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Concrete Technology REV(15) 6015

ANSWER KEY

PART –A

1. It is the property required for full filling all the service requirements of a structure during its intended life with the expected maintenance.
2. It is the ratio of weight of water to weight of cement
3. Compressive strength, flexural strength, Tensile strength, modulus of elasticity, Poissons ratio, shrinkage, creep, permeability, Durability
4. Trial mixes, Nominal mixes, Road Research Laboratory method, Department of Environment method, Minimum void ,maximum density, Fineness modulus, American Concrete Institute, Bureau of Indian Standards
5. Carbonation of concrete is a procees by which carbon dioxide from the air penetrates in to concrete and reacts with calcium hydroxide to form calcium carbonate. (5x2=10)

PART B

1. Ordinary Portland cement, Rapid Hardening cement, Sulphate resisting cement, Portland slag cement, Quick setting cement. Super sulphatedcement,Low heat cement, Portland pozzolana cement, Air Entraining cement, Coloured cement, White cement, Hydrophobic cement, Masonry cement, Expansive cement, Oil well cement, Rediset cement, High Alumina cement.Very High strength cement.
2. The chemical reaction that take place between cement and water is known as hydration of cement.

   Calcium Silicate Hydrate,Calcium Hydroxide,Calcium Aluminate Hydrate.
3. The workability is defined as the property of concrete which determines the amount of useful internal work necessary to produce full compaction.

   Factors Affecting workability are,

   Water content, Mix Proportion, Size of aggregates, Shape of aggregates, Surface texture of aggregate, grading of aggregate, and use of Admixtures.
4. Concrete is economical in the long run as compared to other engineering materials.

b) high compressive strength
c) can be easily handled and moulded in to any shape.
d) It is strong in compression

e) can even be sprayed on and filled in to fine cracks for repairs by the gunitting process

f) Can be pumped and laid in difficult positon

g) It is durable, fire resistant and requires very little maintenance.

5 Mean strength: This is the average strength obtained by dividing the sum of strength of all the cubes by the number of cubes.

Variance: This is the measure of variability or difference between any single observed data from the mean strength.

Standard deviation: This is the root mean square deviation of all the results. This is denoted by s or σ . Numerically it can be explained as $\sigma = \sqrt{\frac{\Sigma(x-\bar{x})^2}{n-1}}$

Coefficient of variation: It is a non dimensional measure of variation obtained by dividing the standard deviation by the arithmetic mean and is expressed as v=s/$\bar{x}$ x100

6 Light-weight concrete, Aerated Concrete, No-fines Concrete, High Density Concrete, Sulphur infiltrated concret, Fibre Reinforced Concrete, Slurry infiltrated fibre concrete, Polymer Concrete,

7 Plastic shrinkage cracks, settlement crack,bleeding,delayed curing, constructional effects, Early frost damage,Unsound materials,drying shrinkage, thermal shrinkage

(5 x 6 = 30)

PART C

III a) cement

Cement is binding material in the cement concrete. This concrete is used for different engineering works where strength and durability are of Prime importance.

Functions of cement

1. It fills up voids existing in the fine aggregate and makes the concrete impermeable.
2. It provides strength to concrete on setting and hardening.
3. It binds the aggregate into a solid mass by virtue of its setting and hardening properties when mixed with water.

Aggregate:

In the cement concrete, to provide good quality of concrete aggregate is used in two size groups:

· Fine aggregate (sand) particle size less than 4.75mm

· Coarse aggregate – Particle size more than 4.75mm

Fine aggregate (sand)

Sand consists of small angular or rounded grains of silica. Sand is commonly used as the fine aggregate in cement concrete. Both natural and artificial sands are used for this purpose.

Functions of sand:

1. It fills the voids existing in the coarse aggregate.

2. It reduces shrinkage and cracking of concrete.

3. By varying the proportion of sand concrete can be prepared economically for any required strength

4. It helps in hardening of cement by allowing the water through its voids.

5. To form hard mass of silicates as it is believed that some chemical reaction takes place between silica of sand and constituents of cement.

4

Coarse aggregate

Functions:

· Coarse aggregate makes solid and hard mass of concrete with cement and sand.

· It increases the crushing strength of concrete.

· It reduces the cost of concrete, since it occupies major volume.

