinkage cracks are not properly controlled, they permit the passage of water, expose steel reinforcements to the atmosphere, reduce shear strength of the member and are bad for appearance of the structure. Shrinkage cracking is often controlled with the incorporation of sufficient reinforcing steel, or the provision of joints to allow movement. After drying shrinkage occurs, if the concrete member is allowed to absorb water, only part of the shrinkage is reversible. This is because water is lost from the capillary pores, the gel pores (i.e., the pore within the C-S-H), as well as the space between the C-S-H layers. The water lost from the capillary and gel pores can be easily replenished. However, once water is lost from the interlayer space, the bond between the layers becomes stronger as they get closer to one another. On wetting, it is more difficult for water to re-enter. As a result, part of the shrinkage is irreversible.

The magnitude of the ultimate shrinkage is primarily a function of initial water content of the concrete and the relative humidity of the surrounding environment. For the same w/c ratio, with increasing aggregate content, shrinkage is reduced. For concrete with fixed aggregate/cement ratio, as the w/c ratio increases, the cement becomes more porous and can hold more water. Its ultimate shrinkage is hence also higher. If a stiffer aggregate is used, shrinkage is reduced.

The shrinkage strain, ε , is time dependent. Approximately 90% of the ultimate shrinkage occursduring the first year.

Both the rate at which shrinkage occurs and the magnitude of the total shrinkage increase as the ratio of surface to volume increases. This is because the larger the surface area, the more rapidly moisture can evaporate.

Based on a number of local investigations in Hong Kong, the value of shrinkage strain (after one year) for plain concrete members appears to lie between 0.0004 and 0.0007 (although value as high as 0.0009 has been reported). For reinforced concrete members, the shrinkage strain values are reduced, as reinforcement is helpful in reducing shrinkage.

Creep

Creep is defined as the time-dependent deformation under a constant load. Water movement under stress is a major mechanism leading to creeping of concrete. As a result, factors affecting shrinkage also affect creep in a similar way. Besides moisture movement, there is evidence that creep may also be due to time-dependent formation and propagation of microcracks, as well as microstructural adjustment under high stresses (where stress concentration exists). These mechanisms, together with water loss from the gel interlayer, lead to irreversible creep. Creeping develops rapidly at the beginning and gradually decreases with time. Approximately 75% of ultimate creep occurs during the first year. The ultimate creep strain (after 20 years) can be 3-6 times the elastic strain.

Creep can influence reinforced concrete in the following aspects.

i). Due to the delayed effects of creep, the long-term deflection of a beam can be 2-3 times larger than the initialdeflection.

ii). Creeping results in the reduction of stress in pre-stressed concrete which can lead to increased cracking and deflection under serviceload.

iii). In a R.C column supporting a constant load, creep can cause the initial stress in the steel to double or triple with time because steel is non-creeping and thus take over the force reduced in concrete due tocreep.

Creep is significantly influenced by the stress level. For concrete stress less than 50% of its strength, creep is linear with stress. In this case, the burger's body, which is a combination of Maxwell and Kelvin models, is a reasonable representation of creep behaviour. For stress more than 50% of the strength, the creep is a nonlinear function of stress, and linear viscoelastic models are no longer applicable. For stress level higher than 75-80% of strength, creep rupture can occur. It is therefore very important to keep in mind that in the design of concrete column, 0.8 f is taken tobe the strength limit.

TOPIC 3: Factors Affecting Creep Of Concrete

a) w/c ratio: The higher the w/c ratio, the higher is thecreep.

b) Aggregate stiffness (elastic modulus): The stiffer the aggregate, the smaller thecreep.

c) Aggregate fraction: higher aggregate fraction leads to reducedcreep.

d) Theoretical thickness: The theoretical thickness is defined as the ratio of section area to the semi- perimeter in contact with the atmosphere. Higher the theoretical thickness, smaller the creep and shrinkage.

e) Temperature: with increasing temperature, both the rate of creep and the ultimate creep increase. This is due to the increase in diffusion rate with temperature, as well as the removal of more water at a highertemperature.

f) Humidity: with higher humidity in the air, there is less exchange of moisture between the concrete and the surrounding environment. The amount of creep is hencereduced.

g) Age of concrete at loading: The creep strain at a given time after the application of loading is lower if loading is applied to concrete at a higher age. For example, if the same loading is applied to 14 day and 56 day concrete (of the same mix), and creep strain is measured at 28 and 70 days respectively (i.e., 14 days after load application), the 56 day concrete is found to creep less. This is because the hydration reaction has progressed to a greater extent in the 56 day concrete. With less capillary pores to hold water, creep isreduced.

UNIT-V

MIX DESIGN & SPECIAL CONCRETE

1. **Explain the test procedure for concrete mix design**
2. **Define special concrete and its types**
3. **Explain about polymer concrete**
4. **Define self-compacting concrete and its types**

TOPIC 1: Procedure for Concrete Mix Design –IS456:2000

1. Determine the mean target strength ftfrom the specified characteristic compressive strength at 28-day $f_{ck}$and the level of qualitycontrol.

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

Where, S is the standard deviation obtained from the Table of approximate contents given after the design mix.

2. Obtain the water cement ratio for the desired mean target using the empirical relationship between compressive strength and water cement ratio so chosen is checked against the limiting water cement ratio. The water cement ratio so chosen is checked against the limiting water cement ratio for the requirements of durability given in table and adopts the lower of the twovalues.
3. Estimate the amount of entrapped air for maximum nominal size of the aggregate fromthe table.
4. Select the water content, for the required workability and maximum size of aggregates(for aggregates in saturated surface dry condition) fromtable.
5. Determine the percentage of fine aggregate in total aggregate by absolute volume from table for the concrete using crushed coarseaggregate.
6. Adjust the values of water content and percentage of sand as provided in the table for any difference in workability, water cement ratio, grading of fine aggregate and for rounded aggregate the values are given intable.
7. Calculate the cement content form the water-cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content fromthe requirements of the durability, and greater of the two values isadopted.
8. From the quantities of water and cement per unit volume of concrete and the percentage of sand already determined in steps 6 and 7 above, calculate the content of coarse and fine aggregates per unit volume of concrete from the followingrelations:

$$V = \left[W + \frac{C}{S_c} + \frac{1}{p}\frac{f_a}{S_{fa}}\right] \times \frac{1}{1000}$$

$$V = \left[W + \frac{C}{S_c} + \frac{1}{1-p}\frac{C_a}{S_{ca}}\right] \times \frac{1}{1000}$$

Where, V = absolute volume of concrete = gross volume ($1m^3$) minus the volume of entrapped air

S_c = specific gravity of cement

W = Mass of water per cubic metre of concrete, kg C = mass of cement per cubic metre of concrete, kg
p = ratio of fine aggregate to total aggregate by absolute volume

fa, Ca = total masses of fine and coarse aggregates, per cubic metre of concrete, respectively, kg, and

S_{fa}, S_{ca} = specific gravities of saturated surface dry fine and coarse aggregates, respectively

9. Determine the concrete mix proportions for the first trial mix.
10. Prepare the concrete using the calculated proportions and cast three cubes of 150 mm size and test them wet after 28-days moist curing and check for thestrength.
11. Prepare trial mixes with suitable adjustments till the final mix proportions arrived.

TOPIC 2: SPECIAL CONCRETE

Special types of concrete are those with out-of-the-ordinary properties or those produced by unusual techniques. Concrete is by definition a composite material consisting essentially of a binding medium and aggregate particles, and it can take manyforms.

These concretes do have advantages as well asdisadvantages.

Types of specialconcrete

1. High Volume Fly AshConcrete.
2. Silica fumesconcrete.
3. GGBS, Slag basedconcrete.
4. Ternary blendconcrete.
5. Light weightconcrete.
6. Polymerconcrete.

7. Self-CompactingConcrete.
8. ColouredConcrete.
9. Fibre-reinforcedConcrete.
10. PerviousConcrete.
11. Water-proofConcrete.
12. Temperature ControlledConcrete

TOPIC 3: Polymerconcrete

Polymer concrete is part of group of concretes that use polymers to supplement or replace cement as a binder. The types include polymer-impregnated concrete, polymer concrete, and polymer-Portland-cement concrete.

• In polymer concrete, thermosetting resins are used as the principal polymer componentdue to their high thermal stability and resistance to a wide variety ofchemicals.

• Polymer concrete is also composed of aggregates that include silica, quartz, granite, limestone, and other high quality material.

- Polymer concrete may be used for new construction or repairing of oldconcrete.
- The low permeability and corrosive resistance of polymer concrete allows it to be used in swimming pools, sewer structure applications, drainage channels, electrolyticcells for base metal recovery, and other structures that contain liquids or corrosivechemicals.
- It is especially suited to the construction and rehabilitation of manholes due to their ability to withstand toxic and corrosive sewer gases and bacteria commonly found in sewer systems.
- It can also be used as a replacement for asphalt pavement, for higher durability and higher strength.
- Polymer concrete has historically not been widely adopted due to the high costsand difficulty associated with traditional manufacturingtechniques.

TOPIC 4: Self compacting concrete

Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congestedreinforcement.

The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibratedconcrete.

Very close to the Kolhapur there is project of steel industry, sand used for the formation of mould when the moulds are opened the waste sand is dumped for the filling the low lying areas while doing this the agriculture areas is converted into barren area. Because there is no space for the waste other than the land filling. similar case is in case of aluminium industry where red mud is concluded to be waste, which contains lot amount of bauxite and that is why red mud is also dump in the nearby areas here it is causing big threat for the society and it is disturbing the eco system of the environment. So it is the need to use this particular otherwise waste material for the constructive in such fashion in the case of concrete so that concrete which became cost effective as well aseco-friendly.

Types

Powder type of self-compacting concrete: This is proportioned to give the required self-compactability by reducing the water-powder ratio and provide adequate segregation resistance.

Viscosity agent type self-compacting concrete: This type is proportioned to provide self-compaction by the use of viscosity modifying admixture to provide segregation resistance.

Combination type self-compacting concrete: This type is proportioned so as to obtain self-compactability mainly by reducing the water powderratio.

16. Unit wise-Question bank

UNIT-I
CEMENT

Two marks question with answers

1. **What is the chemical composition of cement?**

Composition of Portland cement consists essentially of compounds of lime (calcium oxide, CaO) mixed with silica (silicon dioxide, SiO_2) and alumina (aluminum oxide, Al_2O_3). The lime is obtained from a calcareous (lime-containing) raw material, and the other oxides are derived from an argillaceous (clayey) material.

2. **What is grade of cement? List any three grades of cement with their strengths.**

- 721 hr not less than 23 MPa for 43 grade, 27 MPa for 53 grade
- 1682 hrs not less than 33MPa for 43 grade, 37MPa for 53 grade
- 6724 hrs not less than 43MPa for 43 grade, 53 MPa for 53 grade

3. **Explain bogue'scompounds of cement?**

Thornbohm's description of the minerals in cement was found to be similar to Bogue's compound. Hence, Bough's Compounds C3S, C2S, C3A, C4AF are sometimes called in literature as Alite, Belite, Celite, and Felite.

4. **Define hydration of cement?**

The water causes the hardening of concrete through a process called hydration. Hydration is a chemical reaction in which the major compounds in cement form chemical bonds with water molecules and become hydrates or hydration products.

5. **Write brief about Portland cement?**

Concrete is made by Portland cement, water and aggregates. Portland cement is hydraulic cement that hardens in water to form a water-resistant compound. The hydration products act as binder to hold the aggregates together to form concrete. The name Portland cement comes from the fact that the colour and quality of the resulting concrete are similar to Portland stone, a kind of limestone found in England.

Three marks question with answers

1. **List various types of cement.**

- Rapid Hardening Cement
- Quick setting cement
- Low Heat Cement
- Sulphates resisting cement
- Blast Furnace Slag Cement
- High Alumina Cement
- White Cement
- Coloured cement
- Pozzolanic Cement
- Air Entraining Cement
- Hydrographic cement

2. **What is the purpose of plasticizer in concrete?**

Plasticizers or water reducers, and superplasticizer or high range water reducers, are chemical admixtures that can be added to concrete mixtures to improve workability. Unless the mix is "starved" of water, the strength of concrete is inversely proportional to the amount of water added or water-cement (w/c) ratio.

