DETAILED SOLUTIONS

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BPSC Main Exam 2019
ASSISTANT ENGINEER

CIVIL ENGINEERING
Objective Paper-I

Test 5

Answer Key & Solutions

ANSWER KEY

1.	(b)	11.	(a)	21.	(d)	31.	(a)	41.	(d)
2.	(b)	12.	(a)	22.	(b)	32.	(d)	42.	(d)
3.	(c)	13.	(d)	23.	(b)	33.	(c)	43.	(d)
4.	(b)	14.	(b)	24.	(b)	34.	(b)	44.	(c)
5.	(d)	15	(b)	25.	(c)	35.	(a)	45.	(a)
6.	(d)	16.	(c)	26.	(a)	36.	(b)	46.	(b)
7.	(b)	17.	(c)	27.	(c)	37.	(c)	47.	(a)
8.	(a)	18.	(b)	28.	(a)	38.	(a)	48.	(d)
9.	(b)	19.	(a)	29.	(c)	39.	(b)	49.	(c)
10.	(c)	20.	(d)	30.	(b)	40.	(b)	50.	(a)

DETAILED EXPLANATIONS

1. (b)

Isotropic materials have same properties in all directions. The number of independent elastic constants for such materials is 2. Out of E, G, K and μ, if any two constant is known for any linear elastic and isotropic material than rest two can be derived. Examples are steel, aluminium, copper, gold, etc.

Orthotropic materials refers to layered structure such as wood or plywood. The number of independent elastic constants for such materials is 9.

Non-isotropic or anisotropic materials have different properties in different directions. They show non-homogeneous behaviour. The number of independent elastic constants is 21.

2. (b)

The area of bar will become 4 times, and the volume as well as weight will increase 8 times. So increase in elongation

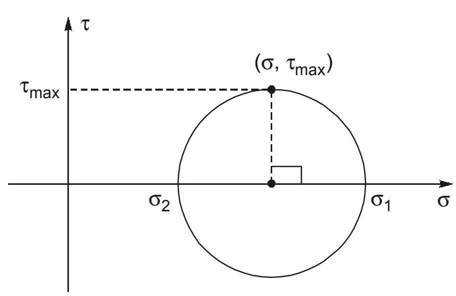
$$\left(\Delta = \frac{WL}{2EA}\right)\text{will be}\frac{8\times 2}{4} = 4 \text{ times}$$

3. (c)

$$\text{Modulus of rigidity, } G = \frac{E}{2(1+\mu)}$$

$$\therefore \quad \frac{E}{G} = 2 \times (1 + 0.25) = 2.5$$

4. (b)



Since the plane of maximum shear stress is at inclination of 90° to principal plane in Mohr's circle.
Inclination of plane Mohr's circle
= 2 × Inclination of plane in actual body
∴ Inclination of plane in actual body

$$= \frac{90°}{2} = 45°$$

10. (c)

Rotation	**Left end**	**Right end**
Clockwise	$\frac{ML}{3EI}$	$\frac{ML}{6EI}$
moment (M)	(clockwise)	(anticlockwise)
at left and		

To keep rotation at right and zero a moment should be applied in anticlockwise direction. Let the moment in M′

$$\frac{M'L}{3EI} = \frac{ML}{6EI} \quad \text{(for zero rotation)}$$

$$\therefore \quad M' = \frac{M}{2}$$

11. (a)

The Code specifies minimum and maximum limits for the spacing between parallel reinforcing bars in a layer. The minimum limits are necessary to ensure that the concrete can be placed easily in between and around the bars during the placement of fresh concrete. The maximum limits are specified for bars in tension for the purpose of controlling crack-widths and improving bond.

12. (a)

Carbonation occurs in concrete when calcium bearing phases present in concrete are attacked by CO_2 present in air, and converted to calcium carbonate.

13. (d)

Since, criteria for minimum area of tension reinforcement.

$$\frac{A_{st}}{bd} = \frac{0.85}{f_y}$$

$$\because \quad f_y = 415 \text{ MPa}$$

$$\Rightarrow \quad \frac{A_{st}}{bd} \times 100 = \frac{0.85}{415} \times 100 = 0.2\%$$

14. (b)

As per **IS:456-2000** maximum area of compression or tension reinforcement shall not exceed 0.04bD.

15 (b)

$$x_{u,\,max} = \left[\frac{0.0035}{0.0055 + \frac{0.87 f_y}{E_s}}\right] d$$

for $f_y = 415 \text{ N/mm}^2$

and $E_s = 2 \times 10^5 \text{ N/mm}^2$

and $x_{u,\,max} = 0.48d$

for $f_y = 250 \text{ N/mm}^2$

$x_{u,\,max} = 0.53\,d$

16. (c)

As per **IS : 456-2000** the cross-sectional area of the longitudinal reinforcement in columns, shall not be less than 0.8% nor more than 6% of the gross cross-sectional area of the column.

