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ESE- 2018 (Prelims) - Offline Test Series Test-13

CIVIL ENGINEERING

SUBJECT: SOLID MECHANICS + DESIGN OF CONCRETE AND MASONARY STRUCTURES + CONSTRUCTION PRACTICE, PLANNING AND MANAGEMENT

SOLUTIONS

01. Ans: (a)

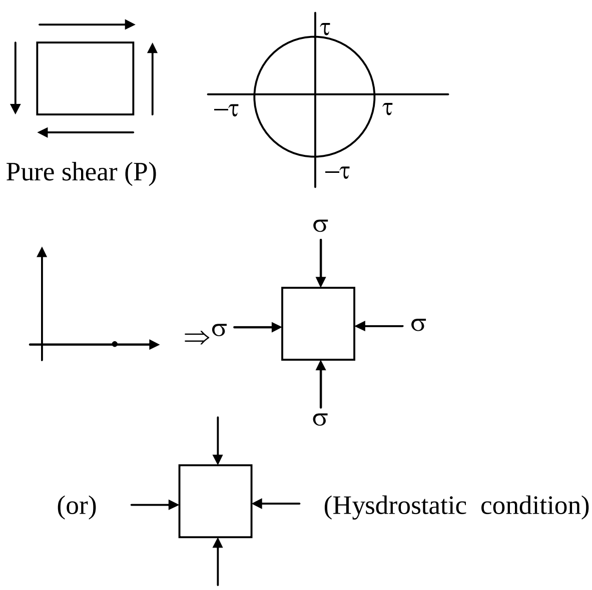
Sol: $\varepsilon_x = \frac{1}{E}\left(\sigma_x - \mu\sigma_y - \mu\sigma_z\right)$

$$\varepsilon_x = \frac{1}{200\times10^3}\left[65 - 0.3\times20 + 0.3(85)\right]$$

$$\varepsilon_x = 0.4225 \times 10^{-3}$$

02. Ans: (c)

Sol:



03. Ans: (c)

Sol: $\varepsilon_V = \frac{\sigma_x + \sigma_y + \sigma_z}{E}(1-2\mu)$

$$\varepsilon_v = \frac{\Delta V}{V}$$

$$\frac{\Delta V}{V} = \frac{100+40+40}{200\times10^3}(1-2\times0.283)$$

$$\Delta V = \frac{180}{200\times10^3}\times(1-2\times0.283)\times200\times40\times40$$

$$\Delta V = 125\ \text{mm}^3$$

04. Ans: (d)

Sol: Brittle materials fails in a plane at 45° from the axis when subjected to torque because they are weak in tension compared to shear. If ductile materials are subjected to torque, then the failure surface will be in a plane at 90° from the axis of shaft.

05. Ans: (a)

Sol: $\phi_{xy} = \dfrac{\partial u}{\partial y} + \dfrac{\partial v}{\partial x}$

$$\frac{\partial u}{\partial y} = (0+7)\times 10^{-3} = 7\times 10^{-3}$$

$$\frac{\partial v}{\partial x} = (-3+0)\times 10^{-3} = -3\times 10^{-3}$$

ϕ_{xy} = (7–3) $\times 10^{-3}$ = 4$\times$ 10^{-3} unit

$$G = \frac{\tau_{xy}}{\phi_{xy}}$$

τ_{xy} = 100 $\times 10^{9}$ $\times$ 4$\times 10^{-3}$

= 400 $\times$ 10^{6} Pa

τ_{xy} = 400 MPa

06. Ans: (b)

Sol: $\sigma_{\text{Allowable}} = \dfrac{\sigma_u}{FOS} = \dfrac{280}{3} = 93.33\ \text{N/mm}^2$

$$A = \frac{P}{\sigma_{\text{allowable}}} = \frac{50\times 10^3}{93.33} = 535.71$$

$$A = \frac{\pi d^2}{4} - \frac{\pi(d-2t)^2}{4}$$

A = πt(d–t)

