Effective depth of footing slab

(*i*) *Bending Moment Consideration*

Bending moment at the face of column,

$$M_u = 236.72 \times \frac{2.18(2.18-0.4)^2}{8}$$

$$= 204.38 \text{ kN-m}$$

For the balanced design,

$$0.36 \times 15 \times 0.48\,(1 - 0.42 \times 0.48)\ 2180\ d^2$$

$$= 204.38 \times 10^6$$

$\therefore$ effective depth, d = 217.85 mm

(*ii*) *Two Way Shear Consideration*

Punching shear,

$$\tau = \frac{236.72(2.18^2 - (0.4+d)^2)}{4(0.4+d)d}$$

where d is expressed in m and is treated as unknown.

Permissible shear stress is as follows :

$$\beta_c = 1.0$$

$$k_s = 0.5 + \beta_c = 0.5 + 1.0 = 1.5$$

which is greater than 1.0

Hence, take k = 1.0

$$\tau_c = 0.25\sqrt{15} = 0.958 \text{ N/mm}^2.$$

Permissible shear stress = $k_s \tau_c$

$$= 1.0 \times 0.0968$$

$$= 0.968 \text{ N/mm}^2 \text{ or } 968 \text{ kN/m}^2$$

For safety, $\tau \leq 968$ kN/m²

i.e. $$\frac{236.72(2.18^2 - (0.4+d)^2)}{4(0.4+d)d} \leq 968 \text{ kN/m}^2$$

$\therefore$ $d \geq 0.344$ m or 344.6 mm.

(*iii*) *One Way Shear Consideration*

Try an effective depth = 345 mm.

As this value of effective depth is greater than that required from bending consideration, the tension reinforcement is calculated as

$$0.87 \times 415\,A_{st}\left(345 - \frac{415A_{st}}{15 \times 2180}\right) = 204.38 \times 10^6$$

$$A_{st} = 1753.9 \text{ mm}^2$$

$$\frac{100A_{st}}{bd} = \frac{100 \times 1753.9}{2180 \times 345} = 0.233$$

From IS : 456, τ_c = 0.35 N/mm², which is the minimum value for concrete grade : M15.

Nominal shear stress,

$$\tau_v = 236.72 \times \frac{(2.18 - 0.4 - 2 \times 0.345)}{2 \times 0.345}$$

$$= 373.95 \text{ kN/m}^2 \text{ or } 0.374 \text{ N/mm}^2.$$

As $\tau_v > \tau_c$, the slab is unsafe in shear. The effective depth should therefore, be increased.

Try an effective depth, d = 360 mm.

$$\therefore \quad \tau_v = 236.72 \times \frac{(2.18 - 0.4 - 2 \times 0.36)}{2 \times 0.36}$$

$$= 348.5 \text{ kN/m}^2 \text{ or } 0.349 \text{ N/mm}^2.$$

As $\tau_v < \tau_c$, the slab is safe in shear.

Hence, an effective depth is 360 mm for the foundation slab is alright.