3. **Explain about Normal consistency test?**

This test is to determine the water required to achievea desired plasticity state (called normal consistency) of cement paste. It isobtained with the Vicat apparatus by measuring the penetration of a loadedneedle.

4. **Explain about Soundness of cement?**

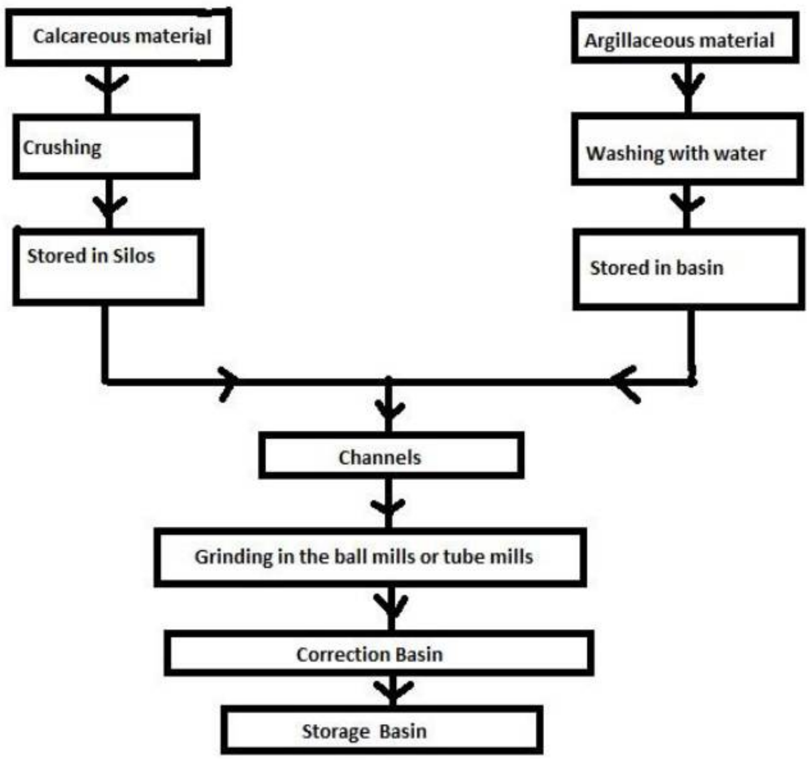
Unsoundness in cement paste refers to excessive volume change after setting and cement is caused by the slow hydration of MgO or freelime.Their reactions are $MgO + H_2O = Mg(OH)_2$ and $CaO + H_2O = Ca(OH)_2$. Another factor that can cause unsoundness is the delayed formation of cement and concrete have hardened. The pressure from crystal growth will lead to cracking and damage. The soundness of the cement must be tested by accelerated methods. Le Chatelier test this test is to measure the potential for volumetric change of cement paste. Another method is Autoclave Expansion test which use an autoclave to increase the temperature to accelerate the process.

Five marks question with answers

1. **Explain the manufacturing process of cement?**

Manufacturing Portland cement:

The basic ingredients of both the dry and wet processes are the same. By mass, lime and silica make up approximately 85% of Portland cement. The materials that are commonly used are limestone, shells, chalk, shale, clay, slate, silica sand, and iron ore.



2. What is hydrated cement? Explain the heat of hydration

A compound produced by combining a substance chemically with water. Many minerals and crystalline substances are hydrates. To combine a compound with water, especially to form a hydrate.to supply water to a person in order to restore or maintain a balance of fluids.

Heat of Hydration

The heat of hydration is the heat generated when water and portland cement react. Heat of hydration is most influenced by the proportion of C_3S and C_3A in the cement, but is also influenced by water-cement ratio, fineness and curing temperature. As each one of these factors is increased, heat of hydration increases. In large mass concrete structures such as gravity dams, hydration heat is produced significantly faster than it can be dissipated (especially in the center of large concrete masses), which can create high temperatures in the center of these large concrete masses that, in turn, may cause undesirable stresses as the concrete cools to ambient temperature. Conversely, the heat of hydration can help maintain favorable curing temperatures during winter

3. Explain the testing method of Compressive Strength of Cement

This test is carried out to determine the **compressive strength of cement**.

Test Procedure for compressive strength of cement:

(i) The mortar of cement and sand is prepared. The proportion is 1:3 which means that (X) gm of cement is mixed with 3(X) gm of sand.

(ii) The water is added to the mortar. The water cement ratio is kept as 0.4 which means that (X) gm of water is added to dry mortar.

(iii) The mortar is placed in moulds. The test specimens are in the form of cubes with side as 70.6 mm or 76 mm. The moulds are of metal and they are constructed in such a way that the specimens can be easily taken out without being damaged. For 70.6 mm and 76 mm cubes, the cement required is 185 gm and 235 gm respectively.

The mortar, after being placed in the moulds, is compacted in vibrating machine for 2 minutes.

(iv) Themoulds are placed in a damp cabin for 24 hours.

(vi) The specimens are removed from the moulds and they are submerged in clean water for curing.

(vii) The cubes are then tested in **compression testing machine** at the end of 3 days and 7 days. The testing of cubes is carried out on their three sides without packing. Thus three cubes are tested each time to find out the compressive strength at the end of 3 days and 7 days. The average value is then worked out. During the test, the load is to be applied uniformly at the rate of 350 kg/cm2 or 35 N/mm2.

(viii) The **compressive strength of cement** at the end of 3 days should not be less than 115 kg/cm2 or 11.50 N/mm2 and that at the end of 7 days should no be less than 175 kg/cm2 or 17.50 N/mm2.

Objective question with answers

1. For quality control of Portland cement, the test essentiallydoneis [ ]
   A. Setting time B. Soundness C.tensilestrength D. All theabove

2. Lower the normalconsistencyvalue, [ ]
   A. Lower will be the strength ofconcrete B. Medium will be the strength ofconcrete
   C. Higher will be the strengthofconcrete D. None of theabove

3. The mixture of different ingredients of cement, isburntat [ ]
   A.1000°C B.1200°C C.1400°C D.1900°C

4. The size of vicat needle,used to conduct setting of cement is [ ]
   A. 10mmDia B.1mm^2 C.3mm2 D. 10 mmDia

5. To obtain cement dry powder, lime stones and shales or their slurry, is burnt in a rotary kiln at a temperaturebetween [ ]
A. 1100° and 1200°C B. 1200° and 1300°C C. 1300° and 1400°C
D.1400° and 1500°C

6. Vicat's apparatus isusedfor [ ]
   A. Finenesstest B.consistencytest C. settingtimetest D. B andC

7. Fine aggregates are the aggregates having the size less than: [ ]
   A. 5mm B.4.75mm C. 3.50mm D. 2mm

8. For the improvement of workability of concrete, the shape of aggregate recommendedis
   A. Angular B.Round C.Flaky D.Irregular

9. In an ordinary Portland cement, the composition oflimeis [ ]

A. 50% B.63% C.21% D.33%

10. Inconcretecubetest,thestandardsizeofcubeis [ ]
    A. 15 cm x 15 cm x15cm B. 10 cm x 10 cm x 10cm
    C. 20 cm x20cmx 20cm D. None

KEY

Q.NO	1	2	3	4	5	6	7	8	9	10
ANS	D	A	C	B	D	D	B	B	B	A

Fill in the blanks question with answers

1. Approximate percentage range of CaO in OPC is=
2. Approximate percentage range of Al_2O_3 in OPCis =
3. Approximate percentage of SIO_2in OPC is=
4. _ number of grades availableinOPC
5. Which compound is liberates higherheat=
6. Which compound is liberateslowerheat=
7. In M20 concrete M refersto=
8. At an early age greater strength contribute compoundis=
9. The role of gypsum in cementis=
10. Least strength contributescompoundsis=

KEY

Q.NO	**ANSWERS**
1	60-67%
2	3-8_%
3	17-25%
4	3
5	C_3A

6	C4AF
7	mix proportion
8	C_2S
9	control the “setting of cement”
10	C4AF

UNIT-II

AGGREGATE AND ADMIXTURES

Two marks question with answers

1. **How does alkali aggregate reaction affect concrete?**

- The alkali–silica reaction (ASR), more commonly known as "concrete cancer", is a swelling reaction that occurs over time in concrete between the highly alkaline cement paste and the reactive non-crystalline (amorphous) silica found in many common aggregates, given sufficient moisture.

2. **What is the common classification of aggregates?**

Aggregates are classified into 2 types according to size

- Fine aggregate
- Coarse aggregate

Aggregates are classified according to shape

- Rounded aggregates
- Irregular or partly rounded aggregates
- Angular aggregates
- Flaky aggregates
- Elongated aggregates
- Flaky and elongated aggregates

3. **List out the types of admixtures?**

a) Accelerating admixtures

b) Retarding admixtures

c) Water-reducing admixtures

d) Air-entraining admixtures

e) Super plasticizing admixtures

f) Air-entraining admixtures

g) Accelerating admixtures

h) Water reducing and set controlling admixtures

i) Admixtures for flowing concrete

j) Miscellaneous admixtures

4. Define admixtures?

A material other than water, aggregates, or cement that is used as an ingredient of concrete or mortar to control setting and early hardening, workability, or to provide additional cementing properties

5. Explain Alkali Aggregate Reaction

Alkali–aggregate reaction is a term mainly referring to a reaction which occurs over time in concrete between the highly alkaline cement paste and non-crystalline silicon dioxide, which is found in many common aggregates. This reaction can cause expansion of the altered aggregate, leading to spalling and loss of strength of the concrete.

The alkali–aggregate reaction is a general, but relatively vague, expression which can lead to confusion. More precise definitions include the following:

1. Alkali–silica reaction (ASR, the most common reaction of this type);
2. Alkali–silicate reaction, and;
3. Alkali–carbonate reaction

Five marks question with answers

1. Explain the soundness of aggregate?

Soundness of Aggregate

The soundness test determines an aggregate’s resistance to disintegration by weathering and, in particular, freeze-thaw cycles. Aggregates that are durable (resistant to weathering) are less likely to degrade in the field and cause premature HMA pavement distress and potentially, failure.

The soundness test repeatedly submerges an aggregate sample in a sodium sulphate or magnesium sulphate solution. This process causes salt crystals to form in the aggregate's water permeable pores. The formation of these crystals creates internal forces that apply pressure on aggregate pores and tend to break the aggregate. After a specified number of submerging and drying repetitions, the aggregate is sieved to determine the percent loss of material.

2. What is Admixtures and explain the classification of admixtures?

A material other than water, aggregates, or cement that is used as an ingredient of concrete or mortar to control setting and early hardening, workability, or to provide additional cementing properties.

Chemical admixtures

Accelerators, Retarders, Water-reducing agents, Super plasticizers, Air entraining agents etc.

Water-reducing admixture / Plasticizers

- To achieve a higher strength by decreasing the water cement ratio at the same workability as an admixture free mix.
- To achieve the same workability by decreasing the cement content so as to reduce the heat of hydration in mass concrete.
- To increase the workability so as to ease placing in accessible locations
- Water reduction more than 5% but less than 12%.

Super Plasticizers:

These are more recent and more effective type of water reducing admixtures also known as *high range water reducer.*

Accelerator

An admixture which, when added to concrete, mortar, or grout, increases the rate of hydration of hydraulic cement, shortens the time of set in concrete, or increases the rate of hardening or strength development.

