ACE Engineering Academy
Head Office : Sree Sindhi Guru Sangat Sabha Association, # 4-1-1236/1/A, King Koti, Abids, Hyderabad – 500001.
Ph: 040-23234418, 040-23234419, 040-23234420, 040 - 24750437
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ESE- 2019 (Prelims) - Offline Test Series Test-1

CIVIL ENGINEERING

SUBJECT: DESIGN OF CONCRETE AND MASONRY STRUCTURES AND BUILDING MATERIALS
SOLUTIONS

01. Ans: (a)

Sol: Maximum permissible pitch for lateral ties is the minimum of

(a) Least lateral dimension = 250 mm

(b) 16 times minimum diameter of longitudinal reinforcement = 16 × 12 = 192 mm

(c) 300 mm

Hence, maximum pitch is 192 mm

02. Ans: (b)

Sol: Factored load = 1.5 × Working load

= 1.5 × 8 = 12 kN/m

Bending moment at mid span (x = 2m from support) $M_u = w \times x \times \frac{x}{2}$ = 12 × 2 × $\frac{2}{2}$

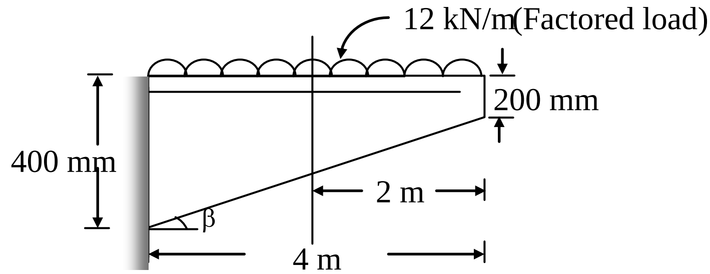
= 24 kNm

Shear force at mid span, V_u = w × x = 12 × 2

= 24 kN

Overall depth at mid span, D = 300 mm

Effective depth, d = 300 – 60 =240 mm



For a uniformly tapering beam, Nominal shear stress, $\tau_v = \dfrac{V_u \pm \frac{M_u}{d}\tan\beta}{bd}$

tan β = 200/4000 = 0.05

Negative sign is used when bending moment increases towards the section in the same direction if effective depth also increases

$$\tau_v = \frac{(24\times1000)-\left(\frac{24\times10^6}{240}\times0.05\right)}{200\times240}$$

$$= \frac{24000-5000}{200\times240} = 0.396\text{MPa} \simeq 0.4 \text{ MPa}$$

03. Ans: (a)

Sol: **Weak storey:** Any storey in which the total lateral storey strength is less than 80% of that of the storey above is called a weak storey. It is characterised by vertical discontinuity in strength. It is created by over strengthening or over stiffening of lower floor.

Soft storey: Any storey, for which the lateral stiffness is less than 60% of that of the storey immediately above, or less than 70% of the combined stiffness of the three storeys above, is classified as a soft storey. **Eg:** Parking lot.

In redundant structures, due the load redistribution in the members, failure of individual member will not lead to progressive collapse. Hence redundant structures are preferred.

04. Ans: (d)

Sol: For live load upto 3 kN/m^2; percentage of LL to be considered = 25%

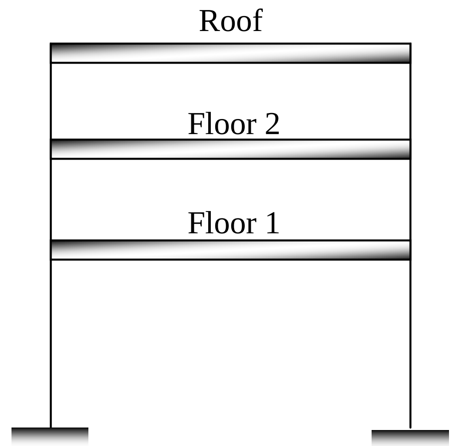
Seismic weight of each floor

$= (10 + 3 \times 0.25) \times 64 = 688$ kN

Seismic weight of roof $= 10 \times 64 = 640$ kN

Total seismic weight $= (688 \times 2) + (640)$

$= 2016$ kN



05. Ans: (b)

Sol:

- Web shear cracks are due to diagonal tension failure. Hence they are inclined to the axis of the beam.
- Flexural cracks are formed when the principal stress is flexural stress. These are normal to the axis of the beam.
- Splitting cracks are common in deep beams, which are due to loss of bond between steel and concrete and the web may buckle and subsequently crush.
- When both flexure and shear are significant then flexural crack is usually formed first, and due to the increased shear stress at the tip of the crack, it extends into a diagonal tension crack. Hence it is normal to the axis of the beam at bottom and then inclined.

06. Ans: (c)

Sol: Area of cross section = 200×600

$= 12 \times 10^4$ mm^2

Section modulus. $Z = 200 \times 600^2/6$

$= 12 \times 10^6$ mm^3

Maximum hogging bending moment occurs at the support = $wl^2/2 = 15 \times 4^2/2 = 120$kNm

Since the bending moment is hogging, tension is induced at the top of the beam. So tendons are placed near to the top edge of the beam as shown in the figure.

Let the eccentricity = e

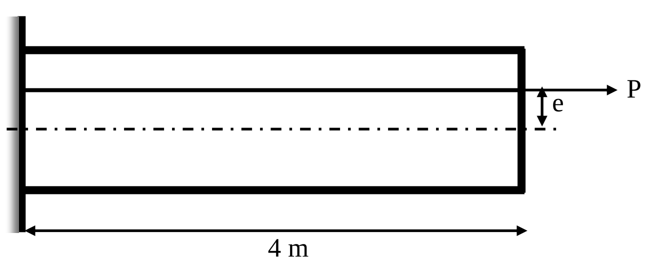
For no tension to develop at the top of the beam at support:

$$\frac{P}{A} + \frac{Pe}{Z} - \frac{M}{Z} = 0$$

$$\frac{1000 \times 1000}{12 \times 10^4} + \frac{1000 \times 1000 \times e}{12 \times 10^6} - \frac{120 \times 10^6}{12 \times 10^6} = 0$$

e = 20mm

Location of the tendon from the bottom of the beam = (600/2) + 20 = 320 mm



07. Ans: (b)

Sol: For post tensioned beams, shrinkage strain in concrete = $\dfrac{2 \times 10^{-4}}{\log_{10}(t+2)}$

$$= \frac{2 \times 10^{-4}}{\log_{10}(8+2)} = 2 \times 10^{-4}$$

Loss of stress due to shrinkage of concrete

$= \varepsilon_s E_s = 2 \times 10^{-4} \times 2 \times 10^5$

= 40 MPa

Percentage loss of stress

$$= \frac{\text{loss of stress}}{\text{Initial Stress}} \times 100$$

$$= \frac{40}{3000} \times 100$$

= 1.33%

08. Ans: (a)

Sol: Transmission length depends on

- Size and type of tendon
- Surface conditions of tendon
- Tendon stress
- Method of transfer
- Concrete strength
- Concrete compaction
- Concrete confinement level (by stirrups or hoops etc)
- State of strain in transfer region
- Concrete cover

09. Ans: (b)

Sol: Factored net soil pressure = (200 × 1.5)/1.5

$= 200\ kN/m^2$

= 0.2 MPa

Critical section for one way shear is at a distance d from the face of the wall

$$= P_o B\left[\frac{B}{2} - \frac{b}{2} - d\right]$$

$$= 200 \times 1.5\left[\frac{1.5}{2} - \frac{0.23}{2} - d\right]$$

= 300 [0.635 – d]

= 190.5 – 300d

Shear resistance of concrete = 0.35 × 1000 × d

= 350 d kN

To be safe against one way shear;

