DETAILED SOLUTIONS

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ESE 2025 : Prelims Exam
CLASSROOM TEST SERIES

CIVIL ENGINEERING

Test 16

Section A : Transportation Engineering + Building Materials [All Topics]

Section B : Flow of Fluids, Hydraulic Machines and Hydro Power [All Topics]

Section C : Design of concrete and Masonry Structures - II [Part Syllabus]

1.	(d)	16.	(b)	31.	(c)	46.	(c)	61.	(a)
2.	(d)	17.	(d)	32.	(b)	47.	(b)	62.	(a)
3.	(d)	18.	(d)	33.	(c)	48.	(d)	63.	(b)
4.	(a)	19.	(c)	34.	(a)	49.	(b)	64.	(c)
5.	(c)	20.	(c)	35.	(c)	50.	(c)	65.	(d)
6.	(c)	21.	(c)	36.	(d)	51.	(b)	66.	(b)
7.	(d)	22.	(c)	37.	(c)	52.	(d)	67.	(a)
8.	(a)	23.	(d)	38.	(b)	53.	(c)	68.	(b)
9.	(b)	24.	(d)	39.	(c)	54.	(b)	69.	(c)
10.	(c)	25.	(c)	40.	(d)	55.	(b)	70.	(c)
11.	(d)	26.	(a)	41.	(d)	56.	(b)	71.	(a)
12.	(c)	27.	(b)	42.	(d)	57.	(c)	72.	(a)
13.	(c)	28.	(b)	43.	(d)	58.	(d)	73.	(b)
14.	(a)	29.	(a)	44.	(c)	59.	(a)	74.	(b)
15.	(b)	30.	(d)	45.	(b)	60.	(b)	75.	(a)

DETAILED EXPLANATIONS

SECTION A : Transportation Engineering + Building Materials

1. (d)

Special considerations while aligning roads in hilly areas:

- Stability of hill side slopes.
- Drainage of surface and subsurface water flowing from the hill side.
- Special geometric standard for hill roads, and
- Resisting length

2. (d)

The friction coefficient may decrease or increase with skid speed and depends on various factors including speed of vehicle and brake efficiency.

All three statements are incorrect.

At maximum coefficient of friction, vehicle comes to a stand still but this does not imply high braking efficiency.

3. (d)

Glare caused by headlights is more on wet pavements.

4. (a)

Given: $V = 85$ kmph, $W = 7.5$ m

$R = 520$ m

For mixed traffic, superelevation should counteract centrifugal force for 75% of design speed.

$$\therefore \quad e = \frac{V^2}{225R}$$

$$\Rightarrow \quad e = \frac{85^2}{225 \times 520}$$

$$\Rightarrow \quad e = 0.062 < 0.07 \quad \text{OK}$$

Raising of outer edge, $E = We$

$$\Rightarrow \quad E = 7.5 \times 0.062 \text{ m}$$

$$\Rightarrow \quad E = 0.465 \text{ m}$$

5. (c)

6. (c)

- Office computations are cumbersome and time consuming.
- It does not give important details such as causes of delays and the duration and number of delays.

7. (d)

The various shapes considered to suit different conditions are circular, elliptical, turbine and tangent shapes with each shape having its own advantages and disadvantages.

8. (a)

- **IRC: SP: 012 – 2015 :** Guidelines for parking facilities in urban roads.
- **IRC: 103 – 2012 :** Guidelines for pedestrian facilities.
- **IRC: 067 – 2022 :** Code of practice for road signs.

9. (b)

10. (c)

Given:

$$v = 80 \text{ km/hr}$$
$$t = 4 \text{ sec.}$$

⇒

$$f_{avg} = 0.75$$
$$v = u + at$$
$$0 = u + (-gf)t$$
$$f_{\text{obtained}} = \frac{u}{gt} = \frac{80 \times \frac{5}{18}}{10 \times 4} = 0.555$$
$$\text{Breaking efficiency, } \eta = \frac{f_{\text{obtained}}}{f_{avg}} \times 100$$
$$= \frac{0.555}{0.75} \times 100 = 74\%$$

11. (d)

Given:

$$S_c = 0.8 \text{ kg/cm}^2, \gamma_c = 2400 \text{ kg/m}^3, \quad f = 1.2$$
$$L_c = \frac{2S_c \times 10^4}{\gamma_c f} = \frac{2 \times 0.8 \times 10^4}{2400 \times 1.2} = 5.55 \text{ m}$$

12. (c)

Untreated wooden sleepers should be laid with sapwood side upwards and heartwood side downwards.