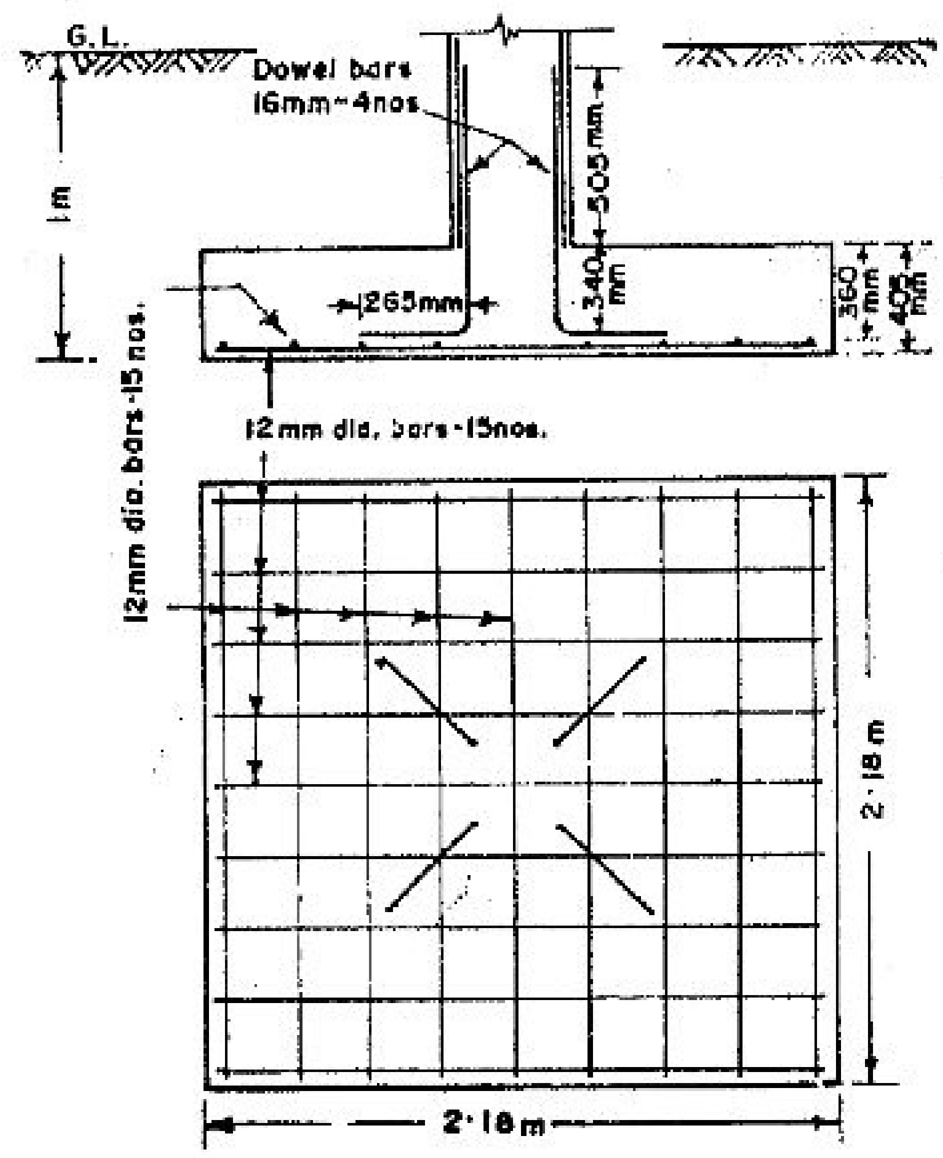
Tension reinforcement

Substituting all the values, we have

$$0.87 \times 415\ A_{st}\left(360 - \frac{415A_{st}}{15 \times 2180}\right) = 204.38 \times 10^6$$

$$A_{st} = 1670.9 \text{ mm}^2$$

Provide 12 mm dia. bars – 15 Nos. in each of the two orthogonal directions. Keep overall depth = 405 mm.



Bearing stress consideration

$$A_1 = (b + 4\,D)^2 = (0.4 + 4 \times 0.4)^2 = 4 \text{ m}^2$$

$$A_2 = 0.4^2 = 0.16 \text{ m}^2$$

$$\sqrt{\frac{A_1}{A_2}} = \sqrt{\frac{4}{0.16}} = 5 > 2.0, \text{ hence, take its value as } 2.0$$

Permissible bearing stress

$$= 0.45\,f_{ck}\sqrt{\frac{A_1}{A_2}}$$

$$= 0.45 \times 15 \times 2.0$$

$$= 13.5 \text{ N/mm}^2$$

$$\text{Actual bearing stress} = \frac{1125\times10^3}{400\times400}$$

$= 7.03$ N/mm^2 $<$ 13.5 N/mm^2, hence it is safe.

Dowel bars

Nominal dowel bars may be provided.

$$\text{Sectional area of bars} = \frac{0.5\times400\times400}{100}$$

$$= 800 \text{ mm}^2$$

16 mm dia. bars – 4 Nos. may be provided.

Development length of bars is as follows :

For 16 mm dia. bars in column,

$$I_d = \frac{16\times0.67\times415}{4\times1.2\times1.85} = 501 \text{ mm.}$$

For 16 mm dia. bars in foundation,

$$I_d = \frac{16\times0.67\times415}{4\times1.0\times1.85} = 601.2 \text{ mm.}$$

Hence, the dowel bars may be embedded for a length of 505 mm in the column and 605 in the foundation slab.