$\pi \times 5$(d–5) = 535–71

d = 39.10 mm

07. Ans: (d)

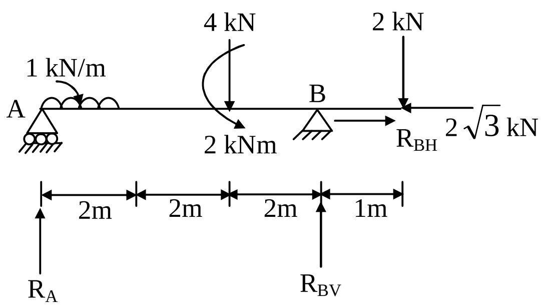
Sol: Since load on each part is same greatest elongation is possible in least area segment, and least elongation is possible in greatest area segment.

$$\delta \propto \frac{1}{\text{area}}$$

$$\frac{\delta_{max}}{\delta_{min}} = \frac{3^2}{1^2} = 9$$

08. Ans: (b)

Sol:



$R_A + R_{BV} = 1\times2 + 4+2 = 8$

By taking moment about point B, we get

$$R_A \times 6 + 2\times1 = 1\times2\times\left(\frac{2}{2}+2+2\right) + 2 + 4\times2$$

$\Rightarrow R_A = 3$ kN

$R_{BV} = 5$ kN

$R_{BH} = 4\cos30 = 2\sqrt{3}$ kN

$$R_B = \sqrt{R_{BV}^2 + R_{BH}^2}$$

$$= \sqrt{5^2 + \left(2\sqrt{3}\right)^2}$$

$R_B = 6.08$ kN $\simeq 6$ kN

09. Ans: (d)

Sol: $$U = \int_0^{\ell} \frac{M^2 dx}{2EI}$$

$$\frac{\sigma}{y} = \frac{M}{I} \Rightarrow \frac{\sigma}{\left(\frac{h}{2}\right)} = \frac{M}{\frac{bh^3}{12}} \Rightarrow M = \frac{1}{6}\sigma bh^2$$

$$U = \int_0^{\ell} \frac{\left(\frac{1}{6}\sigma bh^2\right)dx}{2E\times\frac{bh^3}{12}} = \frac{\sigma^2 bh\ell}{6E}$$

10. Ans: (c)

Sol: Total strain energy stored in bent rod is

$$U = \int_0^b \frac{M^2dx}{2EI} + \int_0^a \frac{M^2dx}{2EI} + \int_0^a \frac{T^2dx}{2GJ}$$

$$U = \int_0^b \frac{P^2x^2dx}{2EI} + \int_0^a \frac{P^2x^2dx}{2EI} + \int_0^a \frac{P^2b^2dx}{2GJ}$$

$$U = \frac{P^2b^3}{2EI(3)} + \frac{P^2a^3}{6EI} + \frac{P^2b^2a}{4GI}$$

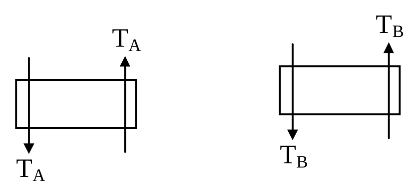
(J = 2I for circular cross –section)

By castigliano's theorem

$$\delta_A = \frac{\partial u}{\partial P} = \frac{Pb^3}{3EI} + \frac{Pa^3}{3EI} + \frac{Pab^2}{2GI}$$

11. Ans: (c)

Sol: In case of indeterminate shaft first of all draw free body diagram at junction



$T_A + T_B = T = 120$

$\because \theta_A = \theta_B$ (angle of twist in each section will be same)

$$\frac{T_A\ L_A}{GJ_A} = \frac{T_B L_B}{GJ_B}$$

$$\frac{T_A \times 400}{(200)^4} = \frac{T_B \times 200}{(120)^4}$$

$T_A = 3.85\ T_B$

$T_A = 95.3$ kNm

$T_B = 24.7$ kN-m

12. Ans: (a)

13. Ans: (c)

Sol:

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

$\Rightarrow \sigma_1 = 102.5$ MN/m^2

$\sigma_2 = -62.5$ MN/m^2

$$\tan 2\theta = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$

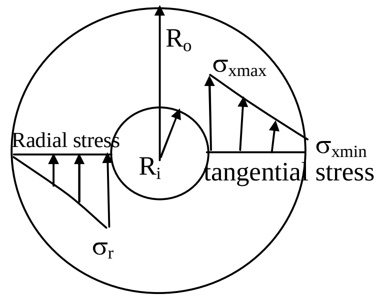
$$\Rightarrow \quad \theta = \frac{\tan^{-1}(4)}{2}$$

14. Ans: (b)

Sol: Maximum shear stress is half of the difference of the maximum and minimum principal stresses.