13. (c)

14. (a)

- Track drainage is the interception, collection and disposal of water from, upon or under the track. It is accomplished by surface and subsurface drainage system.
- Proper drainage of sub-grade is very vital or excess water reduces the bearing capacity of the soil and as well as its resistance to shear.

15. (b)

16. (b)

- The radii of main track curve and the lead curve are equal.

17. (d)

For landing of an aircraft no correction is required for temperature and gradient.

18. (d)

19. (c)

$$R = \frac{V^2}{125f} = \frac{60^2}{125 \times 0.13} = 221.5\,\text{m}$$

From Horonjeff's equation, $R = \dfrac{0.388w^2}{\dfrac{T}{2} - S}$, w = 18.0 m, T = 22.5 m

$$S = 6 + \frac{6.72}{2} = 9.36 \text{ m}$$

$$\therefore \quad R = \frac{0.388 \times 18^2}{\dfrac{22.5}{2} - 9.36} = 66.5 \text{ m}$$

R_{min}. for supersonic aircraft is 180 m.

$\therefore \quad R$ = 221.5 m > 180 m

20. (c)

Distance of centre line of inner lane to the centre of horizontal curve,

$$R = 192 - \frac{8}{4} = 190 \text{ m}$$

$$\frac{\alpha}{2} = 30°$$

Set back distance from centre line of inner lane is given by (when $L > SSD$)

$$= R - R\cos\frac{\alpha}{2}$$

$$= 190 - 190 \cos 30°$$

$$= 25.46 \text{ m} \simeq 25.5 \text{ m}$$

21. (c)

Maximum harbour depth = Loaded draft + 1.2 m (when bottom is soft)

Maximum harbour depth = Loaded draft + 1.8 m (when bottom is rock)

For rock bottom harbours, stable foundation is there which can support great depths of water than the soft bottom harbours.

22. (c)

Compressed air TBM :Confinement is achieved by pressurizing air in the cutter chamber

Slurry shield TBM : Confinement is achieved by pressurzing boring fluid inside cutterhead chamber.

23. (d)

24. (d)

Wind rose diagram shows direction, duration and intensity of wind.

25. (c)

26. (a)

The compressive strength of any individual brick tested in the sample should not fall below the minimum average compressive strength specified for the corresponding class of brick by more than 20 percent.

27. (b)

Now,
$$G_t = \frac{100}{\frac{W_{agg}}{G_{agg}} + \frac{W_B}{G_B}} \qquad \left\{\begin{matrix} \because W_B = 5\% \\ \therefore W_{agg} = 95\% \end{matrix}\right\}$$

$\therefore$
$$2.5 = \frac{100}{\frac{95}{G_{agg}} + \frac{5}{1}}$$

$\Rightarrow$
$$G_{agg} = 2.714$$

28. (b)

Super sulphated portland cement has satisfactory frost and air resistances, but it is less resistant than concrete from portland cement due to the fact that hydrosilicates of low basicity show greater tendency to deformation from humidity fluctuations and resist the combined action of water and frost less effectively.

29. (a)

- Total quantity of heat evolved is same in both fine and coarse cement.

30. (d)

31. (c)

According to flexure test,

$$\text{Modulus of rupture} = \frac{Pl}{bd^2} \qquad (a > 200 \text{ mm})$$
$$= \frac{3Pa}{bd^2} \qquad (200 \text{ mm} > a > 170 \text{ mm})$$

For a = 180 mm, modulus of rupture $= \dfrac{3 \times 20 \times 10^3 \times 180}{150 \times 150^2} = 3.2 \text{ N/mm}^2$

32. (b)

- Sulphate of calcium, magnesium, sodium, potassium or iron usually found in bricks in small proportions are harmful substances in brick earth.
- If sufficient time is not given for burning of brick then carbon and sulphur which are present in brick will not get oxidize properly and results in formation of spongy, swollen structure in brick and the brick will be decoloured by white patches.