Air Entrained Admixtures:

An addition for hydraulic cement or an admixture for concrete or mortar which causes air, usually in small quantity, to be incorporated in the form of minute bubbles in the concrete or mortar during mixing, usually to increase its workability **and** frost resistance**.** Air-entraining admixtures are **surfactants** that change the surface tension of the water. Traditionally, they were based on fatty acid salts or vinsol resin but these have largely been replaced by synthetic surfactants or blends of surfactants to give improved stability and void characteristics to the entrained air. Air entrainment is used to produce a number of effects in both the plastic and the hardened concrete

Mineral admixtures

Fly-ash Blast-furnace slag, Silica fume and Rice husk Ash etc

Fly Ash:

The finely divided residue resulting from the combustion of ground or powdered coal. Fly ash is generally captured from the chimneys of coal-fired power plants; it has POZZOLANIC properties, and is sometimes blended with cement for this reason.

Fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline) and calcium oxide (CaO). Toxic constituents include arsenic, beryllium, boron, cadmium, chromium, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, thallium, and vanadium.

Silica Fume:

The terms condensed silica fume, microsilica, silica fume and volatilized silica are often used to describe the by-products extracted from the exhaust gases of silicon, ferrosilicon and other metal alloy furnaces. However, the terms microsilica and silica fume are used to describe those condensed silica fumes that are of high quality, for use in the cement and concrete industry.

Rice Husk Ash:

This is a bio waste from the husk left from the grains of rice. It is used as a pozzolanic material in cement to increase durability and strength. The silica is absorbed from the ground and gathered in the husk where it makes a structure and is filled with cellulose. When cellulose is burned, only silica is left which is grinded to fine powder which is used as pozzolana.

3. **How does alkali aggregate reaction affect concrete? Also explain thermal properties of aggregates?**

Alkali–aggregate reaction is a term mainly referring to a reaction which occurs over time in concrete between the highly alkaline cement paste and non-crystalline silicon dioxide, which is found in many common aggregates. This reaction can cause expansion of the altered aggregate, leading to spalling and loss of strength of the concrete.

The alkali–aggregate reaction is a general, but relatively vague, expression which can lead to confusion. More precise definitions include the following:

1. Alkali–silica reaction (ASR, the most common reaction of this type);
2. Alkali–silicate reaction, and;
3. Alkali–carbonate reaction.

Thermal properties

Rock and aggregates posses' three thermal properties which are coefficient of expansion, specific heat and thermal conductivity

The thermal conductivity varies with the density of concrete, with heavier aggregates resulting in higher thermal conductivity. The conductivity of concretes known generally to decrease with increased temperature, through the loss of pore water and the dehydration of cement paste.

4. **What is Bulk Density of Aggregates**

Bulk density of aggregates is the mass of aggregates required to fill the container of a unit volume after aggregates are batched based on volume It depends on the packing of aggregate i.e. either loosely packed aggregates **or** well dense compacted aggregates. In case, if the specific gravity of material is known, then it depends on the shape and size of particles. It is because, if all the particles are of same size than packing can be done up to a very limited extent. If the addition of smaller particles is possible within the voids of larger particles than these smaller particlesenhance the bulk density of the packed material**.** Shape of the particles also influence very widely, because closeness particles depends on the shape of aggregates**.**

Loose Bulk Density

Loose bulk density can be determined by filling the container with dried aggregates until it overflows from the container**.** Now level the top surface of container by rolling a rod on it. After that, weight the aggregate mass that is inside the container and divide it by the volume of container. This will give you the bulk density of the loose aggregates.

Compacted Bulk Density

Compacted bulk density can be determined by filling the container in three layers and tamped each layer with a 16mm diameter rounded nosed rod. After filling in three layersnow leveled the top surface and evaluate compacted bulk density by using the same expression as for loose bulk density.

5. **Explain the classification of aggregates?**

Aggregates are classified according to shape

1.Rounded aggregates

2.Irregular or partly rounded aggregates

3.Angular aggregates

4.Flaky aggregates

5.Elongated aggregates

6.Flaky and elongated aggregates

Aggregates are classified according to size

1.Fine aggregate

2.Coarse aggregate

Aggregates are classified according to source

1. Igneous rocks
2. Sedimentary rocks
3. Metamorphic rocks

Aggregates are classified according to weight

1. Normal weight aggregates
2. Light weight aggregates
3. Heavy weight aggregates

Objectives question with answers

1. The rock which is notcalcareous,is: [ ]

   A.limestone B.Macl C.Chalk D.Laterite

2. The resistance of an aggregate to compressive forces isknownas [ ]

   A.Crushingstrength B. Impact value C. Shear resistance D.None of the above

3. For the improvement of workability of concrete, the shape of aggregate recommendedis

   A.Angular B.Round C.Flaky D.Irregular

4. Determination of Moisture Content of aggregateby [ ]

   A.Dryingmethod B. Displacementmethod
   C. CalciumCarbidemethod D. All of theabove.

5. Factors which promote alkali aggregate reactionare [ ]

   A. Reactive typeofaggregate B. High alkalicontent
   C. AvailabilityofMoisture D. All theabove

6. In concrete the fine aggregates is usedto [ ]

   A. Fill up the voidsincement B. Fill up the voids in coarseaggregate
   C. Fill up the voidsinsand D. All theabove

7. In Shape Test, the dimension of thickness gauge is calculatedas [ ]
   A. 2.4timestheaverageofthesizeofretainedandpassingSieve
   B. 1.2timestheaverageofthesizeofretainedandpassingSieve
   C. 0.6timestheaverageofthesizeofretainedandpassingSieve
   D. 1.8timestheaverageofthesizeofretainedandpassingSieve

8. In concrete the material used as a fineaggregateis [ ]
   A. Cement B.Sand C.jelly D.Gypsum

9. The commonly used material in the manufacture of cementis[]
   A.sandstone B.Slate C.limestone D.graphite.

KEY

Q.NO	1	2	3	4	5	6	7	8	9	10
ANS	B	C	B	D	D	D		B	C	

Fill in the blanks question with answers

1. Thesizeofthecoarseaggregateismorethan=
2. Thesizeofthefineaggregateislessthan=
3. The minimum 28 days’ compressive strength of 43 grade cementis=
4. The easiness of handling concrete is knownas=
5. Device which is used to find out normal consistency of cementis=

KEY

Q.NO	ANSWERS

1	4.75mm
2	4.75mm
3	43Mpa
4	workability
5	vicats apparatus
6	
7	

UNIT-III
FRESH CONCRETE

Two marks question with answers

1. Definebleeding.

Bleeding is one form of segregation, where water comes out to the surface of the concrete, being lowest specific gravity among all the ingredients of concrete. Bleeding can be easily identified in the field by the appearance of a thin layer of water in the top surface of freshly mixed concrete.

2. DefineSegregation.

Segregation in concrete is commonly thought as separation of some size groups of aggregates from cement mortar in isolated locations with corresponding deficiencies of these materials in other locations. Segregation results in proportions of the laid concrete being in variation to those as designed Segregation could result from internal factors such as concrete that is not proportioned properly and not mixed adequately, or too workable a mix. It also could result from external factors such as too much vibration, improper transportation, placement, or adverse weather conditions. The corresponding increase in proportion of cement paste in upper areas would tend to make them susceptible to increased shrinkage and formation of cracks. These cracks could be 10 μm to 500 μm wide, formed perpendicular to the surface, and be in the form of map patterns."

1. **Define workability.**

According to Granville "it is that property of the concrete which determines the amount of useful internal work necessary to produce full compaction."

Powers defined it as "that property of plastic concrete mixture which determines the ease with which it can be placed and the degree to which it resists segregation"

ACI (American Concrete Institute) defines it as 'that property of freshly mixed concrete or mortar which determines the ease and homogeneity with which it can be mixed, placed, consolidated and finished'.

ASTM (American Society for Testing and Materials) defines it as "that property determining the effort required to manipulate a freshly mixed quantity of concrete with minimum loss of homogeneity".

4. Listthedifferentfactorsaffectingworkability.

- Cement content of concrete.
- Water content of concrete.
- Mix proportions of concrete.
- Size of aggregates.
- Shape of aggregates.
- Grading of aggregates.
- Surface texture of aggregates.
- Use of admixtures in concrete.

5. Define Compacting Factor of workable concrete?

The ratio of the weight of partiallycompacted concrete to the weight of the concrete when fullycompacted in the same mould. The Compacting Factor Apparatus is used to determine the compaction factor of concrete with low, medium and high workability.

<u>Three marks question with answers</u>

1. **What is the slump test for?**

The slump test is a means of assessing the consistency of fresh concrete. It is used, indirectly, as a means of checking that the correct amount of water has been added to the mix.

2. **What is mixing of concrete and its methods?**

Through mixing of concrete is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency. There are two methods adopted for mixing concrete hand mixing and machine mixing

3. **Define compaction and its methods?**

Compaction of concrete is the process adopted for expelling the entrapped air from the concrete. In process of mixing, transporting, and placing of concrete air is likely to get entrapped in the concrete.

Methods of compaction:

- Hand compaction
- Compaction by vibrators
- Compaction by pressure and jolting
- Compaction by spinning

4. **Flow Table Test**

The flow table test or flow test, also known as the slump-flow test, is a method to determine consistency of fresh concrete. Flow table test is also used to identify transportable moisture limit of solid bulk cargoes. It is used primarily for assessing concrete that is too fluid (workable) to be measured using the slump test, because the concrete will not retain its shape when the cone is removed.

Application when fresh concrete is delivered to a site by a truck mixer, its consistency needs to be checked before it is poured into formwork.

If consistency is not at the desired level, concrete will not have the required strength and other qualities once it has set. If concrete is too pasty, cavities may form within it. Rebar may become corroded, and concrete will crack. Cavities also reduce the concrete strength.

5. What is meant by proportioning of concrete?

The process of relative proportions of cement, sand, coarse aggregate and water, so as to obtain a concrete of desired quality is known as the proportioning of concrete.

The proportions of coarse aggregate, cement and water should be such that the resulting concrete has the following properties:

- When concrete is fresh, it should have enough workability so that it can be placed in the formwork economically.
- The concrete must possess maximum density or in the other words, it should be strongest and most water-tight.
- The cost of materials and labour required to form concrete should be minimum.

Five marks question with answers

1. Explain in detail the slump test procedure and working principles

Concrete slump test is to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of the work. Concrete slump test is carried out from batch to batch to check the uniform quality of concrete during construction.
The slump test is the most simple workability test for concrete, involves low cost and provides immediate results
Factors which influence the concrete slump test:

1. Material properties like chemistry, fineness, particle size distribution, moisture content and temperature of cementitious materials. Size, texture, combined grading, cleanliness and moisture content of the aggregates,
2. Chemical admixtures dosage, type, combination, interaction, sequence of addition and its effectiveness,
3. Air content of concrete,
4. Concrete batching, mixing and transporting methods and equipment,
5. Temperature of the concrete,
6. Sampling of concrete, slump-testing technique and the condition of test equipment,
7. The amount of free water in the concrete, and

8. Time since mixing of concrete at the time of testing.

PROCEDURE FOR CONCRETE SLUMP TEST:

1. Clean the internal surface of the mould and apply oil.

2. Place the mould on a smooth horizontal non- porous base plate.

3. Fill the mould with the prepared concrete mix in 4 approximately equal layers.

4. Tamp each layer with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould. For the subsequent layers, the tamping should penetrate into the underlying layer.

5. Remove the excess concrete and level the surface with a trowel.

6. Clean away the mortar or water leaked out between the mould and the base plate.

7. Raise the mould from the concrete immediately and slowly in vertical direction.

8. Measure the slump as the difference between the height of the mould and that of height point of the specimen being tested.

2. Explain brieflyFactors affecting workability

Workable concrete shows very less internal friction between particles and overcomes the frictional resistance with just the amount of compacting efforts provided. Workability of the concrete depends on a number of interrelating factors. Water content, aggregate properties, use of admixtures, fineness of cement are the factors affecting workability.

1. **Water content:**

   The increase in water content increases the fluidity of the concrete thus providing greater lubrication. This helps to increase the workability of the concrete. Increasing the water content should be the last resort to improve the workability in the concrete as this will seriously affect the strength of the concrete. Even if more amount of water is to be added, more cement also should be added so that the water/ cement ratio remains the same and hence the strength of the concrete remains unaffected.