But generally crushed stone is only used as coarse aggregate.

Water

The water is used in concrete plays an important part in the mixing, laying compaction setting and hardening of concrete. The strength of concrete directly depends on the quantity and quality of water is used in the mix.

Functions:

1. Water is only the ingredient that reacts chemically with cement and thus setting and hardening takes place.

2. Water acts as a lubricant for the aggregate and makes the concrete workable. (4)

b) Normal weight aggregate, Light weight aggregate, Heavy weight aggregate.

Normal weight aggregates are classified as natural aggregates and artificial aggregates.

Natural aggregates:-Sand,gravel, crushed rock such as granite, quartzite,Basalt,sandstone

Artificial aggregate:- Broken brick, Air cooled slag, sintered fly ash, Bloated clay

Classification based on the basis of size of the aggregate as coarse aggregate and fine aggregate. (8)

1V a) An admixture is defined as a material other than cement, water and aggregates that is used as an ingredient of concrete and is added to the batch immediately before or during mixing. Admixture is used to modify the properties of ordinary concrete so as to make it more suitable for any situation. Additive is a material which is added at the time of grinding cement clinker at the cement factory

Admixtures.:-

Plasticizers, Superplasticizers, Retarders and Retarding Plasticizers, Acccelarators and Accelarating Plasticizrs,Air-entraining admixtures, Pozzolanic Mineral Admixtures, Damp proofing and water proofing admixtures, Gas forming Admixtures, Workability admixtures, Grouting Admixtures, Corrosion Inhibiting Admixtures, Bonding admixtures, Colouring Admixtures. (7)

b)It is the reaction between active silica constituent of the aggregate and alkalies. Ie Na_2O and K_2O present in the cement. The reactive forms of silica generally occur in the aggregates obtained from traps, opaline, andestite, and andesite tuffs, siliceous lime stone and certain types of limew stone. The expansive alkali-silicate gels are formed due to the reaction when condition are congenial and progressive manifestation by swelling takes place which result in disruption of concrete with the spreading of pattern of crack and eventual failure of concrete structures.

The factors promoting alkali-aggregate reaction are reactive type of aggregate, high alkali content in cement, availability of moisture and optimum temperature condition (8)

V a) curing can be described as keeping the concrete moist and warm enough so that the hydration of cement can continue. It is the process of maintaining a satisfactory moisture content and a favourable temperature in concrete during the period immediately following placement. The quick surface drying of concrete results in the movement of moisture from the interior to the surface. This steep moisture gradient cause high internal stresses which are responsible for internal micro crack in the semi plastic concrete.

Concrete while hydrating, releases high heat of hydration. This heat is harmful from the point of view of volume stability.

Methods of curing.

1) water curing: immersion, ponding, spraying or fogging, Wet covering

2) Membrane curing

3) Application of heat

4) Miscellaneous

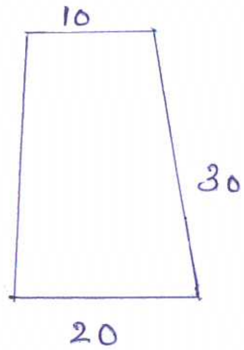
(4)

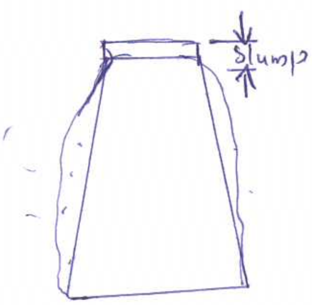
b) Slump test, Compacting factor test, Flow test, Kelly Ball test, Vee Bee Consistometer test

Slump test:- The apparatus for conducting the slump test essentially consist of a metallic mould in the form of a frustum of a cone having

Bottom diameter	- 20cm
Top diameter	10cm
Height	30cm

The internal surface of the mould is thoroughly thoroughly cleaned before commencing the test. The mould is placed on a smooth horizontal rigid and non-absorbant surface. The mould is then filled in four layers each approximately ¼ of the height of the mould. Each layer is tamped 25 times by the tamping rod taking care to taking care to distribute the strokes evenly over the cróss section . After the top layer has been rodded, the concrete is struck off level with a trowel and tamping rod. The mould is removed from the concrete immediately by raising it slowly and carefuly in a vertical direction. This allow the concrete to subside. The subsidence is ref3rred as slump of concrete. The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured. The difference in height in mm is taken as slump of concrete.