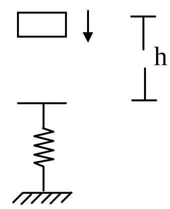
15. Ans: (b)

Sol:



16. Ans: (a)

Sol:



$$\delta = \frac{64WR^3n}{Gd^4}$$

$$200 = \frac{64W \times 100^3 \times 15}{94.5 \times 10^3 \times 25^4} \Rightarrow W = 7690.43 \text{ N}$$

Energy supplied by impact load = energy stored in spring

$$mg(h+\delta) = \frac{1}{2} w \times \delta$$

$$2500\ (h+200) = \frac{1}{2} \times 7690.43 \times 200$$

$h = 107.6$ mm

17. Ans: (d)

Sol: For one end is fixed and other end is hinged

$$\ell_e = \frac{\ell}{\sqrt{2}}$$

$$P_{Euler} = \frac{\pi^2 EI}{\ell_e^2} = \frac{2\pi^2 EI}{\ell^2}$$

If $l_e = 0.666l$, then

$$P_{Euler} = \frac{\pi^2 EI}{(0.666\ell)^2} = \frac{2.25\pi^2 EI}{\ell^2}$$

$$\%\ \text{errors} = \frac{2.25-2}{2}\times 100 = 12.72\%$$

18. Ans: (a)

19. Ans: (c)

Sol: $U = \frac{T^2\ell}{2GJ}$

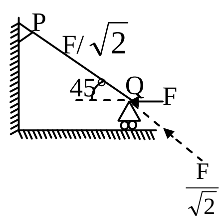
$$U = \frac{(10000)^2\times 100}{2\times 80{,}000}\left[\frac{32}{\pi}\left(\frac{1}{50^4}+\frac{1}{25^4}\right)\right]$$

$$U = \frac{136}{25\pi}$$

20. Ans: (b)

Sol:

$$P_{Cr} = \frac{\pi^2 EI}{\ell_e^2}$$



Here

$$P_{cr} = \frac{F}{\sqrt{2}}$$

$$\therefore\ F = \frac{\sqrt{2}\pi^2 EI}{\ell_e^2}$$

21. Ans: (c)

Sol: $\sigma_1 = -10$

$\sigma_2 = -100$

$$\tau_{max} = \frac{\sigma_1-\sigma_2}{2} = \frac{f_y}{2}$$

$\Rightarrow f_y = -10-(-100) = 90$ MPa

22. Ans: (b)

Sol: $K = \frac{\text{Change in load}}{\text{Change in length}}$

$$K = \frac{(22-2)\times 98}{(200-100)}\frac{N}{mm} = \frac{196\ N}{100\ mm}$$

K = 1.96 N/mm long 1960 N/m

Corresponding to pan weight of 2 kg

Length of spring = 200 mm

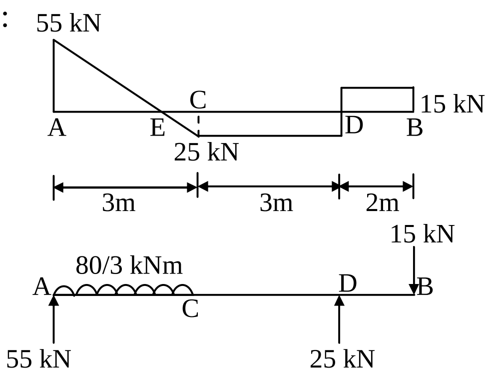
$$\text{Deflection in spring} = \frac{F}{K} = \frac{2\times 9.8}{1.96} = 10\,\text{mm}$$