$\tau_v \le \tau_c$

190.5 – 300d ≤ 350 d

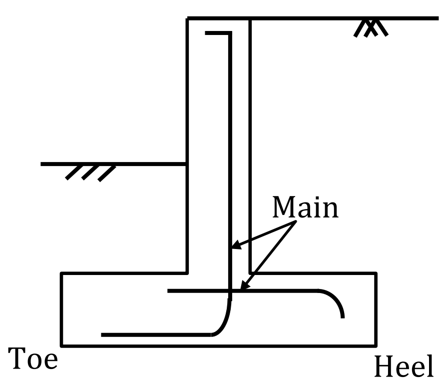
0.293 m ≤ d

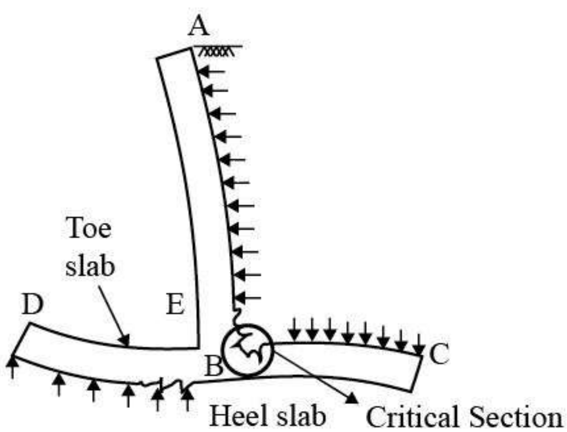
d ≥ 0.293 m

≥ 293 mm

10. Ans: (b)

Sol:





- For heel slab, critical section for shear is at the face of the stem since no compression is induced at the supports.
- Toe slab acts as a cantilever and net load is acting upwards. Hence the reinforcement is placed at the bottom of the slab as tensile stresses are produced at the bottom
- Heel slab acts as a cantilever and net load is acting downwards. Hence the reinforcement is placed at the top of the slab as tensile stresses are produced at the top.

11. Ans: (b)

Sol: As per IS:456-2000, Clause 33.1(b)

Where spanning on to the edge of a landing slab, which spans parallel, with the risers, a distance equal to the going of the stairs plus at each end either half the width of the landing or one metre, whichever is smaller.

Number of risers in each going = (3.2/2)/0.16 = 10

Number of treads = 10 –1 = 9

Width of going = 9 × 300 = 2700 mm = 2.7 m

$x = \frac{1.3}{2} = 0.65 < 1 \quad \therefore$ O.K

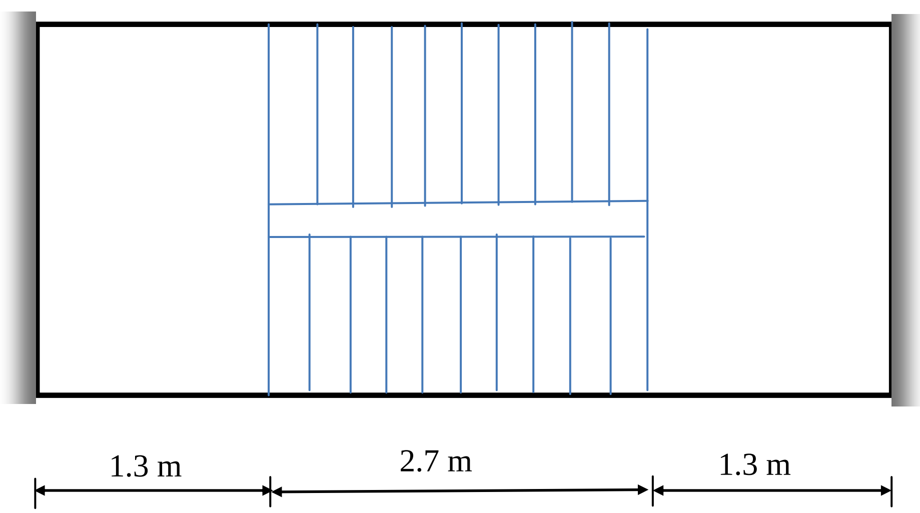
$y = \frac{1.3}{2} = 0.65 < 1 \quad \therefore$ O.K

Since the stair case is supported on masonry walls at the outer edges of landing, parallel to risers;

Effective span = G+ x+ y

= 2.7+0.65+0.65

= 4.0 m

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12. Ans: (d)

Sol: Minimum reinforcement is provided in concrete so that it develops ultimate moment of resistance more than cracking moment of identical PCC.