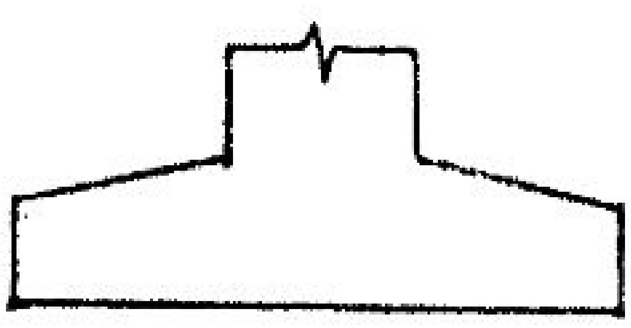
5. A rectangular R. C. column 60 cm × 40 cm carries a load of 80 tonne. Design a rectangular footing to support the column using M15 grade concrete and mild steel reinforcement. Safe bearing capacity of the soil = 20 t/m^2.

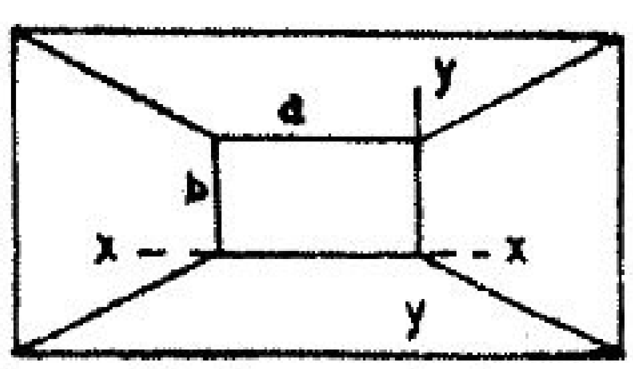
Solution: Load on column = 80 tonnes = 800 kN
Assume self weight of footing @ 10%

$$= 0.1 \times 800 = 80 \text{ kN}$$

Total load coming below footing

$$= (800 + 80) \text{ kN}$$
$$= 880 \text{kN}$$





Area of footing required

$$= \frac{\text{Total}}{\text{S.B.C of soil}} = \frac{880}{200} = 4.4 \text{ m}^2$$

where, S.B.C. of soil = 20 t/m = 200 kN/m^2

Since the column size is of ratio 2:3, therefore -

$$2x \times 3x = 4.4$$

or $\quad x = 0.856$ m

$\therefore$ Size of footing $= 2 \times 0.856$

$$= 1.713$$
$$\cong 1.75 \text{ m}$$
$$L = 3 \times 0.856$$
$$= 2.568$$
$$= 2.75 \text{ m}$$

Adopt a size (1.75 m × 2.75 m) footing

Bearing pressure,

$$q_o = \frac{\text{Net load}}{\text{Area of footing}}$$

$$= \frac{800}{1.75\times2.75} = 166.23 \text{ kN/m}^2$$

$$BM_{x\text{-}x} = q_0\left(\frac{a+L}{2}.\frac{B-b}{2}\right)\times\left[\frac{2L+a}{L+a}.\frac{1}{2}\frac{B-b}{2}\right]$$

$$= \frac{q_0}{24}(2L+a)(B-b)^2$$

$$= \frac{166.23}{24}(2\times2.75+0.60)(1.75 - 0.4)^2$$

$$= 77 \text{ kNm}$$

$$M_{YY} = q_0\left[\frac{B+b}{2}.\frac{L-a}{2}\right]\left[\frac{2B+b}{2B+b}.\frac{1}{3}.\frac{L-a}{2}\right]$$

$$= \frac{q_0}{24}[2B+b][L-a]^2$$

$$= \frac{166.23}{24}[2\times1.75+0.40]\,[2.75-0.6]^2$$

$$= 124.86 \text{ kNm}$$

The effective depths in two directions can be computed from,

$$d_{x\text{-}x} = \sqrt{\frac{77\times10^6}{0.87\times140}} = 795.1 \text{ mm}$$

$$d_{yy} = \sqrt{\frac{124.86\times10^6}{0.87\times140}} = 1012.6 \text{ mm}$$

Provide D = 1100 mm with d = 1025 mm

$$A_{st(x-x)} = \frac{77\times10^6}{140\times0.87\times1025} = 617 \text{ mm}^2$$

$$A_{st(y-y)} = \frac{124.86\times10^6}{140\times0.87\times1025} = 1000.12 \text{ mm}^2$$