$\therefore$ Undeformed (or) free length of spring

= 200 + 10 = 210 mm

23. Ans: (a)

Sol:



$$\text{Load on beam AC} = \frac{80}{3} \times 3 = 80 \text{ kN}$$

24. Ans: (c)

Sol: $P = \dfrac{2\pi N}{60}.T$

$$= 20 \times 10^3 \times 150 \times \frac{2\pi}{60}$$

P= 100 π kW

25. Ans: (b)

26. Ans: (d)

Sol: $\dfrac{\tau}{r} = \dfrac{T}{J} = \dfrac{G\theta}{\ell}$

$$r = \frac{\tau \ell}{G\theta}$$

$$= \frac{80 \times 1200 \times 180}{80 \times 10^3 \times \pi} = \frac{216}{\pi} \text{mm}$$

27. Ans: (a)

Sol:

Support for actual beam	Support for conjugate beam
Fixed	Free
Free	Fired
Intermediate support	Intermediate hinge
Intermediate hinged Rigid link	Intermediate support

28. Ans: (d)

Sol: M = fZ

$$4000W = 100 \times \frac{30^3}{6}$$

W = 112.5 N

29. Ans: (c)

Sol: $\frac{f}{y} = \frac{E}{R} \Rightarrow \frac{f}{E} = \frac{y}{R}$

$$\varepsilon = \frac{\frac{d}{2}}{R}$$

$$2.5\times10^{-3} = \frac{d}{2R}$$

$$\therefore\ 2.5\times10^{-3} = \frac{3}{2R}$$

$\Rightarrow$ R = 600 mm

$\therefore$ Shortest length = $2\pi R$

= 2×3.14 ×600 = 3768 mm

30. Ans: (b)

Sol: $\tau_{max} = \frac{3}{2}\tau_{avg}$

$$3 = \frac{3}{2}\times\left[\frac{60\times10^3}{\frac{1}{2}\times b\times120}\right]$$

$\Rightarrow$ b = 500 mm

31. Ans: (b)

Sol: $\sigma_A = \frac{P}{A} - \frac{M}{Z}; \quad \sigma_B = \frac{P}{A} + \frac{M}{Z}$

Given

$$\frac{P}{A} = \frac{M}{Z}$$

$\therefore\ \sigma_A = 0$

$\sigma_B = \frac{P}{A} + \frac{P}{A} = \frac{2P}{A}$ (Compression)

32. Ans: (d)

Sol: All are correct statements

33. Ans: (c)

Sol: $R_B \times 6 = 20 \times 3 \times 4.5$

$R_B = 45$

$R_A + R_B = 60$

$R_A = 15$

Let ‘x’ be a section from right support

$$60\times x - 20\times x.\frac{x}{2} = 0 \Rightarrow 45x - 10x^2 = 0$$

x = 4.5 m

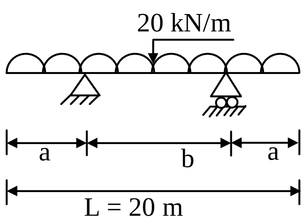
34. Ans: (c)

Sol: The x and y coordinates of centre of Mohr's circle are given by

$$\left(\frac{\sigma_x + \sigma_y}{2}, 0\right) = \left(\frac{100 - 200}{2}, 0\right) = (-50, 0)$$

35. Ans: (c)

Sol:



a = 0.207 × *l*, when both moments are equal,

b = (L – 2a) = 0.586 *l*

b = 0.586 × 20 = 11.72

36. Ans: (a)

Sol: $$\sigma_{max} = \frac{\sigma_y}{\sqrt{3(1-2\mu)}} = \frac{70}{\sqrt{3(1-2\times 0.27)}} = 59.58$$

$$\simeq 60$$

37. Ans: (c)

Sol: As the wheels/crawel is rigid in nature it causes damage to the paved roads.