17. (c)

LSM and ULM follow non linear stress-strain curve of steel and concrete i.e. utilize the strength in plastic zone. So sections designed have lesser depth in comparison to member designed by WSM. For the same load, bending moment is more in case of LSM compared to WSM due to provisions for partial safety factors. As depth decreases in LSM, lever arm decreases and hence larger area of reinforcement is required as compared to WSM.

18. (b)

The diagonal tension reduces.

19. (a)

Maximum pitch of rivets in compression = 12 t or 200 mm whichever is less

23. (b)

Lug angles are sometimes used to reduce the length of the connections. However their main purpose is to accommodate more number of rivets so that size of the gusset plate may be reduced.

24. (b)

The lacing of compression members should be designed to resist a transverse shear, V = 2.5% of axial force in the member.

For single lacing system on two parallel faces, the force (compressive or tensile) in each bar,

$$F = \frac{V}{2\sin\theta}$$

For double lacing system on two parallel planes, the force (compressive or tensile) in each bar,

$$F = \frac{V}{4\sin\theta}$$

25. (c)

If the column ends and gusset materials are not faced/machined for complete bearing, the fasteners are designed for the total forces to be transferred. If they are faced/machined for complete bearing, 50% of the forces are transferred directly by the column and 50% through the fasteners.

40. (b)

$$\text{Relative density} = \frac{e_{max} - e}{e_{max} - e_{min}} \times 100$$

$$= \frac{1.2 - 1.0}{1.2 - 0.4} \times 100 = 25\%$$

41. (d)

$$\because \quad C_v = \frac{K}{m_v \gamma_w}$$

$$\therefore \quad \frac{K_A}{K_B} = \frac{C_{VA} m_{VA}}{C_{VB} m_{VB}} = \left(\frac{16}{9}\right) \times \left(\frac{2}{1}\right) = \frac{32}{9}$$

42. (d)

$$H_c = \frac{4c}{\gamma\sqrt{k_a}} = \frac{4 \times 25}{20} \qquad (\because k_a = 1 \text{ for } \phi = 0°)$$

$$= 5 \text{ m}$$

44. (c)

$$R_A + R_B = 12 \text{ t}$$

$$R_B = \frac{5 \times 2 + 2 \times 2 \times 5 + 3 \times 6}{8} = 6 \text{ t}$$

$$R_A = 6 \text{ t}$$

$$\frac{R_A}{R_B} = 1$$

45. (a)

- Beam with constant moment of inertia will be prismatic beam.
- Beam in which bending stress is uniform at maximum bending moment cross-section will form a plastic hinge at that section..
- Beam of uniform strength are of two types
  (i) Beams of constant width
  (ii) Beams of constant depth

47. (a)

$$\sigma_{1,2} = \frac{\sigma_x \times \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\Rightarrow \quad \sigma_{1,2} = \frac{110 + 30}{2} \pm \sqrt{\left(\frac{110 - 30}{2}\right)^2 + 30^2}$$

$$\Rightarrow \quad \sigma_{1,2} = 70 \pm \sqrt{(40)^2 + (30)^2}$$

$$\Rightarrow \quad \sigma_{1,2} = 70 \pm 50$$

$$\therefore \quad \sigma_1 = 120 \text{ MPa}$$

$$\sigma_2 = 20 \text{ MPa}$$

and, radius of Mohr's circle

$$= \frac{\sigma_1 - \sigma_2}{2} = \frac{120 - 20}{2} = 50 \text{ MPa}$$

48. (d)

$$\text{Proportionality limit shear stress} = \frac{300}{2} = 150\ \text{N/mm}^2$$

$$\text{Maximum shear stress} = \frac{120-(-30)}{2} = 75\,\text{N/mm}^2$$

$$\therefore \quad \text{Factor of safety} = \frac{150}{75} = 2.0$$

49. (c)

The reaction R_B at B is

$$\Sigma M_c = 0$$

$$\therefore \quad R_B \times L - P \times \frac{4L}{3} = 0$$

$$\Rightarrow \quad R_B = \frac{4P}{3}(\uparrow)$$

$$\therefore \quad R_C = \frac{4P}{3} - P = \frac{P}{3}(\downarrow)$$

∴ Total strain energy

$$U = \int \frac{M^2 dx}{2EI}$$

$$\Rightarrow \quad U = \int_0^L \frac{\left(\frac{Px}{3}\right)^2 dx}{2EI} + \int_0^{L/3} \frac{(Px)^2\, dx}{2EI}$$

$$\Rightarrow \quad U = \frac{2P^2L^3}{81EI}$$

So by Castigliano's theorem, deflection at free end

$$\Delta = \frac{\partial U}{\partial P} = \frac{4PL^3}{81EI}$$

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