33. (c)

34. (a)

General conditions of concrete	Pulse velocity (m/s)
Excellent	Above 5000
Good	4000 - 5000
Questionable	3000 - 4000
Poor	2000 - 3000
Very poor	below 2000

35. (c)

36. (d)

37. (c)

Foxiness is a sign of decay appearing in the form of yellow or red tinge or discoloration of overmatured trees.

38. (b)

A well graded mixtures of aggregates provides best workability.

39. (c)

It has been found that sea water reduce the strength of concrete by 10 – 20% and slightly accelerate the setting time. It may lead to corrosion of the reinforcements thereby decreasing durability of concrete.

40. (d)

- Polyether polycarboxylate is superplasticizer.

41. (d)

The composites can be natural or man-made. Wood is a natural composite of cellulose fibres in a matrix of lignin.

42. (d)

Let $$\frac{\text{Fine aggregate}}{\text{Coarse aggregate}} = x$$

So, combined aggregate/coarse ratio will be $(1 + x)$

$$\Rightarrow \quad (1 + x)6 = 1 \times 7.5 + x \times 2.8$$

$$\Rightarrow \quad x = \frac{7.5 - 6}{6 - 2.8} = 0.468 \text{ or } 46.8\%$$

43. (d)

The impregnation of monomer and subsequent polymerization reduces the inherent porosity of concrete.

44. (c)

Water absorbed by coarse aggregate (CA) = 2%

$\therefore$ Water absorbed $= 1350 \times \dfrac{2}{100} = 27$ kg

Similarly, water absorbed by fine aggregate (FA)

$$= 500 \times \frac{0.5}{100} = 2.5 \text{ kg}$$

$\therefore$ Quantity of CA should be decreased by 27 kg and quantity of *FA* should be decreased by 2.5 kg.

Total water absorbed $= 27 + 2.5 = 29.5$ kg

$\therefore$ Total water should be increased by 29.5 kg per m^3 of concrete.

45. (b)

46. (c)

Statement I is true but Statement II is false.

The IRC suggests that the FI of aggregates used in water bound macadam and bituminous macadam should not exceed 15%.

47. (b)

48. (d)

Mixes which bleed excessively are those which are harsh and not sufficiently cohesive.

49. (b)

Statement I is true because of economical utilization of fuel through the elimination of separate drying operations.

Statement II is true as wet process is less responsive to variable clinker demand than the short kilns which can be used in the dry process.

50. (c)

A fibre reinforced concrete requires a considerably greater amount of fine aggregates than that of conventional concrete for convenient handling. For FRC to be fully effective, each fibre needs to be fully embedded in the matrix, thus the cement paste requirement is more.

SECTION-B : Flow of Fluids, Hydraulic Machines and Hydro Power

51. (b)

Euler's equation of motion is conservation of momentum and is applicable to steady, compressible as well as incompressible flow of non-viscous fluid.

52. (d)

53. (c)

Given:

$$P_0 = 1.05 \text{ kPa}$$
$$V_0 = 20 \text{ m/s}$$
$$\rho = 1.2 \text{ kg/m}^3$$

Stagnation or total pressure,

$$P_s = P_0 + \frac{\rho V_0^2}{2}$$
$$= 1.05 \times 10^3 + 1.2 \times \frac{20^2}{2}$$
$$= 1.29 \times 10^3 \text{ N/m}^2 = 1.29 \text{ kPa}$$

54. (b)

Series connection

$$\frac{L_1}{D^2} = \frac{l}{d^5} + \frac{l}{d^5} = \frac{2l}{d^5}$$

$\therefore$ $$L_1 = 2l$$

Parallel connection

$$h_{f2} = h_{f1}$$
$$\frac{fL_2Q^2}{12.1\,D^5} = \frac{fl(Q/2)^2}{12.1\,D^5}$$
$$L_2 = \frac{l}{4}$$

$\therefore$ $$\frac{L_1}{L_2} = \mathbf{8:1}$$

55. (b)

The friction factor is a function of surface roughness in turbulent flow.