Nominal shear stress,

$$\tau_v = \frac{V}{2[(a+d)+(b+d)]d_{cc}}$$

$$d_{cc} = 300 + \frac{960-300}{1650} \times \left(1650 - \frac{885}{2}\right)$$

$$= 783 \text{ mm}$$

$$\therefore \qquad \tau_v = \frac{1722.15 \times 10^3}{2[(550+885)+(550+885)]783}$$

$$= 0.383 \text{ N/mm}^2$$

Permissible shear stress = $k_s \tau_c$

where $\quad k_s = 0.5 + \frac{550}{550} = 1.5$

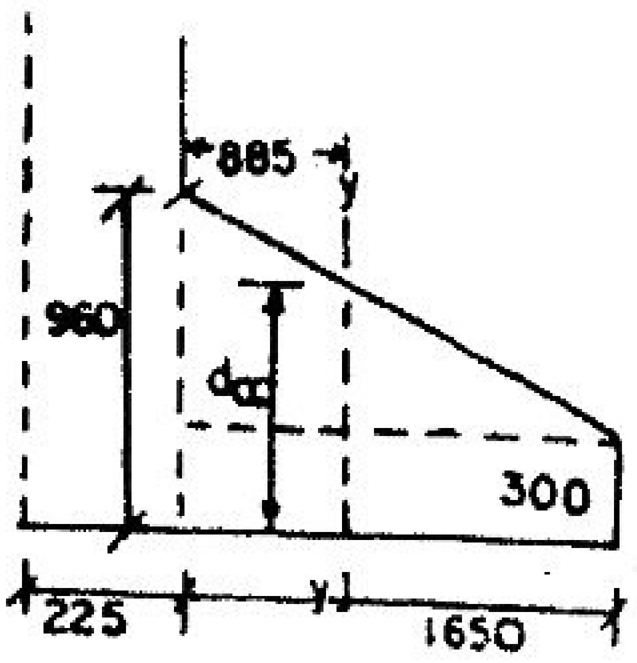
but $\quad k_s \not> 1.0$

$\therefore \quad k_s = 1.0$

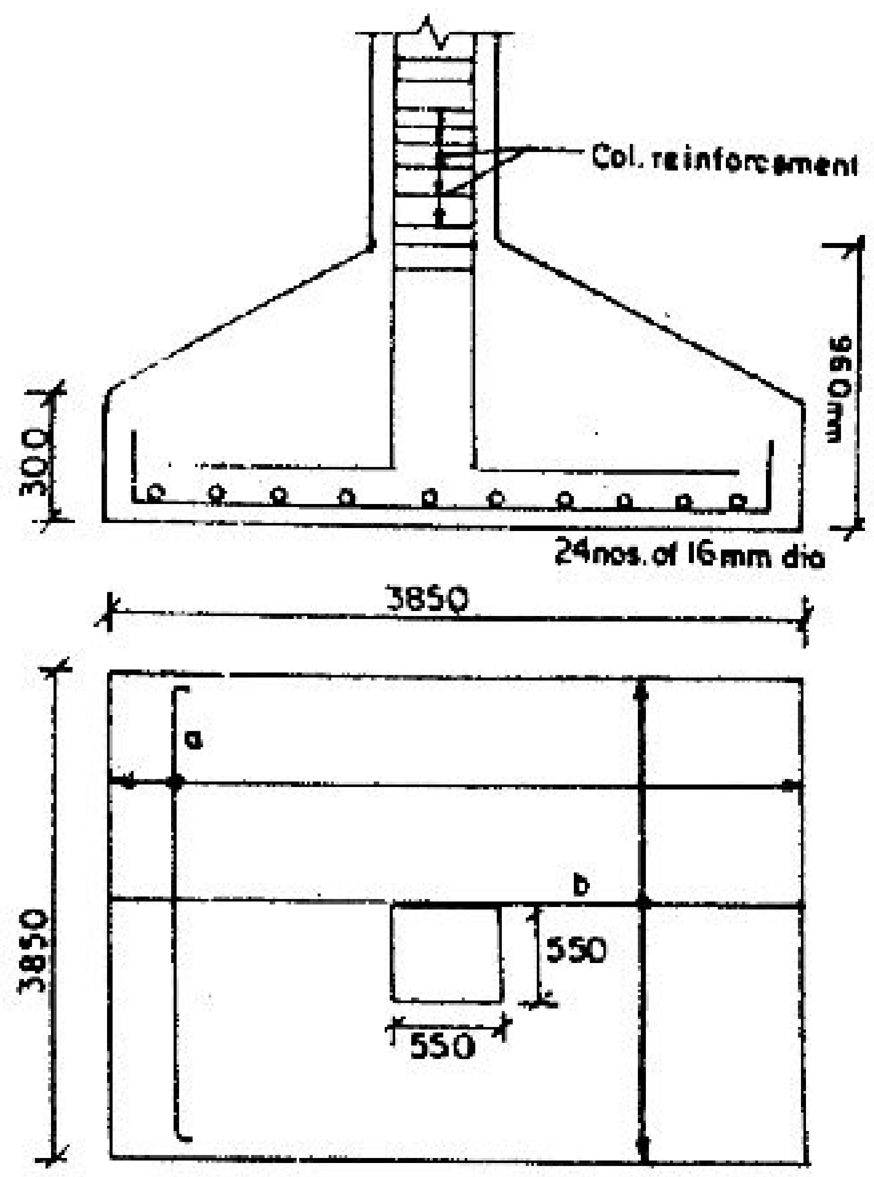
$\therefore$ Permissible shear stress $= 1.0 \times 0.16\sqrt{f_{ck}}$