(8)

V1 a) Methods adopted for compacting of concrete are

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

1) Hand compaction – a) Rodding b) Ramming c) Tamping
2) Compaction by vibration:
Internal vibrator(Needle vibrator),Formwork vibrator(External vibrator), Table vibrator, Platform vibrator, Surface vibrator (7)

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b) Creep can be defined as the time-dependent part of the strain resulting from stress.
Factors Affecting creep
Influence of aggregate, Influence of mix proportion, Influence of age
Effects of creep
In reinforced concrete beams creep increases the deflection with time and may be a critical consideration in design. In eccentrically loaded columns, creep increases the deflection and can load to buckling.In case of statically indeterminate structures and column and beam junctions creep may relieve the stress concentration induced by shrinkage., temperature changes or movement of support. Creepproperty of concrete will be useful in all concrete structures to reduce the internal stresses due to non uniform load or restrained shrinkage.
In mass concrete structures such as dams, on account of differential temperature conditions at the interior and surface, creep is harmful and by itself may be a cause of cracking in the interior dams (8)

V11 a) Factors influencing the choice of mix proportion

1 . Grade designation 2) Type and grade of cement 3) Maximum nominal size of aggregate 4) Grading of combined of combined aggregate 5) water cement ratio 6) workability 7) Durability 8) Quality control (7)

b) 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.
The first object is to achieve the stipulated minimum strength and durability. The second object is to make the concrete in the most economical manner.

8

Requirements

The concrete should be mixed thoroughly to from a homogeneous mix.

(ii) Concrete should be compacted properly to prevent it from being porous.

(iii) Sufficient curing of concrete is required for developing full strength.

(iv) The water cement ratio should be appropriate, considering the strength and workability criteria.

(v) The concrete mix should be designed properly and should have all the ingredients in right proportions.

(vi) The water used for mixing should be free from all harmful organic substances.

(vii) The aggregate should be hard, durable and properly graded. For most R.C.C. works, 20mm size of aggregate is suitable.

(viii) The cement used for R.C.C. work should be of good quality and measured by weight only, and not by volume. (8)

IX a) High-Strengh concrete has compressive strengths of upto 100MPa as against conventional concrete which has compressive strength of less than 50MPa. Concrete having compressive strength greater than 200MPa is classified as ultra high strength concrete .High strength concrete essentially has a lower water binder ratio. A value of 0.3 is suggested as the boundary between normal and high strength concrete.

Advantages

Reduction in member size, reduction in self weight, reduction in area, reduction in formwork,superior durability, reduction in axial shortening effectsv in column. Floor thickness and beam height,lower creep and shrinkage, higher resistance to crack,reduced maintenance cost.

The term High Performance Concrete is used to refer to concrete of required performance for the majority of construction applications.The following six criteria for material selection, mixing,placing, and curing procedures for concrete

Ease placement 2) Long term mechanical properties, 3) Early age strength 4) Toughness 5)Life in service environments 6) volume stability.

High performance requirements are

Compressive strength >70MPa, Very early strength, High degree impermeability, High resistance to sulphate attack, Smooth structured surface, Absence of micro cracking, High level corrosion resistance,High relectrical resissstivity, High resistance to abrasion, erosion and cavitation

b) a)Delay in setting and hardening
b) Freezing of concrete at early age
c) Freezing and thawing

Explanation

X a)Most soils contains some sulphate in the form of calcium, sodium, potassium and magnesium. They occur in soil or ground water. Because of solubility of calcium sulphate low, ground water contains more of other sulphate and less of calcium sulphate.Ammonium sulphate is frequently present in agricultural sol and water from the use of fertilizers or from sewage and industrial effluent.Decay of organic matters in marshy land shallow takes often leads to the formation of H2Swhich can be formed into sulphuric acid Water used in concrete cooling towers can also be a potential source of sulphate attack on concrete.The term sulphate attack denote in increase in the volume of cement paste in concrete or mortar due to chemical action between products of hydration of cement and the solution containing sulphates.In the hardened concrete calcium aluminate hydrate can react with sulphate salt from outside.