This ensures that sudden failure is avoided.

13. Ans: (d)

Sol: Minimum reinforcement required for the walls, floors and roof of water tank which are upto 100mm thickness is 0.3%

For sections of thickness > 100 m and < 450 mm it linearly reduces to 0.2%

For 450 mm thick wall, reinforcement required = (0.2/100) × 450 × 1000

$= 900\ \text{mm}^2$

14. Ans: (c)

Sol: In earth quake resistant design

- High strength concrete is not preferred because, it has lower ultimate compressive strain which affects ductility
- Mild steel has longer yield plateau, resulting in the formation of plastic hinges that have greater rotation capacity. The code prohibits the use of grades higher than Fe415.
- Brittle failure (like shear failure) should not occur before ductile flexural failure. Hence the shear design is different from ordinary structure. Due to extensive cracking in the zones of high shear, it is preferred to ignore shear strength of concrete and the stirrups are designed to resist entire shear.
- Inclined bars are effective in resisting shear in one direction only. In case of earthquake, the direction of shear is alternating .Hence the direction of diagonal tensile stress is also alternating. So the inclined stirrups are not preferred as shear reinforcement.

15. Ans: (b)

Sol: Compressive strength of cube is more than cylinder because of the effect of lateral restraint generated due to the friction between end surfaces of concrete specimen and adjacent steel platens. It results in more confinement of specimen at the edges. This effect decreases as the distances from platen restraint increases. As the length of cylinder is more than cube, the effect is less for cylinder resulting in lower compressive strength than cube. Also standard cylindrical specimen has $\frac{L}{D}$ ratio = 2

16. Ans: (a)

Sol: For M25 grade concrete σ_{cbc} = 8.5 MPa

$$\text{Modular ratio (m)} = \frac{280}{3\times\sigma_{cbc}}1$$

$$= \frac{280}{3\times 8.5} = 10.98 \approx 1$$

For actual depth of neutral axis

$$\frac{bx_a^2}{2} = mA_{st}(d-x)$$

$$\frac{200\times x_a^2}{2} = 11\times\left(\frac{\pi}{4}\times 12^2\times 4\right)(400-x_a)$$

$$0.02\,x^2 + x - 400 = 0$$

$$x = 118.61\text{ mm}$$

17. Ans: (b)

Sol: In a composite beam with concrete to concrete interface a slab is cast over precast beam, then the beam acts as a single composite flexural member across the entire cross section. Hence the horizontal shear has to transmitted across the interface and to prevent slippage.

In case of concrete to concrete interface this can be ensured by providing full depth stirrups with bond and friction along the interface.

18. Ans: (c)

Sol: The effective flange width of continuous T beam = $l_o/6 + b_w + 6D_f$ and not greater than actual flange width = (1800/6) + 200 + (6 × 150) = 1400 mm > 1300 mm

Effective flange width = 1300 mm

19. Ans: (d)

Sol: As per IS 456-2000, in Limit state design it is assumed that, the maximum strain at the ultimate limit state at the level of centroid of reinforcement shall not be less than

$$0.002 + \frac{0.87f_y}{E_s} = 0.002 + \frac{0.87\times 500}{2\times 10^5}$$

$$= 0.004175$$

So that ductile failure occurs in steel.

20. Ans: (c)

Sol: In limit state method, stress strain curve of concrete is parabolic and then constant. i.e. it is not linear. (It is elasto plastic stress strain curve)

Critical depth of neutral axis in limit state method depends only on grade of steel and is given by

$$\left[\frac{0.0035}{0.0055 + \left(\frac{0.87f_y}{E_s}\right)}\right]d$$

i.e 0.46d for Fe500; 0.48d for Fe 415 ; 0.53d for Fe 250

In working stress method, critical depth of neutral axis is given by

$$\frac{m\sigma_{cbc}}{m\sigma_{cbc}+\sigma_{st}}, \text{ Where } m=\frac{280}{3\sigma_{cbc}}$$

Hence it depends only on grade of steel.