$= 1.0 \times 0.16\sqrt{20}$

$= 0.716 \text{ N/mm}^2$



Hence, safe in shear



6. A singly reinforced beam is made up of concrete grade M 15 and steel grade : Fe 415. Width of section = 300 mm and effective depth = 570 mm. Tension reinforcement is 16 mm dia. bars 6 Nos. The beam is provided with 6 mm dia. Two legged closed strirrups at a spacing of 150 mm c/c. Concrete cover on stirrups is 15 mm. If a tensile plastic hinge forms in the beam, estimate its rotation capacity. Distance of the point of conlra-flexure from the section = 1.23 m.

Solution: As the ultimate moment capacity is reached, plastic rotations occur.

Compressive force in concrete,

$$C = 0.36 f_{ck} X_u b$$

$$= 0.36 \times 15 \times 300\, X_u = 1620\, X_u N$$

Tensile force in reinforcement,

$$T = 0.87 \times f_y A_{st}$$

$$= 0.87 \times 415 \times 4 \times 201.06 = 290371 \text{ N}$$

Equating compressive and tensile forces, we have

$$1620\, X_u = 290371$$

or $\quad X_u = 179.24$ mm

Volume of concrete core in compression zone

$$= (300 - 2 \times 15)(179.24 - 15)$$

$$= 44345 \text{ mm}^3 \text{ per mm run}$$

Volume of transverse reinforcement per stirrup $= (300 - 2 \times 15 + 2\,(179.24 - 15)) \times 28.27$

$$= 16919 \text{ mm}^3$$

Hence,

$$\text{ratio, } p_b = \frac{16919}{150} \times \frac{1}{44345} = 0.00254$$

$$\therefore \quad \varepsilon_{cu} = 0.0015$$

$$\left(1 + 150 \times 0.00254 + (0.7 - 10 \times 0.00254)\frac{570}{179.24}\right)$$

$$\text{Now} \quad \varepsilon_{sy} = \frac{f_y}{1.15 E_s} + 0.002$$

$$= \frac{415}{1.15 \times 200000} + 0.002 = 0.0038$$

$$\varepsilon_{cy} = \frac{X_u}{d - X_u} \times \varepsilon_{sy} = \frac{179.24}{570 - 179.24} \times 0.0038$$

$$= 0.00174$$

$$\therefore \quad \varepsilon_p = \varepsilon_{cu} - \varepsilon_{cy}$$

$$= 0.00529 - 0.00174 = 0.00355$$

Here, $k_1 = 0.9$,

$k_3 = 0.887$ for concrete grade : M15

by interpolation, $z = 1230$ mm, $d = 570$ mm and $X_u = 179.24$ mm.