Methods of controlling Sulphate attack are

a) Use of Sulphate Resisting cemet
b) Quality concrete
c) Use of air-entrainment
d) Use of pozzolana
e) High pressure steam curing
f) Use of High Alumina Cement

(7)

X b) precautions during underwater concreting

a) Dry ingredients should not be dumped into water nor should the concrete be allowed to fall through water from any height
b) Pumping or bailing out of water should not be done while the concrete is being deposited
c) No tamping, ramming or compaction of concrete should be done until the concrete surfaces rises above the water level.
d) The concrete should be rich and have 10% to 30% extra cement. The cement content of concrete should not be less than 380-390kg/m3
e) The aggregates should be properly graded
f) Concrete should not be placed in very cold water as this causes hardening problems
g) No construction joint is allowed within 600 mm below the water level

(8)

VIII 11

Calculation of cement and fly ash content

w/c ratio = 0.45

Cementitious material (cement + fly ash) content = $\frac{148}{0.45}$ = 329 kg/m^3

Since 329 > 320 it is OK.

IS 456 table number 5 permits minimum cement content 320 kg/m^3 for severe exp... condition.

Since fly ash is not as active as that of cement, it is usual to increase the cementi... material by some percentage, based on experience and trials.

In this example an increase of 10% in considered.

∴ Cementitious material content = 329 × 1.1 = 362 kg/m^3

Let us take the percentage of fly ash as 25%

∴ Fly ash content = $\frac{25}{100}$ × 362 = 91 kg/m^2

cement = 362 – 91 = 271 kg/m^3

w/cementious ratio = $\frac{148}{362}$ = 0.41

Proportion of volume of C.A. and F.A. content

From Table 11.24, volume of coarse aggregate for 20 mm MSA and fine aggregate fall... on zone I and w/c of 0.5 = 0.60.

In the present case w/c is 0.45. Therefore volume of C.A. is required to be increased ... decrease the F.A. content. As the w/c is lower by 0.05, the proportion of volume of coa... aggregate is increased by $\frac{0.01}{0.05}\times 0.05$ = 0.01. Therefore corrected proportion of volume ... coarse aggregate for the water cement ratio of 0.45 = 0.60 + 0.01 = 0.61.

For pumpable concrete, C.A. may be reduced by 10 per cent.

∴ Volume of C.A. = 0.61 × 0.9 = 0.55

and volume of F.A = 1 – 0.55 = 0.45

Mix Calculation

Volume of concrete = 1 m^3

Absolute Volume of cement = $\frac{271}{3.15}\times\frac{1}{1000}$ = 0.086 m^3

Absolute Volume of Fly ash = $\frac{91}{2.2}\times\frac{1}{1000}$ = 0.041 m^3

Volume of water = 0.148 m^3

Volume of chemical admixture, assuming dossage of 1.2% by weight of cementitious material and sp.gr of 1.1 = $\frac{1.2}{100}\times 362 = 4.34$ kg/m^3

$= \frac{4.34}{1.1}\times\frac{1}{1000}$ = 0.004 m^3

Total volume of all in aggregate = 1 – {0.086 + 0.04 + 0.148 + 0.004}
= 1 – (0.279)
= 0.721 m^3

Weight of coarse aggregate = 0.721 × 0.55 × 2.78 × 1000
= 1102 kg/m^3

Weight of fine aggregate = 0.721 × 0.45 × 2.70 × 1000
= 876 kg/m^3

Mix proportion for Trial Number 1

Cement	271 kg/m^3
Fly ash	91 kg/m^3
Water	148 kg/m^3
Fine aggregate	876 kg/m^3
Coarse aggregate	1102 kg/m^3
Chemical Admixture	4.00 kg/m^3
Wet density	2492 kg/m^3

Water/Cementitious ratio = $\frac{148}{362}$ = 0.41

Coarse aggregate can be further divided into 10 mm size and 20 mm size, depending on the grading. requireds

We may divided the total aggregate into 40 percent of 10 mm size and 60 percent of ... mm size.

In that case quantity of 10 mm size = $1102\times\frac{40}{100}$ = 440 kg/m^3

Quantity of 20 mm size = $1102\times\frac{60}{100}$ = 662 kg/m^3

...eld correction

Fine aggregate quantity = 876 kg/m^3.