38. Ans: (c)

Sol: Cycle time (c) = total travel time including losses

$$= \left(\frac{5}{40} + \frac{5}{50}\right) \times 60 + 2$$

= 13.5 + 2 = 15.5 min

39. Ans: (c) **40. Ans: (a)**

41. Ans: (d)

Sol: $\sigma = \sqrt{16} = 4$

95% probability Z ≃ 1.65

$$Z = \frac{T_S - T_E}{\sigma},$$

$T_S = \sigma \times Z + T_E$

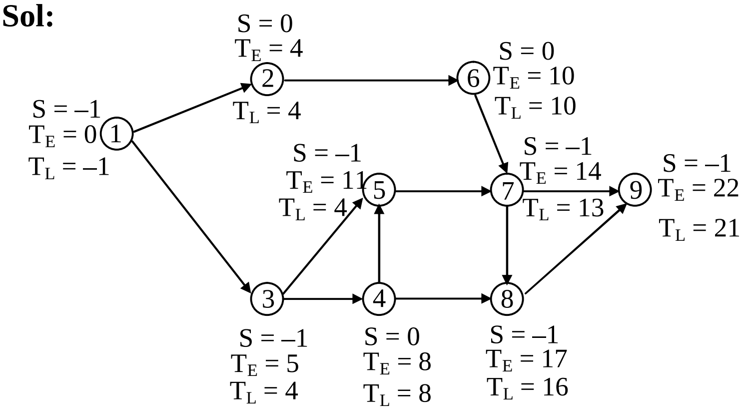
$T_S = 4 \times 1.65 + 50 \simeq 57$

42. Ans: (b)

Sol: Mixing time shall be closer to 2 min

43. Ans: (d)

Sol:



44. Ans: (d)

45. Ans: (c)

Sol:

Activity	t_o	t_L	t_P	$\sigma^2 = \left(\frac{t_p - t_o}{6}\right)^2$
1-2	2	6	8	1
2-3	5	7	17	4
3-4	4	10	16	4

$$\sigma = \sqrt{\sigma^2{}_{1-2} + \sigma^2{}_{2-3} + \sigma^2{}_{3-4}} = \sqrt{1+4+4}$$

$= 3$

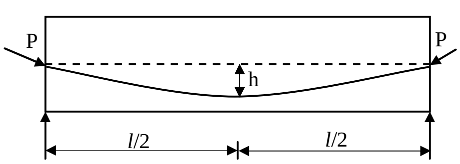
46. Ans: (a)

Sol: When prestressed concrete beam is completely load balanced then the net moment at any section = 0

Only axial compressive force due to prestressing will act on the section. Hence only axial stress exists in the beam

Note: For prestressed beam with only self weight, the cable profile is same as that of BM variation. To be completely load-balanced. Such that at midsection.

$$ph = \frac{w\ell^2}{8}$$



47. Ans: (a)

Sol: Minimum spacing limits are specified in order to ensure that the correct with required size of aggregate safely between the bars. i.e. the spacing should be more than the size of the aggregate.

Maximum spacing limits are specified since if the spacing is more, then concrete has to take all the stresses, which result in the formation of cracks.

48. Ans: (c)

Sol: As per IS456-2000; C*l* = 23.2.1, for sensibility ceiteria. For continuous span;

$\frac{\text{span}}{\text{effective depth}} \leq 26$ for spans upto 10 m.

For span > 10 m; the above ratio

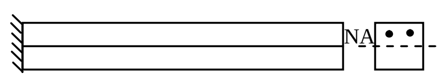
$$= 26 \times \frac{10}{\text{span length is m}}$$

$$= 26 \times \frac{10}{20} = 13$$

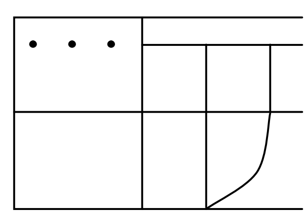
49. Ans: (d)

Sol: In a reinforced concrete beam, it is assumed that concrete does not take tension.

In a cantilever beam, subjected to dead and live loads, hogging bending moment occurs, resulting is the compressive stresses at the bottom and tensile stresses at the top of the beam. Hence, reinforcement is placed at the top and concrete above neutral axis is neglected.