21. Ans: (b)

Sol: Compressive strength of concrete = $0.6f_{ck}$

Partial safety factor for concrete = 1.6

Design compressive strength = $0.6\frac{f_{ck}}{1.6}$

$= 0.375f_{ck}$

Compressive force when the design strength of concrete is $0.447f_{ck} = 0.36f_{ck}bx$

Since all other factors remains same; compressive force for the given case

$= 0.36f_{ck}bx\ (0.375/0.447) = 0.302\ f_{ck}bx$

Note: This can be verified by finding the corresponding area of stress diagram

22. Ans: (b)

Sol: Factored Bending moment at mid span

$= wl^2/8 = 16 \times 10^2/8 = 200$ kNm

Designing the section as balanced section;

$M_u = 0.138f_{ck}bd^2$

$200 \times 10^6 = 0.138 \times 20 \times 200 \times d^2$

d = 601.93 mm

Effective cover = 40mm; total depth

= 601.93 + 40 = 641.93 mm

From the given options (b) is closer.

23. Ans: (a)

Sol: Since the development of bond stress (τ_{bd}) as uniform over the length L_d,

$\pi\phi L_d\tau_{bd} = \frac{\pi}{4}\phi^2\sigma_s$ (f_s = maximum stress at critical section = $0.87f_y$)

$$\tau_{bd} = \frac{\phi\sigma_s}{4L_d} = \frac{20\times0.87\times415}{4\times900} = 2\,\text{MPa}$$

24. Ans: (c)

Sol: Shrinkage and temperature are independent of stress conditions in concrete. Hence they are reversible to greater extent. Since creep depends on the stress conditions, and under same loading conditions it is not reversible.

When the reinforcement is not placed symmetrically on the cross-sections, the locations with less reinforcement shrink more than the locations with more reinforcement. This causes differential shrinkage.

25. Ans: (c)

Sol: **Explanation:** When the equivalent torsion moment (M_t) is greater than flexural moment (M_u) then the tension reinforcement is designed for $M_{e1} = (M_t + M_u)$. Also, compression reinforcement is designed for $M_{e2} = (M_t – M_u)$

26. Ans: (d)

Sol: Since failure should occur in region I of Load-Moment interaction curve, it is a compression failure with minimum eccentricity and ultimate load carrying capacity is given by

$P_u = 0.4f_{ck}A_c + 0.67f_yA_{sc}$

Area of concrete (ignoring area of steel)

$= (400 \times 600) = 240000\text{mm}^2$

Area of steel = $6\times\frac{\pi\times 20^2}{4} = 1884.95\text{ mm}^2$

$P_u = (0.4 \times 25 \times 240000) + (0.67 \times 415 \times 1884.95)$

$= 2924.11$ kN

27. Ans: (b)

Sol: In a post tensioned beam , loss due to elastic shortening is zero if all the tendons are tensioned simultaneously.

If the tendons are tensioned sequentially, then when a tendon is tensioned (say tendon II), the tendons which were tensioned (say I) earlier will undergo shortening.

Hence the loss is tendon I will be due to tensioning of II, III and IV

loss is tendon II will be due to tensioning of III and IV

loss is tendon III will be due to tensioning of IV

loss in tendon IV= 0

Since all the tendons are at same level,

Loss in tendon I > II > III > IV

28. Ans: (c)

Sol: Fine aggregates don't affect the strength of concrete.

29. Ans: (c)

Sol: Aluminium has high thermal and electrical conductivity. There fore, statement '2' is wrong. The only option without statement -2 is (c).

30. Ans: (b)

Sol: PVC is an example of thermoplastic.

31. Ans: (c)

Sol: Attrition test is used to assess the hardness.

Acid test is used to test for calcium carbonate.

Smith's test is used to test for the presence of soluble materials in the stone.

32. Ans: (c)

Sol: Stainless steel is very less magnetic because of the presence of high carbon and chromium content.

33. Ans: (b)

Sol: Chemical admixtures don't improve the strength of concrete.

34. Ans: (a)

Sol: All mineral admixtures are pozzolanic materials. No mineral admixture is an accelerator.