2. **Size of aggregates:**

The surface area of bigger aggregates is less and hence less amount of water is required for lubricating the surface to reduce the friction. Thus the concrete having large sized aggregate is more workable (of course, within certain limits).

3. **Mix proportions:**

Aggregate/ cement ratio is the measure of how lean or rich the concrete is. If aggregate/ cement ratio is higher, the concrete becomes leaner. In lean concrete less paste is available for the lubrication of the aggregate, while in rich concrete with low a/c ratio, more paste is available which makes the mix more cohesive and hence provides better workability.

4. **Shape of aggregates:**

Rounded aggregates have considerably less surface area and less voids in comparison to angular or flaky aggregates which provide better possibility of overcoming the frictional resistance. Further, angular and flaky aggregates make concrete very harsh.

5. **Surface texture of aggregates:**

The aggregates having smooth or glossy texture have less surface area compared to rough textured aggregates. This provides better workability as less amount of water is required for lubricating effect. But, taking into account the poor interlocking action provided by the glossy textured aggregate, its use is generally discouraged in high strength concrete.

6. **Grading of aggregates:**

Well graded aggregate is the one with least amount of voids in a given volume. If the grading of aggregate is good, the voids will be less and hence higher the workability.

7. **Use of admixtures:**

Use of admixtures in concrete is the major factor that affects the workability. The use of plasticizers and super-plasticizers amply increase the workability of the concrete. Air entraining agents produce air bubbles which act as rollers between particles and provide better mobility thus improving the workability.

8. **Time and temperature:**

Fresh concrete gets stiffened as the time flows. This is because some of the water used to mix the concrete gets evaporated and some gets absorbed by the aggregates. Thus the workability of concrete reduces with time. This loss of workability with time is known *as slump loss.* The effect of temperature on workability of concrete is noteworthy. As the temperature increases, the workability of the mix reduces.

3. Explain the Measurements of workability/Workability Tests

<u>Slump test</u>

- It is the most common method for measuring the workability of freshly mixed concrete. It can be performed both in lab and at site. Uniformity of the concrete regarding workability and quality aspects can be assessed from batch to batch by observing the nature in which the concrete slumps. It is not very suitable for very wet or very dry concrete.
- A steel mould in the form of frustum of cone is used in slump test which has the top diameter of 100 mm, bottom diameter of 200 mm and the height is 300 mm. According to Indian standard specification, the maximum size of the aggregate in concrete that can be used to perform slump test is restricted to 38 mm.
- The mould is cleaned and freed from any surface moistures and then the concrete is placed in three layers. Each layer is tamped 25 times with a standard tamping rod (16 mm dia, 0.6 meter length). Immediately after filling, the cone is slowly lifted and the concrete is allowed to subside. The decrease in the height of the center of the slumped concrete is called slump and is measured to the nearest 5mm.
- If the concrete subsides evenly all round, the slump measured is true slump. If one half of the cone slides down an inclined plane, a shear slump is said to have taken place and the test has to be repeated. Too wet mix shows collapsible nature of slump.

<u>Compacting factor test</u>

- This test is generally carried out in laboratory but can be used in site also. It is particularly useful for concrete mixes of very low workability (or very dry concrete) as they are insensitive to slump test.
- This test works on the principle of determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height.

Container	**Top diameter (mm)**	**Bottom diameter (mm)**	**Height (mm)**
Upper hopper	254	127	279
Lower hopper	229	127	229
Cylinder	152	152	305
Distance between bottom of upper hopper and top of lower hopper = 203 mm			
Distance between bottom of lower hopper and top of cylinder = 203 mm			

- The concrete is placed in the upper hopper gently so that no effort is applied to produce compaction. The bottom door is opened so that the concrete falls on the lower hopper. Again the bottom door of the lower hopper is opened and the concrete falls on the cylinder. After removing the excess concrete by the help of blades, the weight of the cylinder (known volume) is taken to nearest 10 grams. This weight is known as "weight of partially compacted concrete". The cylinder is emptied and then filled with the same sample rammed heavily so as to obtain full compaction. The cylinder is weighed to nearest 10 grams. This weight is known as "weight of fully compacted concrete".
- Compacting factor = (weight of partially compacted concrete) / (weight of fully compacted concrete)

Vee-Bee test

- Vee-Bee test is a good laboratory test suitable for stiff concrete mixes having low and very low workability. It consists of a vibrating table, a metal pot, a sheet of metal cone and a standard iron rod.
- In this test, Slump test as mentioned above is performed by placing the slump cone inside the sheet metal cylindrical pot. Then the vibration is started and the time on a stop watch is noted. The time taken by the concrete to take cylindrical shape after the conical shape disappears is noted. This time recorded is known as Vee-Bee Degree or Vee-Bee seconds.

Flow Test

- This is a laboratory test. It gives an indication of the quality of the concrete with respect to consistency, cohesiveness and the proneness to segregation. The spread of the flow of the concrete is measured and this is related to workability. This test is best suitable for flowing concrete made by the use of superplasticizing admixtures.

Kelly Ball Test

- This is a simple field test consisting of the determination of the indentation made by 15 cm diameter metal hemisphere weighing 13.6 kg when freely placed on fresh concrete. It is quite faster and provides precise measurement of workability than slump test. But it requires large amount of concrete to be

4. Briefly explain manufacturing procedureofconcrete.

Batching:

The measurement of materials making concrete is known as batching, these batching are two methods weigh batching and volume batching

Mixing:

Mixing of material is essential for the production of uniform concrete. The mixing should ensure that the mass becomes uniform in color and consistency .there are two methods adopted for mixing concrete hand mixing and machine mixing

Transporting:

The method adopted for transportation of concrete

Mortar pan, wheel barrow hand cart, crane bucket and rope way, truck mixer, belt conveyor, transit mixer, pump and pipeline, helicopter.

Placing of concrete:

Concrete is invariably laid as a foundation bed below the walls or columns before placing the concrete in the foundation all the loose earth must be removed from the bed.

Compaction:

Compaction of concrete is the process adopted for expelling the entrapped air from the concrete. the method of compaction is hand compaction, vibration compaction, compaction by pressure and jolting, compaction by spinning.

Curing:

curing can also be described as keeping the concrete moist and warm enough so that the hydration of cement can continue more elaborately it can be described as the process of maintaining a satisfactory moisture content and a favorable temperature in concrete during the period immediately following placement so that hydration of cement may continue until the desired properties are developed to a sufficient degree to meet the requirement of service. Curing methods are water curing, membrane curing, and application of heat.

Finishing:

It’s the last operation making concrete. Its increases does not apply to all concrete operations

5. Explain briefly quality of mixing water inconcrete

Concrete is a chemically combined mass which is manufactured from binding materials and inert materials with water.

Function of Water in Concrete:

To wet the surface of aggregates to develop adhesion because the cement pastes adheres quickly and satisfactory to the wet surface of the aggregates than to a dry surface.

To prepare a plastic mixture of the various ingredients and to impart workability to concrete to facilitate placing in the desired position and

Water is also needed for the hydration of the cementing materials to set and harden during the period of curing.

The quantity of water in the mix plays a vital role on the strength of the concrete. Some water which have adverse effect on hardened concrete. Sometimes may not be harmless or even beneficial during mixing. So clear distinction should be made between the effect on hardened concrete and the quality of mixing water.

The effect on concreting for different types of contamination or impurities are described below:

Suspended Solids:

Mixing water which high content of suspended solids should be allowed to stand in a setting basing before use as it is undesirable to introduce large quantities of clay and slit into the concrete.

Acidity and Alkalinity:

Natural water that is slightly acidic are harmless, but presence of humic or other organic acids may result adverse affect over the hardening of concrete. Water which are highly alkaline should also be tested.

Algae:

The presence of algae in mixing water causes air entrainments with a consequent loss of strength. The green or brown slime forming algae should be regarded with suspicion and such water should be tested carefully.

Sea Water:

Sea water contains a total salinity of about 3.5%(78% of the dissolved solids being NaCl and 15% $MgCl_2$ and $MgSO_4$), which produces a slightly higher early strength but a lower long-term strength. The loss of strength is usually limited to 15% and can therefore be tolerated. Sea water reduces the initial setting time of cement but do not effect final setting time.

Chloride:

Water containing large amount of chlorides tends to cause persistent dampness and surface efflorescence. The presence of chlorides in concrete containing embedded steel can lead to its corrosion.

Moisture Content of Aggregate:

Aggregate usually contains some surface moisture. Coarse aggregate rarely contains more than 1% of surface moisture but fine aggregate can contain in excess of 10%. This water can represent a substantial proportion of the total mixing water indicating a significant importance in the quality of the water that contributes surface moisture in aggregate

6. Explain the Effect of time and temperature on workability

When fresh concrete is laid at the site then proper curing of concrete is required, because structures are exposed to the environment and in these conditions if there is no such an arrangement against the environment, then there are many factors that affect the workability of concrete and temperature is One of them. Temperature, almost in every aspect has negative effects on the properties of concrete and same is the case with the workability of fresh concrete.

When temperature increases, then in the same proportion workability of fresh concrete decreases. The reason that stands behind is " when temperature increases then evaporation rate also increases due to that hydration rate decreases and hence, concrete will gain strength earlier ". Due to fast hydration of concrete, a hardening comes in concrete and that decreases the workability of fresh concrete. Therefore, In return manipulation of concrete becomes very difficult.

It indicates that the temperature has a negative effect on the workability of concrete as well as strength up to some extent. Temperature decreases the setting time by increasing hydration rate and that increase the early age strength of the concrete.

This is an advantage that less time will be required before removing of form works on site, but this decrease the use of proper placement of concrete in the initial stages. And if concrete is not properly laid, then strength distribution will not remain the same throughout the cross-section

7. Explain briefly the setting time of concrete?

Generally Initial setting is the time elapsed between the moment water is added to the cement to the time at which paste starts losing its plasticity. Final setting time of cement is the time elapsed between the moment the water is added to the cement to the time at which paste has completely lost its plasticity and attained sufficient firmness to resist certain definite pressure.

Cement + water = paste

Paste + fine aggregate = mortar,

Mortar + coarse aggregate = concrete

Time is required for mixing, transporting, placing, compacting and finishing. During this time the above mentioned cement paste/mortar/concrete must be in plastic condition which is termed as Initial setting time of cement. Here 30 min are given while handling these mixing operations, here fineness of cement and suitable constituents are maintained in such a way that concrete is remained in plastic condition for handling procedures.

Initial setting time:

1. Cement is mixed with 0.85 times the water required for standard consistency.
2. As per vicat's test "the time elapsed since the addition of water to the cement up to the time at which the needle cannot penetrate 5 to 7 mm from the bottom of the vicat'smould.

Final setting time:

1. Determined by Vicat's apparatus using vicat's needle with annular collar of 5cm diameter.
2. As per vicat's test "the time elapsed since the addition of water to the cement up to the time at which the needle with annular collar can only make a mark on the hard cement surface.

8. What is segregation and how can it be prevented?

Segregation of concrete is separation of ingredients of concrete from each other. In good concrete all concrete aggregates are evenly coated with sand and cement paste and forms a homogeneous mass.

During handling, transporting and placing, due to jerks and vibrations the paste of cement and sands gets separated from coarse aggregate. If concrete segregates during transit it should be remixed properly before depositing. However a concrete where initial setting time is over, should not be used.

Prevention of Segregation of Concrete:

Wherever depth of concreting is more than 1.5 meters it should be placed through temporary inclined chutes. The angle of inclination may be kept between 1:3 and 1:2 so that concrete from top of chutes travels smoothly to bottom, use of small quantity of free water from top at intervals helps in lubricating the path of flow of concrete to bottom smoothly. The delivery end of chute should be as close as possible to the point of deposit.