∴ Shear stress variation is

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3 EE
4 EE HARSHIT KUMAR SINGH
5 EE NIKHIL KUMAR
6 EE DUSHYANT SINGH
8 EE APOORVA GUPTA
9 EE KIRAN BABU KONERU
ME
3 ME SAURABH
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50. Ans: (a)

Sol: According to d.26.5.32 of IS 456-2000, pitch of transverse reinforcement shall not be more than the least of

(a) lateral dimension of column

(b) 16 × smallest dia of longitudinal reinforcement bar to betide

(c) 300 mm

i.e (a) 250 mm

(b) 16 × 16 = 256 mm

(c) 300 mm

∴ Max. pitch value = 250 mm

51. Ans: (a)

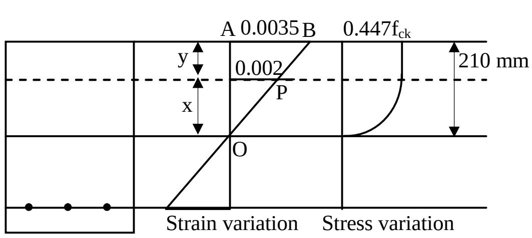
Sol: Effective flange width $= \frac{\ell_o}{6} + b_w + 6D_f$

$$= \frac{1800}{6} + 200 + 6(150)$$

= 1400 mm

52. Ans: (a)

Sol:



From the above figure: considering similar triangles OAB, OCD

$$\frac{0.0035}{210} = \frac{0.002}{x}$$

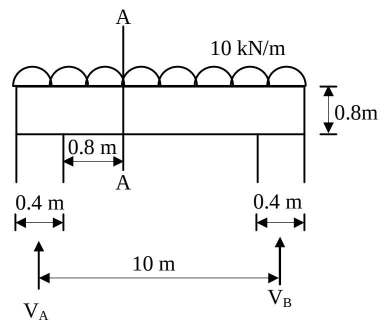
⇒ x = 120 mm

x + y = 210 mm

∴ y = 90 mm

53. Ans: (a)

Sol: Critical section for shear is at a distance ‘d’ from the face of column i.e. section A-A



From symmetry, $V_A = V_B = \frac{10\times10}{2} = 50\,\text{kN}$

Shear force at,

$$A = 50 - 10\left(0.8 + \frac{0.4}{2}\right) = 40\text{ kN}$$

54. Ans: (d)

Sol: Long term modulus of concrete $E_{ce} = \frac{E_c}{1+\theta}$

$$E_c = 5000\sqrt{f_{ck}} = 5000\sqrt{25} = 25000\,\text{MPa}$$

θ = Creep coefficient

$$= \frac{\text{Ultimate creep strain}}{\text{elastic strain at age of loading}}$$

$$= \frac{0.0015}{0.001} = 1.5$$

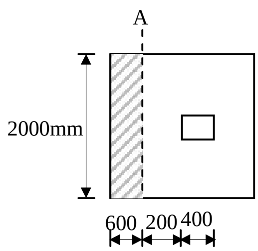
$$\therefore\ E_c = \frac{25000}{1+1.5} = 10{,}000\,\text{MPa}$$

55. Ans: (c)

Sol: As per d.2.6.6.17 of IS 456-2000, addition longitudinal bars are provided, when c/s dimension of member exceed 450 mm to satisfy the requirements of minimum reinforcement and spacing.

56. Ans: (a)

Sol: Critical section for shear is a distance 'd' from the face of column i.e. section A-A



Soil pressure,

$$W_o = \frac{P}{A} = \frac{400\times1000}{2000\times2000} = 0.1\,\text{N/mm}^2$$

Shear force at A-A

$$= 0.1 \times (2000)\text{ mm} \times \left(\frac{2000-400}{2} - 200\right)$$

V = 12,00,00 N

$$\text{Shear stress} = \frac{V}{Bd} = \frac{12,00,00}{2000\times200}$$

$$= 0.3\text{ N/mm}^2$$

57. Ans: (d)

Sol: Slenderness ratio of wall is minimum of

$$\frac{h}{t}\text{(or)}\frac{1}{t}$$

58. Ans: (b)

Sol: Toe slab is subjected to upward soil pressure and self weight of the slab

Heel slab is subjected to weight of the retared soil, upward soil pressure and self weight of the slab.