Length of plastic hinge,

$$l_p = 0.8 \times 0.9 \times 0.887 \times \frac{1230}{570} \times 179.24$$

$$= 247 \text{ mm}$$

Hence, plastic hinge rotation capacity,

$$\theta_p = \frac{\varepsilon_p l_p}{X_u}$$

$$= \frac{0.00355 \times 247}{179.24} = 0.00489 \text{ radians.}$$

7. A compression member has width = 300 mm and depth = 500 mm. It carries axial force along with a bending moment about the stronger axis. 8 mm diameter lateral ties are provided at 200 mm c/c concrete grade : M20 and steel grade : Fe 415. If a compression plastic hinge forms in the member, estimate its rotation capacity. Assume the length of plastic hinge to be equal to the depth of the member.

Solution: Cover on lateral ties

$$= 50 - \frac{1}{2} \times 16 - 8 = 34 \text{ mm.}$$

Volume of concrete core

$$= (500 - 2 \times 34)(300 - 2 \times 34) \times 1$$

$$= 100224 \text{ mm}^3/\text{mm}$$

Volume of transverse reinforcement

$$= 2\,[(500 - 2 \times 34 - 8) + (300 - 2 \times 34 - 8)] \times \frac{50.26}{200}$$

$$= 325.7 \text{ mm}^3/\text{mm}$$

$$p_b = \frac{\text{Volume of transverse reinforcement}}{\text{Volume of the core}}$$

$$= \frac{325.7}{100224} = 0.00325$$

Substituting all the values, we get

$$\varepsilon_{cu} = \left(\frac{p_b}{14600}\right)^{1/3} + 0.0035$$

$$= \left(\frac{0.00325}{14600}\right)^{1/3} + 0.0035$$

$$= 0.00956$$

Now

$$\varepsilon_{cc} = \varepsilon_{cu} - \varepsilon_c$$

$$= 0.00956 - 0.002$$

$$= 0.00756$$

Hence, rotation capacity,

$$\theta_p = \frac{0.00756 \times 500}{500}$$

$$= 0.00756 \text{ radians.}$$

EXERCISE - I

1. Reinforced concrete is advantageous because of its
(*a*) fire resistance and durability
(*b*) less maintenance cost
(*c*) monolithic character
(*d*) All of the above

2. If the adhesion of reinforced concrete is not per feet
(*a*) the concrete will be weak in compression
(*b*) the concrete may break in tension
(*c*) the steel will be always overstressed
(*d*) None of the above

3. Higher modulus ratio results in
(*a*) increase in the cross-sectional area
(*b*) increase in the quantity of steel in the section
(*c*) increase in the weight of concrete
(*d*) None of the above

4. Which one of the following statements about creep is correct ?
(*a*) It is a time dependent phenomenon which occurs at very high temperatures
(*b*) It is a time dependent phenomenon which can occur even at normal temperature
(*c*) It is a cycle dependent phenomenon and dependent only on the number of cycles
(*d*) It is a time dependent phenomenon

5. Minimum grade of concrete to be used in reinforced concrete is
(*a*) M 7.5 (*b*) M 10
(*c*) M15 (*d*) M20

6. Steam curing accelerates attainment of strength in concrete because
(*a*) more water is available for curing
(*b*) rapid hardening occurs
(*c*) hydration of cement is faster
(*d*) None of the above

7. Addition of common salt to RCC can lead to
(*a*) corrosion of reinforcement
(*b*) high strength
(*c*) retardation of initial set
(*d*) None of the above

8. Three cubes of concrete were tested for compressive strength. The test results are acceptable only if the individual variation is
(*a*) not more than ± 15 per cent of average
(*b*) negligible
(*c*) not more than 5 per cent of average
(*d*) None of the above

9. If the side of concrete cubes is reduced from 15 cm to 5 cm the test results
(*a*) are likely to be the same
(*b*) will give increased strength
(*c*) will give reduced strength
(*d*) are independent of the side the cube

10. A particular grade of steel is termed as Fe-415 when its value of
(*a*) permissible stress is 415 N/mm^2
(*b*) yield stress is 415 N/mm^2
(*c*) ultimate stress is 415 N/mm^2
(*d*) characteristic strength is 415 N/mm^2