Segregation in deep foundations and rafts of thickness more than 1 meter, there is every possibility of presence of segregated concrete near bottom or in center if proper supervision is not there. Such segregation can be detected by advanced method of testing like ultrasonic testing. In case of doubt random ultrasonic testing should be conducted and if it is present, designer's opinion should be taken. This type of segregation can be rectified by pressure grounding with special chemical compounds.

After any defect rectified by pressure grouting core test has to be performed to ensure that the strength of concrete has reached to the desired level

9. **What is meant by curing of concrete?**

Curing of concrete is defined as the process of maintaining the moisture and temperature conditions of concrete for hydration reaction to normally so that concrete develops hardened properties over time. The main components which need to be taken care are moisture, heat and time during curing process.

Why curing of concrete is required?

Curing of concrete is required for the following reasons:

- To prevent the concrete to dry out prematurely due to solar radiation and wind. This prevents plastic shrinkage of concrete.
- It helps to maintain the concrete temperature by allowing the hydration process. Hydration process requires water to carry on and releases heat.
- Curing helps the concrete to harden and bond with internal materials and reinforcement. This helps to prevent damage to bond between concrete and reinforcement due to vibration and impact.
- This helps development of impermeable, crack free and durable concrete.

Objective question with answers

1. In rich mixes; use of _size aggregate givesbetterresults. [ ]
   A. Larger B.Medium C.Smaller D.None

2. For given water content, workability decreases if the concrete aggregates

contain an excess of

A. Thin particles B. elongated particles Flakyparticles D. all theabove

B.

3. For ensuring quality of concrete use [ ]

A. Single sized aggregates B. two sized aggregate

C. graded aggregates D. coarseaggregates

4. The standard sand now a days used in India, is obtainedfrom[ ]

A. Jaipur B.Jullundur C.Hyderabad D.Ennore

5. The maximum amount of dust which may be permitted in aggregates is [ ]

A. 5%of the total aggregates for low workability with a coarse grading

B. 10% of the total aggregates for low workability with a fine grading

C. 20% of the total aggregates for a mix having high workability with finegrading

D. all the above.

.

6. The bulk density of aggregates does not depend upon: [ ]

A. size and shape of aggregates B. specific gravity ofaggregates

C. gradingofaggregates D. size and shape of the container

7. An aggregate is said to be flaky if its least dimension is less than [ ]

A. 1/5th ofmeandimension B. 2/5th of meandimension

C. 3/5th ofmeandimension D. 4/5th of meandimension

8. To ensure constant moisture content inaggregates [ ]

A. height of each aggregate pile should not exceed 1.50m

B. aggregatepileshouldbeleftfor24hoursbeforeaggregatesareused

C. conical heaps of aggregates should be avoided to prevent moisturevariation

D. all theabove

9. For the construction of cement concrete floor, the maximum permissible size of fine aggregate is [ ]

A.4.75mm B.6.23mm C.8.12mm D. 10.50mm

10. The process of proper and accurate measurement of concrete ingredients for uniformity of proportion, is known [ ]

A. grading B.Curing C.Mixing D.Batching

KEY

Q.NO	1	2	3	4	5	6	7	8	9	10
ANS	C	D	C	D	D	D	C	D	D	D

Fill in the blanks question with answers

1. In rich mixes; use of size aggregate gives better results.
2. Slump test is done for=
3. Concrete mainly consists of=
4. Workability of concrete is measured by =
5. The property of separation of cement paste from concrete material is known as=
6. Commonly employed test for measurement of cement workability is=
7. The process of proper and accurate measurement of concrete ingredients foruniformity of proportion is known=
8. In order to make concrete durable, the water cement ratio should be=
9. While compacting the concrete by a mechanical vibrator, the slump should not exceed=
10. Compacting factor formula =

Q.NO	ANSWERS
1	small
2	concrete
3	cement, aggregates and admixtures
4	slump test
5	segregation
6	vee-bee test
7	batching
8	Moderate
9	5CM
10	partially compacted concrete/fully compacted concrete

UNIT-IV

HARDENED CONCRETE

Two marks question with answers

1. Define Water/cement ratio?

The water–cement ratio is the ratio of the weight of water to the weight of cement used in a concrete mix. A lower ratio leads to higher strength and durability, but may make the mix difficult to work with and form. Workability can be resolved with the use of plasticizers or super-plasticizers.

2. What is meant by gel-space ratio?

Strengths of cement pastes with different mixture properties and maturities depend in a very similar over linear fashion on the gel–space ratio, which is the ratio of the volume of hydration products over the volume of both hydration products and capillary pores.

3. Why is the modulus of elasticity important?

It is dependent upon temperature and pressure however. The Young's Modulus (or Elastic Modulus) is in essence the stiffness of a material. In other words, it is how easily it is bended or stretched. ... When a material reached a certain stress, the material will begin to deform.

4. Define Shrinkage cracking?

When concrete is subjected to compressive loading it deforms instantaneously. This immediate deformation is called instantaneous strain. ... This time-dependent strain is termed as creep. Drying shrinkage (often, simply shrinkage) is the reduction in volume of hardened concrete due to loss of moisture by evaporation.

Drying shrinkage is defined as the contracting of a hardened concrete mixture due to the loss of capillary water. This shrinkage causes an increase in tensile stress, which may lead to cracking, internal warping, and external deflection, before the concrete is subjected to any kind of loading.

5. Define Tension cracking?

The stress intensity factors at the tension crack tip are computed with three tensile loading conditions Instead, researchers believe that the angular outline was produced by giant tension cracks in the moon's crust as it cooled around an upwelling plume of hot material from the deep interior.

<u>Three marks question with answers</u>

1. **Define Concrete creep**

Concrete creep is defined as deformation of structure under sustained load. Basically as long term pressure or stress on concrete can make it change shape. This deformation usually occurs in the direction the force is being applied. Like a concrete column getting more compressed, or a beam bending.

2. **What is plastic shrinkage?**

They are usually parallel to each other on the order of 1 to 3 feet apart, relatively shallow, and generally do not intersect the perimeter of the slab. Plastic shrinkage cracking is more likely to occur when high evaporation rates cause the concrete surface to dry out before it has set.

3. **What is Poisson's ratio?**

Poisson's ratio is the ratio of transverse contraction strain to longitudinal extension strain in the direction of stretching force. Tensile deformation is considered positive and compressive deformation is considered negative.

4. **What is the modulus of elasticity?**

Young's modulus(E) describes tensile elasticity, or the tendency of an object to deform along an axis when opposing forces are applied along that axis; it is defined as the ratio of tensile stress to tensile strain. It is often referred to simply as the elastic modulus.

5. **What is tensile modulus?**

Tensile Modulus is defined as the "ratio of stress (force per unit area) along an axis to strain (ratio of deformation over initial length) along that axis" It can be used to predict the elongation or compression of an object as long as the stress is less than the yield strength of the material

Five marks question with answers

1. Explain nondestructive tests. What are the codal provisions for NDT?

Nondestructive testing of concrete can be defined as the test method used to examine the properties of concrete used in the actual structure. These test methods can also be said as in-situ tests or in-place tests. Traditionally these tests are said to be as the non-destructive test although some minor damage to the structure may be involved. An important feature of non-destructive test is that the place where test is done can be used for re-testing. The use of non-destructive tests has increased the safety level of construction and also helps in improving the scheduling of construction. All this increases the speed of construction besides keeping the economy of construction in considerable limits.

These tests can be categorized in two parts:

- Tests used to determine the strength of concrete

- Tests used to determine the other characteristics of concrete like voids, cracks etc

The most common tests which are usually conducted are:

Rebound Hammer Test

It is one of the oldest nondestructive tests. This test is widely used because of its economical procedure

Penetration Resistance Test

In this test resistance to the penetration of steel rod in the concrete is used as the strength value

Ultrasonic Pulse Velocity Test

This test has automatic program apparatus. Apparatus is just placed on specimen. The waves pass through the specimen. Time taken by waves to reach from one end of specimen to other is considered to be the strength of specimen. Less the time taken, weaker will be the specimen and vice versa

Pull out Test

This test measure the strength of specimen by means of special tension jacks that are usually used to be inserted in test specimen

2.Explain briefly factors affecting concrete strength

Concrete strength is affected by many factors, such as quality of raw materials, water/cement ratio, coarse/fine aggregate ratio, and age of concrete, compaction of concrete, temperature, relative humidity and curing of concrete.

Quality of Raw Materials:

Cement, aggregate and water

Water / Cement Ratio:

The higher the water/cement ratio, the greater the initial spacing between the cement grains and the greater the volume of residual voids not filled by hydration products.

Coarse / fine aggregate ratio:

Following points should be noted for coarse/fine aggregate ratio:

- If the proportion of fines is increased in relation to the coarse aggregate, the overall aggregate surface area will increase.
- If the surface area of the aggregate has increased, the water demand will also increase.

- Assuming the water demand has increased, the water cement ratio will increase.
- Since the water cement ratio has increased, the compressive strength will decrease.

Age of concrete:

The degree of hydration is synonymous with the age of concrete provided the concrete has not been allowed to dry out or the temperature is too low.

Compaction of concrete:

Any entrapped air resulting from inadequate compaction of the plastic concrete will lead to a reduction in strength. If there was 10% trapped air in the concrete, the strength will fall down in the range of 30 to 40%.

Temperature

The rate of hydration reaction is temperature dependent. If the temperature increases the reaction also increases. This means that the concrete kept at higher temperature will gain strength more quickly than a similar concrete kept at a lower temperature.

Relative humidity:

If the concrete is allowed to dry out, the hydration reaction will stop. The hydration reaction cannot proceed without moisture. The three curves shows the strength development of similar concretes exposed to different conditions

Curing:

It should be clear from what has been said above that the detrimental effects of storage of concrete in a dry environment can be reduced if the concrete is adequately cured to prevent excessive moisture loss.

3. Explain neat procedure for Compressive strength of concrete?

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not.

Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, and quality control during production of concrete etc.

Procedure: Compressive Strength Test of Concrete Cubes

For cube test two types of specimens either cubes of 15cm X 15cm X 15cm or 10cm X 10cm x 10cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15cm x 15cm x 15cm are commonly used.

This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of this specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen.

These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

4. What is tensile strength of concrete? **Explain its types in detail?**

Flexural strength of concrete:

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 6 x 6 inch (150 x 150-mm) concrete beams with a span length at least three times the depth. The flexural strength is expressed as Modulus of Rupture (MR) in psi (MPa) and is determined by standard test methods ASTM C 78 (third-point loading) or ASTM C 293 (center-point loading).

Flexural Strength of Concrete Flexural MR is about 10 to 20 percent of compressive strength depending on the type, size and volume of coarse aggregate used. However, the best correlation for specific materials is obtained by laboratory tests for given materials and mix design. The MR determined by third-point loading is lower than the MR determined by center-point loading, sometimes by as much as 15%.

Split tensile strength of concrete:

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete.

The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.

5.Explain in detail the creep of concrete and its factors?

Creep is the time-dependent flow of concrete caused by its being subjected to stress.
This deformation, which occurs rapidly at first and then decreases with time, can be several times larger than the strains due to elastic shortening.Using more scientific approach; When load is applied to concrete at time to, a deformation occurs immediately which can be expressed as the elastic strain, ε (to). If this applied load is left on concrete producing a constant stress, the instantaneous elastic strain ε (to) begins to increase.
The rate of increase is fast during the first 3 months, after which it begins to slow down.

Factors effecting creep

Creep has been found to depend on
-the mix proportions (w/c ratio,aggregate type)
-humidity,temperature
-curing conditions,
-maturity of the concrete when first loaded
The deformation due to creep causes a shortening of the pre-stressing strands, which leads to a loss in stress in the strand.

Effects of Creep:

Creep of plain concrete does not by itself affect strength, although under very high stresses creep hastens the approach of the limiting strain at which failure takes place.

The influence of creep on the ultimate strength of a simply supported, reinforced concrete beam subjected to a sustained load is insignificant, but deflection increases considerably and may in many cases be a critical consideration in design.
Another instance of the adverse effects of creep is its influence on the stability of the structure through increase in deformation and consequent transfer of load to other components.