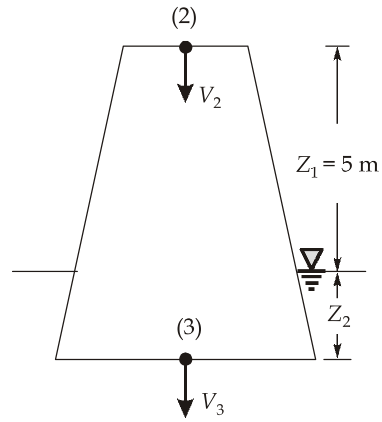
56. (b)

We know that Kinetic energy correction factor for laminar flow between stationary plates is 1.54 and for laminar flow through pipe is 2.0 .

$$\text{Ratio} = \frac{1.54}{2} = 0.77$$

57. (c)

58. (d)



Applying Bernoulli's equation between (2) and (3)

$$\frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_1 + Z_2 = \frac{P_3}{\gamma} + \frac{V_3^2}{2g} + 0 + \text{losses}$$

$$\Rightarrow \quad \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_1 + Z_2 = Z_2 + \frac{V_3^2}{2g} + \text{losses} \qquad \left[\because \frac{P_3}{\gamma} = Z_2\right]$$

[Assuming P_2 and P_3 as gauge pressures]

$$\Rightarrow \quad \frac{P_2}{\gamma} = -Z_1 - \left(\frac{V_2^2 - V_3^2}{2g}\right) + \text{losses}$$

$$\Rightarrow \quad \frac{P_2}{\gamma} = -5 - \frac{\left[6^2 - (1.25)^2\right]}{2 \times 9.81} + 0.10$$

$$\Rightarrow \quad \frac{P_2}{\gamma} = -6.655 \text{ m}$$

59. (a)

$$\eta_d = \frac{\text{Net gain in pressure head}}{\text{Velocity head at entrance of draft tube}}$$

$$\Rightarrow \quad \eta_d = \frac{\left(\frac{V_2^2 - V_3^2}{2g}\right) - h_f}{\frac{V_2^2}{2g}}$$

$$\Rightarrow \quad \eta_d = \frac{V_2^2 - V_3^2 - 2gh_f}{V_2^2} \qquad (h_f = \text{losses in draft tube})$$

$$\Rightarrow \quad \eta_d = \frac{6^2 - 1.25^2 - 2 \times 9.81 \times 0.1}{6^2}$$

$$\Rightarrow \quad \eta_d = 0.902 \simeq 90.2\%$$

60. (b)

$$\text{Given: Total head, } H = 90 \text{ m}$$
$$\text{Design speed, } N = 1000 \text{ rpm}$$
$$\text{Specific speed, } N_s = 30$$
$$\text{Discharge through each pump, } Q = 0.25 \text{ m}^3/\text{s}$$

$$N_s = \frac{N\sqrt{Q}}{(H)^{3/4}}$$

$$\Rightarrow \quad 30 = \frac{1000 \times \sqrt{0.25}}{(H_m)^{3/4}}$$

$$\Rightarrow \quad H_m = \left(\frac{1000 \times \sqrt{0.25}}{30}\right)^{4/3} = \left(\frac{100}{3} \times \frac{5}{10}\right)^{4/3} = 42.57 \text{ m} \simeq 42.6 \text{ m}$$

$$\therefore \quad \text{Number of pump stages} = \frac{90}{42.6} = 2.11 \simeq 3$$

61. (a)

The highest component of total construction cost in a channel section is the cost of lining and if perimeter is kept minimum, then the cost of lining will be minimum. Hence it will be most economical section.

62. (a)

In a diverging section, flow separation may occur due to adverse pressure gradient, to avoid this it is kept much longer then converging section.

Section C : Design of concrete and Masonry Structures - II

63. (b)

Moment coefficients for slabs have been derived, assuming unyielding supports.