35. Ans: (b)

Sol: Glass is a brittle material. Refractories have high alumina content in the raw materials.

36. Ans: (d)

Sol: Due to the addition of fibers, the formation of micro-cracks during the hydration of cement decrease, hence the tensile strength increases. The compressive strength remains the same.

37. Ans: (b)

Sol: In stretcher bond, the size of a single unit of brick with mortar is $20 \times 10 \times 9$ (Since, mortar is not present on the stretcher faces).

For one cubic meter of masonry the total number of bricks needed = $1/(0.2 \times 0.1 \times 0.09) = 556$. Say 560.

38. Ans: (a)

Sol: Both, one point loading and two point loading methods are used to determine the flexural tensile strength of concrete.

39. Ans: (d)

Sol: Wrought iron has a carbon content less than 0.08% and hence it is one of the purest forms of iron. The percentage of carbon content in mild steel is around 0.1 to 0.25% and in cast iron is around 2.5%. Cast iron is more brittle than mild steel as the brittleness of a steel increases with increase in its carbon content. Hence, cast iron has high compressive strength and low tensile strength compared to mild steel.

40. Ans: (b)

Sol: Ceramics are very brittle materials, they have very less elongation before failure.

41. Ans: (a)

Sol: Only C_3A takes part directly in Sulphate attack, by forming sulpho aluminates.

42. Ans: (c)

Sol: Both the statements are true.

43. Ans: (a)

Sol: Super Sulphate Cement is prepared by grinding 85% slag, 10% Calcium Sulphate and 5% cement clinkers. Since slag is the main constituent of this cement, its strength gain is primarily due to pozzolanic action.

44. Ans: (c)

Sol: The standard consistency of cement (P) is needed to perform the Setting time tests, Le Chatlier's Test and Compressive strength test, hence Standard Consistency Test must be performed first.

45. Ans: (a)

Sol: More the fineness, more will be the surface area of the cement and hence more will be the shrinkage. Hence, as the fineness of cement increases, shrinkage effects also increase.

46. Ans: (d)

Sol: Purification of Aluminium oxide is done using Bayer's process while smelting of Aluminium oxide is done using Hall-Heroult process. Hence, option (d) is the correct answer.

47. Ans: (b)

Sol: Presence of alumina improves the plasticity of the brick earth.

Hence, option (b) is the correct option.

48. Ans: (b)

Sol: Thermosetting materials are cost-effective, but are non-recyclable. Hence, option (b) is the correct answer.

49. Ans: (b)

Sol: Sodium Alumino Ferrite (Na_3ALF_6) is added to act as flux in the absence of iron oxide. Calcium Chloride is an accelerator used in the manufacture of extra rapid hardening cement.

Hence, option (b) is the correct answer.

50. Ans: (c)

Sol: IS 2386 : 1963 gives the guidelines for testing of aggregates.

Hence, option (c) is the correct option.

51. Ans: (c)

Sol: In charring method, the whole timber is not completely burned, instead only the surface of the timber is charred, which then acts as a protective layer against fungal attack.

Hence, Option (c) is the correct option.

52. Ans: (c)

Sol: Gypsum is a setting retarder which is added to cement while grinding the cement clinkers to prevent flash set caused to due to the reaction of C_3A with water.

53. Ans: (c)

Sol: Volume of fine aggregates needed for 1 m^3 of concrete $= 2 \times 1.54 / (1 + 2 + 4)$

$= 0.44\ m^3$.

54. Ans: (a)

Sol: Marine borers don't feed on timber, instead they make holes or bores for their shelter. Teak and Sal woods have a high natural resistance against fungal attack.

Hence, option (a) is the correct option.

55. Ans: (c)

Sol: The development of one or more local swellings on the finished plaster surface is called as Blistering. Hence, option (c) is not correct statement.

56. Ans: (a)

Sol: Rapid and Extra rapid hardening cements are best suited for cold weather conditions.

Excess lime leads to unsoundness and not alkali aggregate reaction.

57. Ans: (b)

Sol: Seasoning does not kill fungi. Preservatives are used to kill fungi.