Thus, even when creep does not affect the ultimate strength of the component in which it takes place, its effect may be extremely serious as far as the performance of the structure as a whole is concerned.

The loss of prestress due to creep is well known and accounted for the failure of all early attempts at prestressing. Only with the introduction of high tensile steel did prestressing become a successful operation.

The effects of creep may thus be harmful. On the whole, however, creep unlike shrinkage is beneficial in relieving stress concentrations and has contributed to the success of concrete as a structural material.

6. Explain in detail the shrinkage of concrete and its types?

Concrete is subjected to changes in volume either autogenus or induced. Volume change is one of the most detrimental properties of concrete, which affects the long-term strength and durability. To the practical engineer, the aspect of volume change in concrete is important from the point of view that it causes unsightly cracks in concrete.

We have discussed elsewhere the effect of volume change due to thermal properties of aggregate and concrete, due to alkali/aggregate reaction, due to sulphate action etc. Presently we shall discuss the volume change on account of inherent properties of concrete "**shrinkage".**

One of the most objectionable defects in concrete is the presence of cracks, particularly in floors and pavements. One of the important factors that contribute to the cracks in floors and pavements is that due to shrinkage. It is difficult to make concrete which does not shrink and crack. It is only a question of magnitude.

Now the question is how to reduce the shrinkage and shrinkage cracks in concrete structures. The term shrinkage is loosely used to describe the various aspects of volume changes in concrete due to loss of moisture at different stages due to different reasons.

Types of Shrinkage in Concrete

To understand this aspect more closely, shrinkage can be classified in the following way:

(a) Plastic Shrinkage

(b) Drying Shrinkage

(c) Autogeneous Shrinkage

(d) Carbonation Shrinkage

7. Define modulus of elasticity and dynamic modulus of elasticity?

Modulus Elasticity

Defining modulus of elasticity of concrete is difficult; Because concrete is not a linearly elastic material Since the slope of σ-ε curve of concrete is not constant. We must first describe modulus of elasticity (Ec). In general; Modulus of elasticity defined for concrete is the instantaneous Ec. This is not influenced by the time effect (mean Ec is function of many variables) Instantaneous Ec can be defined in 3 ways.

– Initial Modulus of Elasticity, E

– Secant modulus

– Tangent modulus

Dynamic Modulus of Elasticity

Dynamic modulus is the ratio of stress to strain under vibratory conditions (calculated from data obtained from either free or forced vibration tests, in shear, compression, or elongation). It is a property of visco elastic materials

8. What is curing? What are the different methods of curing?

Curing can be described as keeping the concrete moist and warm enough so that the hydration of cement can continue. More elaborately, it can be described as the process of maintaining satisfactory moisture content and a favorable temperature in concrete during the period immediately following placement, so that hydration of cement may continue until the desired properties are developed to a sufficient degree to meet the requirement of service.

If curing is neglected in the early period of hydration, the quality of concrete will experience a sort of irreparable loss. An efficient curing in the early period of hydration can be compared to a good and wholesome feeding given to a new born baby.

Methods of Curing Concrete

Concrete curing methods may be divided broadly into four categories:

1. Water curing
2. Membrane curing
3. Application of heat
4. Miscellaneous

1. Water curing

This is by far the best method of curing as it satisfies all the requirements of curing, namely, promotion of hydration, elimination of shrinkage and absorption of the heat of hydration. It is pointed out that even if the membrane method is adopted, it is desirable that a certain extent of water curing is done before the concrete is covered with membranes. Water curing can be done in the following ways:

- Immersion
- Ponding
- Spraying or Fogging
- Wet Covering

2. Membrane curing

Sometimes, concrete works are carried out in places where there is acute shortage of water. The lavish application of water for water curing is not possible for reasons of economy. Curing does not mean only application of water; it means also creation of conditions for promotion of uninterrupted and progressive hydration. It is also pointed out that the quantity of water, normally mixed for making concrete is more than sufficient to hydrate the cement, provided this water is not allowed to go out from the body of concrete. For this reason, concrete could be covered with membrane which will effectively seal off the evaporation of water from concrete.

3. Application of heat

The development of strength of concrete is a function of not only time but also that of temperature. When concrete is subjected to higher temperature it accelerates the hydration process resulting in faster development of strength. Concrete cannot be subjected to dry heat to accelerate the hydration process as the presence of moisture is also an essential requisite. Therefore, subjecting the concrete to higher temperature and maintaining the required wetness can be achieved by subjecting the concrete to steam curing.
A faster attainment of strength will contribute to many other advantages mentioned below. The exposure of concrete to higher temperature is done in the following manner:

- Steam curing at ordinary pressure
- Steam curing at high pressure
- Curing by Infra-red radiation
- Electrical curing.

4. Miscellaneous methods

Calcium chloride is used either as a surface coating or as an admixture. It has been used satisfactorily as a curing medium. Both these methods are based on the fact that calcium chloride being a salt shows affinity for moisture. The salt not only absorbs moisture from atmosphere but also retains it at the surface. This moisture held at the surface prevents the mixing water from evaporation and thereby keeps the concrete wet for a long time to promote hydration. Formwork prevents escaping of moisture from the concrete, particularly, in the case of beams and columns.

Keeping the form work intact and sealing the joint with wax or any other sealing compound prevents the evaporation of moisture from the concrete. This procedure of promoting hydration can be considered as one of the miscellaneous methods of curing.

9. Explain the procedure for Ultra Sonic Pulse Velocity(UPV)

UPVrocedure

i) Preparing for use: Before switching on the 'V' meter, the transducers should be connected to the sockets marked "TRAN" and " REC". The 'V' meter may be operated with either:

a) the internal battery,

b) an external battery or

c) the A.C line.

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

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

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

Pulse velocity= (Path length/Travel time)

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

10. Explain the procedure for rebound hammer test?

<u>Procedure for rebound hammer.</u>

i) Before commencement of a test, the rebound hammer should be tested against the test anvil, to get reliable results, for which the manufacturer of the rebound hammer indicates the range of readings on the anvil suitable for different types of rebound hammer.

ii) Apply light pressure on the plunger – it will release it from the locked position and allow it to extend to the ready position for the test.

iii) Press the plunger against the surface of the concrete, keeping the instrument perpendicular to the test surface. Apply a gradual increase in pressure until the hammer impacts. (Do not touch the button while depressing the plunger. Press the button after impact, in case it is not convenient to note the rebound reading in that position.)

iv)Take the average of about 15 readings.

InterpretationoResults

The rebound reading on the indicator scale has been calibrated by the manufacturer of the rebound hammer for horizontal impact, that is, on a vertical surface, to indicate the compressive strength. When used in any other position, appropriate correction as given by the manufacturer is to be taken into account.

Objective question with answers

1. Inultrasonictestforhardenedconcretegoodquality ofconcreteisindicatedifthepulsevelocityis

   A. below3km/s B. above 3.5km/s
   C. Above4.5km/s D. None of theabove

2. Specified compressive strength of concrete is obtainedfrom cube tests at the end of

   A. 3days B.7days C.14days D. 28days

3. Shrinkage in concrete can be reduced by using

A. low watercementratio B. less cement in theconcrete
C. properconcretemix D.None

4.The ratio between stress in steel to that of stress in concrete in expressedas
A. Poisson'sratio B. Modularratio C. Densityratio D.None

5. Select the Non – destructive test amongthefollowing
A. Compressiontest B. Flexuretest C. Reboundhammerstest D. All theabove

6. According to IS 456-2000, the modulus of elasticity o f concrete Ec, can be taken
A. Ec = 570√fck B. 5700fck C.5700√fck D.5000√fck

7. Compressive strength of M 150 grade concrete is
A.100 Kg/cm^2 B.150 Kg/cm^2 C.200Kg/cm^2 D. 300Kg/cm^2

8. The process of mixing, transporting, placing and compacting concrete using OPC should not take more than

A. 30 min B.40 min C. 50 min D. 90 min

9. Strength of concrete with passage of time

A. Increases B. Decreases C. Equal D. None

Q.NO	1	2	3	4	5	6	7	8	9	10
ANS	C	D	A	B	C	D	B	A	A	

Fill in the Blanks question with answers

1. Modulus of rupture of concrete is a measure of=

2. Increase in the moisture contentinconcrete =

3. The factor of safetyforconcreter _than steel

4. Select the Non – destructive test=

5. Modulus of rupture of concrete is a measure of=

6. The formula for determining the cement content is givenby=

7. Maturity of concrete is the product of=

8. As per IS: 456-2000, the high strength concrete should have thecharacteristic Strengthof=

9. The ratio between stress in steel to that of stress in concrete in expressed as=

10. Concrete gains strength due to=

KEY

Q.NO	ANSWER
1	Tensile strength
2	Reducesthestrength
3	greater
4	rebound hammer test
5	flexural strength
6	water/cement ratio
7	time x temperature
8	>M 40
9	modular ratio
10	hydration of cement

UNIT-V

MIX DESIGN

&

SPECIAL CONCRETE

Two marks question with answers

1. **Define concrete mix design?**

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. One of the ultimate aims of studying the various properties of the materials of concrete, plastic concrete and hardened concrete is to enable a concrete technologist to design a concrete mix for a particular strength and durability.

2. What are the factors influencing the selection of materials?

A wide range of construction materials is available. The proper selection of materials to be used in a particular construction project depends on the following factors

- Strength
- Availability
- Durability
- Workability
- Ease of Transportation
- Cost
- Aesthetics
- Resistance to Fire
- Ease of Cleaning

3. What are the Requirements of concrete mix design as per BIS?

The requirements which form the basis of selection and proportioning of mix ingredients are

a) The minimum compressive strength required from structural consideration

b) The adequate workability necessary for full compaction with the compacting equipment available.

c) Maximum water-cement ratio and/or maximum cement content to give adequate durability for the particular site conditions

d) Maximum cement content to avoid shrinkage cracking due to temperature cycle in mass concrete.

4. What are the types of concrete mixes? Explain

1. Nominal Mixes: In the past the specifications for concrete prescribed the proportions of cement, fine and coarse aggregates. These mixes of fixed cement-aggregate ratio which ensures adequate strength are termed nominal mixes. These offer simplicity and under normal circumstances, have a margin of strength above that specified. However, due to the variability of mix ingredients the nominal concrete for a given workability varies widely in strength.

2. Standard mixes: The nominal mixes of fixed cement-aggregate ratio (by volume) vary widely in strength and may result in under- or over-rich mixes. For this reason, the minimum compressive strength has been included in many specifications. These mixes are termed standard mixes.

5. What are the Factors affecting the choice of mix proportions?

- Compressive strength of concrete
- Workability of concrete
- Durability of concrete
- Maximum nominal size of aggregate
- Grading and type of aggregate
- Quality Control at site

6. Define Aerated Concrete

Autoclaved aerated concrete (AAC), also known as autoclaved cellular concrete (ACC), autoclaved lightweight concrete (ALC), autoclaved concrete, cellular concrete, porous concrete, Aircrete, Hebel Block, and Ytong is a lightweight, precast, foam concrete building material invented in the mid-1920s that simultaneously provides structure, insulation, and fire- and mold-resistance. AAC products include blocks, wall panels, floor and roof panels, cladding (facade) panels and lintel

7. What is the general use of Shotcrete?

Shotcrete is concrete (or sometimes mortar) conveyed through a hose and pneumatically projected at high velocity onto a surface, as a construction technique. It is reinforced by conventional steel rods, steel mesh, and/or fibers.

8. What is meant by No fine concrete?

No-Fines Concrete is a method of producing light concrete by omitting the fines from conventional concrete. No-fines concrete as the term implies, is a kind of concrete from which the fine aggregate fraction has been omitted. This concrete is made up of only coarse aggregate, cement and water.

9. What do you mean by Fibre Reinforced Concrete?

Fiber reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers.