Absorption = Nil

Surface moisture = 1.5%

Quantity of surface moisture = $\frac{1.5}{100}$ × 876 = 13.14 kg

∴ Weight of fine aggregate in field condition
= 876 + 13.14
= 889 kg/m^3

Absorption of C.A. = 1102 × $\frac{0.5}{100}$ = 5.51 kg/m^3

∴ Weight of C.A. in field condition = 1102 – 5.51 = 1096.49 kg/m^3

say 1097 kg/m^3

w/c ratio = 0.42

The above quantity of aggregates are on saturated and surface dry con... it is given in the problem that the aggregates are absorptive and there is no ... It is required to make the necessary correction for the actual site condition of the ... with respect to absorption characteristics.

Site Correction

Absorption of fine aggregate = 1.0%

$$= \frac{1}{100}\times 846 = 8.46 \text{ litre}$$

Absorption of coarse aggregate $= \frac{0.5}{100}\times 1163 = 5.82$ litre

Total absorption = 14.28 litres

∴ Actual amount of water to be used = 152 + 14.28 = 166.28 litres

Actual weight of F.A. to be used = 846 – 8.46 = 837.5

Actual weight of C.A. to be used = 1163 – 5.82 = 1157.20

∴ Proportion of materials at the site

Cement	362 kg/m^3
Water	166.28 kg/m^2
C.A	1157.2 kg/m^3
F.A.	837.5 kg / m^3
Admixture	4.0 kg/m^3

With the above proportion of materials carry out trial mix number 1 and see the ... of concrete. If it is not satisfactory carry out trial mix number 2, 3 and 4 as indicated ... under trial mixes. Arrive at the final proportions of concrete mix to satisfy the ... parameters.

The above mix proportions can be expressed in another way. Also small contractors ... mix proportions for one bag mix. This information is given below.

To express the proportion in the usual way,

	Cement	:	FA	:	CA	:	Water	
	362	:	846	:	1163	:	152	
or	1	:	2.34	:	3.21	:	0.42	

or proportion for one bag mix

50	:	117	:	161	:	21	(All in kg for S.S.D. condi...

The proportion in field/site condition is

	362	:	838	:	1157	:	166
or	1	:	2.31	:	3.2	:	0.46

or proportion for one bag mix in the field/site

50	:	116	:	160	:	23	(All in kg for site condition)

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Illustrative Example of Mix-Design Using Fly Ash as per IS 10262 : 2009

...n a Concrete mix for M35 grade using fly ash. Other data are given below

Type of cement	OPC 43 grade
Type of fly ash	F type conforming to IS 3812 (Part I)
Max size of Aggregate (MSA)	20 mm
Minimum Cement Contact	320 kg / m3
Maximum w/c ratio	0.45
Workability	100 mm slump
Exposure Condition	Severe (RCC)
Method of placing concrete	Pumping
Degree of Supervision	good
Chemical Admixture	Superplasticizer
Specific gravity of cement	3.15
Sp. gr. of fly ash	2.2
Sp. gr. of C.A.	2.78
Sp. gr. of F.A.	2.70
Water absorption	
(i) C.A.	0.5 percent
(ii) F.A.	Nil
Free Surface moisture	
(i) C.A.	Nil
(ii) F.A.	1.5 percent

(q) Grading of C.A. is conforming to Table 2 of IS 383 and grading of F.A. is falling in Zone I

...et mean strength

$$f'_{ck} = f_{ck} + 1.65 \times \text{standard deviation}$$
$$= 35 + 1.65 \times 5$$
$$= 35 + 8.25 = 43.25 \text{ N/mm}^2$$

...ction of w/c ratio

From the experience of designer, 43.25 N/mm^2 can be achieved in 28 days by using a ... ratio of 0.46.

But as per table 5 of IS 456, a maximum w/c ratio permitted is 0.45.

∴ Adopt w/c ratio of 0.45.

...ction of Water Content

From table 11.23, maximum water content for MSA 20 mm aggregate is 186 litre (for ...mp up to 50 mm and w/c ratio of 0.5)

Estimated water content for 100 mm slump $= 186 + 186 \times \frac{6}{100} = 197$ litre

As superplasticizer is used, it is assumed that water content can be reduced to the extent 25 percent.

∴ net amount of water required to be used = 197 × 0.75 = 148 litres