64. (c)

$$\text{Spacing, } S = \frac{a}{A_{st}} \times 1000$$

where a = Area of one bar

A_{st} = Area of reinforcement provided

$$A_{st} = \frac{a}{S} \times 1000$$

Since A_{st} is same,

$$\therefore \quad \frac{a_1}{S_1} = \frac{a_2}{S_2}$$

$$\Rightarrow \quad \frac{d_1^2}{S_1} = \frac{d_2^2}{S_2}$$

$$\Rightarrow \quad \frac{10^2}{10\,\text{cm}} = \frac{12^2}{S_1}$$

$$\Rightarrow \quad S_1 = \frac{12^2}{10^2} \times 10\,\text{cm}$$

$$\Rightarrow \quad S_1 = 14.4\text{ cm}$$

65. (d)

- 'Positive' yield lines form in the interior regions of slab and terminate at the slab boundaries.
- 'Negative' yield lines form along the lines of continuous or fixed supports, and sometimes run through or form closed loops within the slab.

66. (b)

Permissible punching shear stress,

$$\tau_{vp(\text{per})} = k_\beta \times 0.25 \times \sqrt{f_{ck}}$$

where,

$$k_\beta = \left(0.5 + \frac{b}{a}\right) \not> 1$$

$$b = 160\text{ mm and } a = 400\text{ mm}$$

$$\therefore \quad k_\beta = \left(0.5 + \frac{160}{400}\right)$$

$$= 0.9 < 1 \qquad \text{(O.K.)}$$

$$\therefore \quad \tau_{vp(\text{per})} = 0.9 \times 0.25 \times \sqrt{30} = 1.23\text{ MPa}$$

67. (a)

Length of footing = 5 m

Width of footing = 4 m

Area of steel to be provided in central band = $A_{st} \times \frac{2}{\beta + 1}$ where, $\beta = \frac{L}{B} = \frac{5}{4} = 1.25$

$$= 2576 \times \frac{2}{1.25 + 1} = 2289.78\text{ mm}^2 \simeq 2290\text{ mm}^2$$

68. (b)

In case the front buttress is provided, the thickness of toe slab may be taken as 0.05 h, otherwise 0.08 h.

69. (c)

For important buildings, $I = 1.5$

For spl. moment resisting frame (SMRF), $R = 5$

For zone III, $Z = 0.16$

Base shear = $A_h \times W$

$$= \left(\frac{Z}{2} \times \frac{I}{R} \times \frac{S_a}{g}\right) \times W$$

$$= \left(\frac{0.16}{2} \times \frac{1.5}{5} \times 0.36\right) \times 5000$$

$$= 43.2 \text{ kN}$$

70. (c)

Except (c) all other (a), (b) and (d) are considered for masonry design.

71. (a)

$$R_D = \frac{1}{\left|1 - \left(\frac{\omega}{\omega_n}\right)^2\right|}$$

$$\omega_n = \frac{2\pi}{T} = \frac{2\pi}{2} = \pi \text{ rad/s}$$

$$R_D = \frac{1}{\left|1 - \left(\frac{3\pi}{\pi}\right)^2\right|} = \frac{1}{8}$$

$$= 0.125 \text{ or } 12.5\%$$

72. (a)

For post tensioned concrete shrinkage strain

$$\varepsilon = \frac{2 \times 10^{-4}}{\log(t+2)} = \frac{2 \times 10^{-4}}{\log(98+2)} = \frac{2 \times 10^{-4}}{2}$$

$$= 1 \times 10^{-4}$$

But when light weight aggregates are used in dry atmospheric condition the above value is increased by 50%.

$\therefore$ Design shrinkage strain $= 1.5 \times 1 \times 10^{-4} = 1.5 \times 10^{-4}$

73. (b)

74. (b)

The moment coefficients based on IS Code method are based on Rankine-Grashoff theory.

75. (a)

Eventual collapse of a beam generally results in a localized failure whereas collapse of a column may lead to global failure. Hence, it is desired that plastic hinge first forms in beams. Similarly it is desired to have plastic hinge is column first instead of footing.

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