Seasoning of timber increases the life span of timber (durability) and increases the strength of the timber.

58. Ans: (b)

Sol: Weight of cement = (1/4) × 1440 = 360 kg.

59. Ans: (c)

Sol: Iron Pyrites presence in brick earth leads to crystallization of brick and hence it will lead to the disintegration of the brick. Iron Oxide, in fine powdered form acts as catalyst in the fusion of ingredients.

60. Ans: (c)

Sol: Since the frog is filled with mortar in the masonry construction, it does not act as hallow, and it gives extra in the masonry.

61. Ans: (b)

Sol: Flemish bond is used for its aesthetic appearance. If the brick surface is plastered, there is no need to use Flemish bond. English bond is used in that case.

62. Ans: (c)

Sol: Similar to Initial Setting Time test. The amount of water to be added in cement for final setting time test is 0.85P.

63. Ans: (d)

Sol: Bulking, as high as 36% can be observed in fine sands at 6% moisture content.

64. Ans: (a)

Sol: Because of the formation of air bubbles, use of Air-Entraining cement increases the workability of concrete. Hydrophobic cement is a OPC with thin protective films made of oleic or stearic acid. Strength of OPC and Hydrophobic cement are the same.

65. Ans: (b)

Sol: Density of concrete = 2400kg/m^3

$2400 = (0.5 + 1 + 3 + 6) \times W_c$

$W_c = 228.6$ kg.

66. Ans: (d)

Sol: Statement (I) is not correct, as Refractory Timbers are non-resinous and thus they don't catch fire easily.

67. Ans: (c)

Sol: Statement (II) is not correct since addition polymerization does not lead to any loss of mass. Hence, option (c) is the correct option.

68. Ans: (a)

Sol: Both the statements are true, and Statement (II) is the correct reason for statement (I). Hence, option (a) is the correct option.

69. Ans: (d)

Sol: Statement (I) is incorrect. Since coarse aggregates contribute towards strength of the concrete, angular aggregates should be used for the preparation of concrete, as they give better interlocking.

70. Ans: (c)

Sol: Statement (II) is incorrect. Perforated clay bricks are costly compared to ordinary clay bricks, but if they are used in the construction of high-rise buildings, they reduce the dead weight of the structure, hence the cost of construction is reduced.

71. Ans: (d)

Sol: Statement I is correct in quarrying of stones by blasting, stones of different sizes (non-uniform) are produced.

72. Ans: (d)

Sol: Statement I is incorrect in solution. Tie bars are provided in column to prevent premature buckling of reinforcement and to confine concrete. It also helps in holding primary reinforcement when the concrete is casted. When ultimate stress is reached longitudinal steel it yields even if the lateral ties are provided. Hence it does not increase the load carrying capacity of column. However in the absence of lateral ties failure will be brittle caused by crushing and shearing of concrete (accompanied by buckling of bars)

If ties are provided some ductility is induced resulting in yielding in tension prior to the collapse of column.

73. Ans: (b)

Sol: When the applied moment is less than cracking moment, the section remains uncracked and the second moment of area corresponds to gross transformed section

When the applied moment exceeds cracking moment, the section gets cracked and concrete in the tension zone is neglected theoretically. Hence second moment of area corresponds to cracked transformed section.

As the second moment of area (I) of gross transformed section is more than cracked transformed section, flexural rigidity (EI) for uncracked section is more than cracked section

(**Note:** In practise, it was observed that concrete between the cracks resists tension and this causes and increase in the stiffness over the "cracked section stiffness". This is called tension stiffening effect.

Flexural rigidity is the slope of moment (M) – curvature (1/R) relation.

74. Ans: (a)

Sol: In earth quake resistant design, under strong ground motion, structure should not collapse however, damage to the structural elements is permitted. Since damage is allowed, structure should be designed for seismic forces less than base shear if it has to remain elastic. Hence a factor called response reduction factor is used for calculating lateral force from the base shear.

75. Ans: (a)

Sol: Both the statements are correct.

Statement (II) is the correct explanation for statement (I).


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