In toe slab main reinforcement is provided at bottom of the slab.

In heel slab main reinforcement is provided at top of the slab.

59. Ans: (d)

Sol: As per IS:456-2000 (clause. 26.5.1.5) maximum spacing between vertical stirrups in an RC beam of effective depth, d= 300 mm

$\not> 0.75\times d = 0.75\times300 = 225$ mm

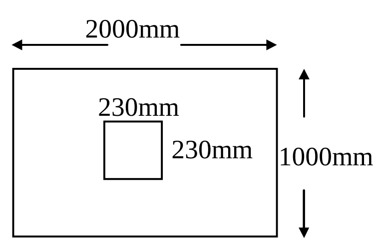
And also $\not>$300 mm

Minimum value must be used

$\therefore$ Spacing $\not>$225 mm

60. Ans: (c)

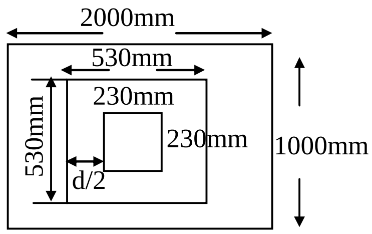
Sol:



Base pressure

$$q = \frac{P}{A} = \frac{450\times1000}{2000\times1000} = 0.225\text{N/mm}^2$$

Given d = 300 mm



Punching shear stress

$$= \frac{(q)\times(2000\times1000-530\times530)}{(4\times530)\times300}$$

$$= \frac{(0.225)(2000\times1000-530\times530)}{4\times530\times300}$$

$= 0.61\ N/mm^2$

61. Ans: (d)

Sol: Tor steel do not have specific yield point

62. Ans: (a)

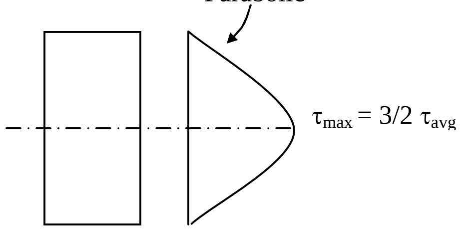
63. Ans: (c)

Sol: The effect of wire winding is to put the cylinder wall under on initial compressive stress

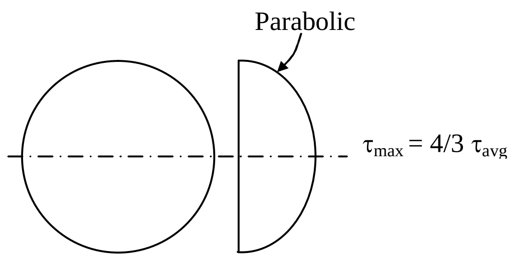
64. Ans: (b)

65. Ans: (a)

Sol:



Shear stress distribution



Shear stress distribution

The distribution of shear stress in circular section is more uniform than rectangular section

66. Ans: (b) **67. Ans: (b)**

68. Ans: (b)

Sol: Hand operated chain hoist are screw geared and differential type i.e., they are self locking and will automatically hold a load in position.

Which is used for pulling and hoisting objects, lower is the gear ratio higher is the power.

69. Ans: (a)

Sol: For new project all are based on estimates using probability

∴ PERT is more accurate for new projects.

70. Ans: (d)

Sol: Steel is a ductile material and concrete is a brifill material.

In over reinforced sections, failure occurs due to concrete which is brittle, then sudden failure occurs without any warning.

In under-reinforced section, failure occurs due to failure of steel which is a ductile material. Hence it yields before failure giving significant warning.

71. Ans: (d)

Sol: Limiting deflection of 2-way slabs is primarily fortune of shorter span.

For flexural member deflection is proportional to the length of the span.

72. Ans: (c)

Sol: In working stress method, actual depth of neutral axis is found by equation the areas above and below neutral axis.

'd' depends on amount of reinforcement

73. Ans: (a)

Sol: The probability of occurrence of wind loads and earthquake loads simultaneously is very less. If the combination of these two loads, is considered then the design of structure would be uneconomical.

74. Ans: (a) **75. Ans: (b)**