Three marks question with answers

1. **What is M20 Mix concrete?**

If the ratio for M20 concrete is 1:1.5:3 then 1 part cement, 1.5 part sand and 3 part aggregate (crushed stone) in volume is batched for mixing. Ordinary concrete up to M20 grade can be designed by nominal mix concrete procedure.

2. **Define Standard mixes.**

The nominal mixes of fixed cement-aggregate ratio (by volume) vary widely in strength and may result in under- or over-rich mixes. For this reason, the minimum compressive strength has been included in many specifications. These mixes are termed standard mixes.

3. **What are designed mixes?**

In these mixes the performance of the concrete is specified by the designer but the mix proportions are determined by the producer of concrete, except that the minimum cement content can be laid down. This is most rational approach to the selection of mix proportions with specific materials in mind possessing more or less unique characteristics. The approach results in the production of concrete with the appropriate properties most economically. However, the designed mix does not serve as a guide since this does not guarantee the correct mix proportions for the prescribed performance.

4. What is an acceptance criterion of concrete?

It is often observed that construction engineer neglects acceptance criteria of the concrete from flexural strength point of view under the argument that flexural strength of the concrete is of no/least importance as in the strength design the tensile strength of the concrete is neglected.

5. **What is self-compacting concrete?**

Self-consolidating concrete, also known as self-compacting concrete (SCC), is a highly flowable, non-segregating concrete that spreads into place, fills formwork, and encapsulates even the most congested reinforcement, all without any mechanical vibration.

6. **What is the Aspect ratio of the fiber?**

- A fiber's aspect ratio is defined as its length divided by its diameter.
- Long, thin fibers (fiber B) often provide superior properties, but are also often more expensive to produce and may be more difficult to disperse uniformly in the composite.
- Small aspect ratio fibers(fiber A) typically provide better compressive properties but these composites are typically less resistant to damage propogation.

7. **What is SIFCON?**

Slurry infiltrated fibre concrete (SIFCON) is one of the recently developed construction material. SIFCON could be considered as a special type of fibre concrete with high fibre content. The matrix consists of cement slurry or flowing cement mortar.

8. **What are the types of polymer concrete?**

- Polymer impregnated concrete (PIC).
- Polymer cement concrete (PCC).
- Polymer concrete (PC).

9. **What is meant by high performance of concrete?**

High performance concrete is a concrete mixture, which possess high durability and high strength when compared to conventional concrete. This concrete contains one or more of cementious materials such as fly ash, Silica fume or ground granulated blast furnace slag and usually a super plasticizer.

Five marks question with answers

1. **Describe ACI method of mix design in detail.**

ACI method of concrete mix design is based on the estimated weight of the concrete per unit volume. This method takes into consideration the requirements for consistency, workability, strength and durability.

Following are the steps of ACI Method of Concrete Mix Design:

(a) Depending on the degree of workability and placing condition determine the slump value.

(b) Depending on the economical availability and dimensions of the structure determine the maximum size of aggregate.

(c) For the given slump and maximum size of coarse aggregate determine the amount of mixing water

(d) Determine the minimum water-cement ratio either from strength considerations or from durability considerations.

(e) Determine the amount of cement per unit volume of concrete from steps (c) and (d). This cement content should not be less than the cement content required based on durability criteria.

(f) Determine the amount of coarse aggregate required for a unit volume of concrete. This value is multiplied by the dry rodded unit weight of the aggregate to get the required dry weight.

(g) Determine the amount of fine aggregate. If the weight of concrete per unit volume is assumed, the required weight of fine aggregate is obtained by the difference between the weight of fresh concrete and the total weight of all other ingredients.

2. Describe Indian standard method of mix design in detail.

1. Determine the mean target strength ft from the specified characteristic compressive strength at 28-day fck and the level of quality control.

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

where S is the standard deviation obtained from the Table of approximate contents given after the design mix.

2. Obtain the water cement ratio for the desired mean target using the empirical relationship between compressive strength and water cement ratio so chosen is checked against the limiting water cement ratio. The water cement ratio so chosen is checked against the limiting water cement ratio for the requirements of durability given in table and adopts the lower of the two values.

3. Estimate the amount of entrapped air for maximum nominal size of the aggregate from the table.

4. Select the water content, for the required workability and maximum size of aggregates (for aggregates in saturated surface dry condition) from table.

5. Determine the percentage of fine aggregate in total aggregate by absolute volume from table for the concrete using crushed coarse aggregate.

6. Adjust the values of water content and percentage of sand as provided in the table for any difference in workability, water cement ratio, grading of fine aggregate and for rounded aggregate the values are given in table.

7. Calculate the cement content form the water-cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content from the requirements of the durability, and greater of the two values is adopted.

8. From the quantities of water and cement per unit volume of concrete and the percentage of sand already determined in steps 6 and 7 above, calculate the content of coarse and fine aggregates per unit volume of concrete from the following relations:

$$V = \left[W + \frac{C}{S_c} + \frac{1}{p}\frac{f_a}{S_{fa}}\right] \times \frac{1}{1000}$$

$$V = \left[W + \frac{C}{S_c} + \frac{1}{1-p}\frac{C_a}{S_{ca}}\right] \times \frac{1}{1000}$$

9. Determine the concrete mix proportions for the first trial mix.

10. Prepare the concrete using the calculated proportions and cast three cubes of 150 mm size and test them wet after 28-days moist curing and check for the strength.

11. Prepare trial mixes with suitable adjustments till the final mix proportions are arrived at.

3. Explain in detail about the statistical quality control and acceptance criteria of concrete.

Concrete cube strength is a random variable and the test results are influenced by many different factors related to variations in the materials, batching, sampling, concrete testing, equipment and personnel.

Being a random variable, the results of a concrete cube test taken from a particular grade of concrete will, for practical purposes, take the form of a normal distribution when plotted graphically. **This type of distribution is sometimes called a "bell" curve because of its shape.** Like many aspects of concrete technology this is not strictly true – low strength and very high strength concrete test results give skewed distribution curves to the left and right respectively, but for practical purposes a symmetrical distribution is assumed.

The normal distribution curve is characterised by two values: the mean or average value, and the standard deviation which quantifies the spread of the curve either side of the mean value. The requirement that the average strength exceeds the specified (characteristic) strength by

1.64 times the standard deviation implies that slightly fewer than 5% of results will fall below the specified strength.

The only factor under the concrete suppliers control is the standard deviation, the specified strength and the "1.64" being fixed.

The value 1.64 x SD is called the margin. The higher the SD, the higher the margin and the higher the average binder content of the concrete. In other words, **the higher the SD, the more expensive the concrete in terms of binder cost.**

For example, improving control from poor (SD = 7 MPa) to good (SD = 5 MPa) reduces the margin by 1.64 *(7-5) MPa = 3.4 MPa. **A reduction in average strength by 3.4 MPa is equivalent to saving 20 kg of binder**per cubic metre of concrete.

At current prices this is a saving of roughly R25 / m^3. Of course one has to balance this against the cost of the additional quality control necessary to reduce the SD and there is an optimum point where it becomes uneconomical to reduce the SD any further. For sophisticated concrete suppliers this point would be an SD somewhere in the region of 2.5 to 3 MPa.

4.Define Nominal Mixes and Standard mixes. What are designed Mixes?

Nominal Mixes:

In the past the specifications for concrete prescribed the proportions of cement, fine and coarse aggregates. These mixes of fixed cement-aggregate ratio which ensures adequate strength are termed nominal mixes. These offer simplicity and under normal circumstances, have a margin of strength above that specified. However, due to the variability of mix ingredients the nominal concrete for a given workability varies widely in strength.

Standard mixes:

The nominal mixes of fixed cement-aggregate ratio (by volume) vary widely in strength and may result in under- or over-rich mixes. For this reason, the minimum compressive strength has been included in many specifications. These mixes are termed standard mixes.

Design mixes:

In these mixes the performance of the concrete is specified by the designer but the mix proportions are determined by the producer of concrete, except that the minimum cement content can be laid down. This is most rational approach to the selection of mix proportions with specific materials in mind possessing more or less unique characteristics. The approach results in the production of concrete with the appropriate properties most economically. However, the designed mix does not serve as a guide since this does not guarantee the correct mix proportions for the prescribed performance.

5. Explain detail the factors in the choice of mix design

Concrete mix design:

It is defined as the appropriate selection and proportioning of constituents to produce a concrete with pre-defined characteristics in the fresh and hardened states. In general, concrete mixes are designed in order to achieve a defined workability, strength and durability.

The various factors affecting the choice of concrete mix design are:

<u>Compressive strength of concrete:</u>

It is one of the most important properties of concrete and influences many other describable properties of the hardened concrete. The mean compressive strength required at a specific age, usually 28 days, determines the nominal water-cement ratio of the mix. The other factor affecting the strength of concrete at a given age and cured at a prescribed temperature is the degree of compaction. According to Abraham's law the strength of fully compacted concrete is inversely proportional to the water-cement ratio.

<u>Workability of concrete:</u>

The degree of workability required depends on three factors. These are the size of the section to be concreted, the amount of reinforcement, and the method of compaction to be used. For the narrow and complicated section with numerous corners or inaccessible parts, the concrete must have a high workability so that full compaction can be achieved with a reasonable amount of effort. This also applies to the embedded steel sections. The desired workability depends on the compacting equipment available at the site.

Durability of concrete:

The durability of concrete is its resistance to the aggressive environmental conditions. High strength concrete is generally more durable than low strength concrete. In the situations when the high strength is not necessary but the conditions of exposure are such that high durability is vital, the durability requirement will determine the water-cement ratio to be used.

Maximum nominal size of aggregate

In general, larger the maximum size of aggregate, smaller is the cement requirement for a particular water-cement ratio, because the workability of concrete increases with increase in maximum size of the aggregate. However, the compressive strength tends to increase with the decrease in size of aggregate. IS 456:2000 and IS 1343:1980 recommend that the nominal size of the aggregate should be as large as possible.

Grading and type of aggregate

The grading of aggregate influences the mix proportions for a specified workability and water-cement ratio. Coarser the grading leaner will be mix which can be used. Very lean mix is not desirable since it does not contain enough finer material to make the concrete cohesive. The type of aggregate influences strongly the aggregate-cement ratio for the desired workability and stipulated water cement ratio. An important feature of a satisfactory aggregate is the uniformity of the grading which can be achieved by mixing different size fractions.

Quality Control at site:

The degree of control can be estimated statistically by the variations in test results. The variation in strength results from the variations in the properties of the mix ingredients and lack of control of accuracy in batching, mixing, placing, curing and testing. The lower the difference between the mean and minimum strengths of the mix lower will be the cement-content required. The factor controlling this difference is termed as quality control

5. Write a brief note on self-compacting concrete?

SCC is defined as "a concrete that is able to flow under its own weight and completely fill the formwork, while maintaining homogeneity even in the presence of congested reinforcement, and then consolidate without the need for vibrating compaction"

The noise associated with the compaction of conventional concrete can be significant. SCC affords quiet casting, and the environmental loadings from noise are therefore reduced. It also eliminates the issue of blood circulatory problems caused by the vibration of concrete.

SCC affords the designer greater flexibility in designing complex shapes. It is independent of the quality of mechanical vibration and therefore provides homogeneity leading to improved durability and potential for reuse.

Self compacting concrete (SCC) can be classified as an advanced construction material. The SCC as the name suggests, does not require to be vibrated to achieve full compaction. This offers following benefits and advantages over conventional concrete.

- Improved quality of concrete and reduction of onsite repairs.
- Faster construction times.
- Lower overall costs.
- Facilitation of introduction of automation into concrete construction.
- Improvement of health and safety is also achieved through elimination of handling of vibrators.
- Substantial reduction of environmental noise loading on and around a site.

6. Explain the properties of polymer Impregnated Concrete.

Polymer impregnated concrete consists of polymers or epoxies which are used to impart certain special properties to concrete. Various applications of polymers in concrete and their properties is discussed.

The polymers are used in the concrete due to the following reasons:

- Polymers improve the strength and durability of hardened concrete
- The chemical resistance and the impermeability of hardened concrete is increased

- The flow properties of fresh concrete can be modified based on the required specifications
- The bond characteristics between old and new concrete can be improved

Some of the polymers that are used popularly are:

1. Urethanes: Urethanes are produced by the reaction of isocyanates with the polyols
2. Acrylics: These are esters of acrylic and methacrylic acids
3. Vinyl
4. Epoxies: These are type of synthetic fibers
5. SBR or Styrene Butadiene Resins: These are synthetic rubbers in the solution

6. **Applications of Different Polymers in Concrete**

The different ways in which the polymer is introduced into the concrete (hardened concrete) will vary widely based on the commercial objective. The polymers can be employed in concrete in different ways. They are:

- Polymer Impregnated Concrete (PIC)
- Polymer-Modified Concrete (PMC)
- Polymer Concrete (PC)
- Polymer as Protective Coating
- Polymer as Bonding Agent
- Other Applications

7. **Explain briefly about the types of fiber reinforced concrete**

Different Types of Fiber Reinforced Concrete

Following are the different type of fibers generally used in the construction industries.

- Steel Fiber Reinforced Concrete
- Polypropylene Fiber Reinforced (PFR) cement mortar & concrete
- GFRC Glass Fiber Reinforced Concrete
- Asbestos Fibers

- Carbon Fibers
- Organic Fibers

Steel Fiber Reinforced Concrete:

A no of steel fiber types are available as reinforcement. Round steel fiber the commonly used type are produced by cutting round wire in to short length. The typical diameter lies in the range of 0.25 to 0.75mm. Steel fibers having a rectangular c/s are produced by silting the sheets about 0.25mm thick. Fiber made from mild steel drawn wire. Conforming to IS:280-1976 with the diameter of wire varying from 0.3 to 0.5mm have been practically used in India. Round steel fibers are produced by cutting or chopping the wire, flat sheet fibers having a typical c/s ranging from 0.15 to 0.41mm in thickness and 0.25 to 0.90mm in width are produced by silting flat sheets. Deformed fiber, which are loosely bounded with water-soluble glue in the form of a bundle are also available. Since individual fibers tend to cluster together, their uniform distribution in the matrix is often difficult. This may be avoided by adding fibers bundles, which separate during the mixing process.

Polypropylene Fiber Reinforced (PFR) concrete:

Polypropylene is one of the cheapest & abundantly available polymers polypropylene fibers are resistant to most chemical & it would be cementitious matrix which would deteriorate first under aggressive chemical attack. Its melting point is high (about 165 degrees centigrade). So that a working temp. As (100 degree centigrade) may be sustained for short periods without detriment to fiber properties.

Polypropylene fibers being hydrophobic can be easily mixed as they do not need lengthy contact during mixing and only need to be evenly distressed in the mix.

Polypropylene short fibers in small volume fractions between 0.5 to 15 commercially used in concrete.

8. Glass Fiber Reinforced Concrete:

Glass fiber is made up from 200-400 individual filaments which are lightly bonded to make up a stand. These stands can be chopped into various lengths, or combined to make cloth mat or tape. Using the conventional mixing techniques for normal concrete it is not possible to mix more than about 2% (by volume) of fibers of a length of 25mm.

The major appliance of glass fiber has been in reinforcing the cement or mortar matrices used in the production of thin-sheet products. The commonly used verities of glass fibers are e-glass used. In the reinforced of plastics & AR glass E-glass has inadequate resistance to alkalis present in Portland cement where AR-glass has improved alkali resistant characteristics. Sometimes polymers are also added in the mixes to improve some physical properties such as moisture movement.

Asbestos Fibers:

The naturally available inexpensive mineral fiber, asbestos, has been successfully combined with Portland cement paste to form a widely used product called asbestos cement. Asbestos fibers here thermal mechanical & chemical resistance making them suitable for sheet product pipes, tiles and corrugated roofing elements. Asbestos cement board is approximately two or four times that of unreinforced matrix. However, due to relatively short length (10mm) the fiber have low impact strength.

Carbon Fibers:

Carbon fibers from the most recent & probability the most spectacular addition to the range of fiber available for commercial use. Carbon fiber comes under the very high modulus of elasticity and flexural strength. These are expansive. Their strength & stiffness characteristics have been found to be superior even to those of steel. But they are more vulnerable to damage than even glass fiber, and hence are generally treated with resign coating.

Organic Fibers:

Organic fiber such as polypropylene or natural fiber may be chemically more inert than either steel or glass fibers. They are also cheaper, especially if natural. A large volume of vegetable fiber may be used to obtain a multiple cracking composite. The problem of mixing and uniform dispersion may be solved by adding a super plasticize.

9. **Explain about polymer – modified concrete**

Polymer concretes are a type of concrete that use polymers to replace lime-type cements as a binder. In some cases the polymer is used in addition to portland cement to form Polymer Cement Concrete (PCC) or Polymer Modified Concrete (PMC)

Properties

The exact properties depend on the mixture, polymer, aggregate used etc. etc. but generally speaking with mixtures used:

- The binder is more expensive than cement
- Significantly greater tensile strength than unreinforced Portland concrete (since plastic is 'stickier' than cement and has reasonable tensile strength)[1]
- Similar or greater compressive strength to Portland concrete[1]
- Much faster curing
- Good adhesion to most surfaces, including to reinforcements
- Good long-term durability with respect to freeze and thaw cycles[1]
- Low permeability to water and aggressive solutions
- Good chemical resistance
- Good resistance against corrosion
- Lighter weight (slightly less dense than traditional concrete, depending on the resin content of the mix)
- May be vibrated to fill voids in forms
- Allows use of regular form-release agents (in some applications)
- Dielectric
- Product hard to manipulate with conventional tools such as drills and presses due to its density. Recommend getting pre-modified product from the manufacturer
- Small boxes are more costly when compared to its precast counterpart however pre cast concretes induction of stacking or steel covers quickly bridge the gap.

10. How can high-strength concrete be classified? Explain.

High strength concrete is defined purely on the basis of its compressive strength, defined the **high-performance concrete (HPC)** as concrete mixtures possessing high workability, high durability and high ultimate strength.

High strength of concrete is achieved by reducing porosity, in-homogeneity, and micro-cracks in the hydrated cement paste and the transition zone. Consequently, there is a reduction of the thickness of the interfacial transition zone in high-strength concrete. The densification of the interfacial transition zone allows for efficient load transfer between the cement mortar and the coarse aggregate, contributing to the strength of the concrete. For very high-strength concrete where the matrix is extremely dense, a weak aggregate may become the weak link in concrete strength.

Materials for High-Strength Concrete:

Cement

Cement composition and fineness play an important role in achieving high strength of concrete. It is also required that the cement is compatible with chemical admixtures to obtain the high-strength. Experience has shown that low-C3A cements generally produce concrete with improved rheology.

Aggregate

Selection of right aggregates plays an important role for the design of high-strength concrete mix. The low-water to cement ratio used in high-strength concrete makes the concrete denser and the aggregate may become the weak link in the development of the mechanical strength. Extreme care is necessary, therefore, in the selection of aggregate to be used in very high-strength concrete.

The particle size distribution of the fine aggregates plays an important role in the high strength concrete. The particle size distribution of fine aggregate that meets the ASTM specifications is adequate for high-strength concrete mixtures.

Guidelines for the selection of materials:

- For the higher target compressive strength of concrete, the maximum size of concrete selected should be small, so that the concrete can become more dense and compact and less void ratio.
- Up to 70 MPa compressive strength can be produced with a good coarse aggregate of a maximum size ranging from 20 to 28 mm.
- To produce 100 MPa compressive strength aggregate with a maximum size of 10 to 20 mm should be used.
- To date, concretes with compressive strengths of over 125 MPa have been produced, with 10 to 14 mm maximum size coarse aggregate.
- Using supplementary cementitious materials, such as blast-furnace slag, fly ash and natural pozzolans, not only reduces the production cost of concrete, but also addresses the slump loss problem.
- The optimum substitution level is often determined by the loss in 12- or 24-hour strength that is considered acceptable, given climatic conditions or the minimum strength required.
- While silica fume is usually not really necessary for compressive strengths under 70 MPa, most concrete mixtures contain it when higher strengths are specified.

11. Explain the polymer concrete and its advantages and types?

➢ Polymer concrete is an ordinary concrete produced with OPC (Ordinary portland cement) wet cured and inseminated with liquid or vaporous chemical compound (Methyl methacrylate monomer) and polymerized by gamma radiation or with chemical initiated implies, i.e by utilizing thermal catalytic method (Adding 3% Benzoyl peroxide) to the monomer as a catalyst. The impregnation is helped by drying the concrete at an extreme temperature by evacuations and absorbing the monomer under limited pressure.

Application of Polymer Concrete:

Polymer concrete is broadly utilizing in several circumstances as following

1. Nuclear power plants. 2. Kerb-stones.

3. Prefabricated structural element.
4. Precast slabs for bridge decks.
5. Roads.
6. Marine Works.
7. Pre-stressed concrete.
8. Irrigation works.
9. Sewage works.
10. Waterproofing of building.

Advantages of polymer concrete:

1. It has high impact resistance and high compressive strength.

2. Polymer concrete is highly resistant to freezing and thawing.

3. Highly resistant to chemical attack and abrasion.

4. Permeability is lower than other conventional concrete.

Objective question with answers

1. The compaction ofconcrete,improves [ ]

   A. Density B.Strength C. Durability D. all theabove.

2. Segregation isresponsiblefor [ ]

   A. honey-combedconcrete B. porous layers inconcrete
   C. surface scalinginconcrete D. sand streaks inconcrete

3. Addition of pozzolanatocement [ ]

   A. decreasesworkability B. increasesstrength
   C. increases heatofhydration D. Increaseworkability

4. PermissiblecompressivestrengthofM150concretegradeis [ ]

   A. 100kg/cm^2 B.150kg/cm^2
   C.200kg/cm^2 D. 250kg/cm2

5. Pozzolana cement is used with confidence forconstructionof [ ]

A. Dams B.massivefoundations C. Abutments D. All the above

6. Efflorescence in cement is caused due to an excessof [ ]

A. Alumina B. iron oxide C.MagnesiumOxide D.alkalis

7. ThediameteroftheVicatplungeris10mmanditslengthvariesfrom [ ]

A. 20 mm to30mm B. 30 mm to40mm C. 40 mm to50mm D. 50 mm to 60mm

8. The ratio of various ingredients (cement, sand, aggregates) in concrete of grade M 20, is

A. 1:2:4 B. 1:3: 6 C. A&B D. None of theAbove

9. Tri-calciumaluminate [ ]

A. reacts fastwithwater B. generates less heat ofhydration

C. causes initial setting and early strength ofcement

D. does not contribute to develop ultimatestrength

10. Hightemperature

A. increases the strengthofconcrete B. decreases the strength ofconcrete

C. has no affecton the strengthofconcrete D. none ofthese.

KEY

Q.NO	1	2	3	4	5	6	7	8	9	10
ANS	D	A	A	C	D	C	C	D	C	C

Fill Inthe Blanks question with answers

1. Increase in the moisture contentinconcrete=

2. Modulus of rupture of concrete is a measureof=

3. The relation between modulus of rupture for and characteristic strength ofconcrete fck is givenby =

4. ModulusofelasticityofsteelasperIS:456—2000shallbetaken as =

5. The factor of safetyforconcrete _than steel

6. The characteristic strength of M50 concreteis=

7. Maturity of concrete is the productof =

8. The cylindrical strength of concrete istimes the strength ofthecube

9. The ratio of various ingredients in concrete of grade M 25=

10. The ratio of various ingredients in concrete of grade M 10 =

KEY

Q.NO	**ANSWERS**
1	Decreases strength
2	Flexural strength
3	0.7√fck
4	2 X10 ^{6}N/cm^{2}
5	LESS
6	50N/mm2
7	Time x Temp
8	1.25times
9	1:1:4
10	1:3:6