11. For the water to be fit for concreting the IS code lays down permissible limits for
(*a*) Sulphate and oxides
(*b*) Chlorides and iron
(*c*) Sulphates and chlorides
(*d*) None of the above

12. An estimate of the flexural strength of concrete can be obtained in terms of characteristic compressive strength by the formula
(*a*) $f_{cr} = \sqrt{f_{ck}}$ (b) $f_{cr} = f_{ck}^2$
(*c*) $f_{cr} = \sqrt{f_{ck}}/0.7$ (*d*) None of the above

13. Factors influencing most, the shrinkage of concrete is
(*a*) cement content
(*b*) elastic modulus of aggregate
(*c*) total amount of water present
(*d*) All of them effect equally

14. Creep coefficient may be defined as
(*a*) Ultimate creep strain/elastic strain
(*b*) Ultimate creep stress/elastic stress
(*c*) Ultimate creep elongation/elastic elongation
(*d*) None of the above

15. Minimum cement content specified in the code is basically to control the
(*a*) durability of concrete
(*b*) water/cement ratio
(*c*) workability
(*d*) None of the above

16. Approximate allowable stress in axial compression in RCC is
(*a*) 0.25 f_{ck} (*b*) 0.33 f_{ck}
(*c*) 0.44 f_{ck} (*d*) None of the above

17. In the working stress design, the allowable bending compressive strain in RCC is

(*a*) 0.003 (*b*) 0.0003

(*c*) 0.002 (*d*) None of the above

18. Ultimate bending compressive strain in RCC is

(*a*) 0.003 (*b*) 0.0035

(*c*) 0.00033 (*d*) None of the above

19. Approximate allowable bond stress in RCC with plain bars is

(*a*) $f_{ck}/5$ (*b*) $f_{ck}/7.5$

(*c*) $f_{ck}/15$ (d) $f_{ck}/30$

20. Unit weight of RCC is taken as

(*a*) 1.6 t/m^2 (*b*) 2.0 t/m^2

(*c*) 2.4 t/m^2 (*d*) 2.8 t/m^2

21. Ratio of modulus of elasticity of steel in that of concrete is

(*a*) Modular ratio (*b*) Poisson's ratio

(*c*) both (*a*) and (*b*) (*d*) None of the above

22. Expression for modular ratio $m = \dfrac{280}{3\sigma_{cbc}}$ where σ_{cbc} is the permissible compressive stress due to bending is concrete in N/mm^2

(*a*) fully takes into account, the long term effect such as creep

(*b*) partially takes into account, the long term effect such as creep

(*c*) does not take into account the long term effect such as creep

(*d*) is the same as the modular ratio based on the value of modulus of elasticity of structural concretes

23. The safe bond stress between concrete and steel is determined by

(*a*) compression test (*b*) pull out test

(*c*) tensile test (*d*) sonic test

24. Bond strength of concrete increases with

(*a*) the quantity of steel

(*b*) the quantity of concrete

(*c*) the tensile strength of steel

(*d*) all of the above

25. For a reinforced concrete section the shape of shear stress diagram is

(*a*) wholly rectangular

(*b*) wholly parabolic

(*c*) rectangular above neutral axis and parabolic below neutral axis

(*d*) Parabolic above neutral axis and rectangular below axis

26. If a beam fails in bond, it would be best to

(*a*) increase the depth of beam

(*b*) use thinner but more number of bars

(*c*) use thicker but less number of bars

(*d*) providing vertical stirrups

27. If nominal shear stress τ_v exceeds design shear strength of concrete τ_c the shear reinforcement to be provided as per I.S 456-1978 carrying shear stress is

(*a*) τ_v (*b*) τ_c

(*c*) $\tau_v - \tau_c$ (*d*) $\tau_v + \tau_c$

28. If the depth of actual neutral axis is less than the depth of critical neutral axis, then the beam is called

(*a*) balanced beam

(*b*) under reinforced beam

(*c*) over reinforced beam

(*d*) None of the above

29. Neutral axis of the Reinforced beam passes through

(*a*) C.G of the concrete section

(*b*) Meta centre of the concrete section

(*c*) Centroid of the concrete section

(*d*) Centroid of the transformed concrete section

30. In case of a singly reinforced beam the effective depth is measured

(*a*) from top to bottom

(*b*) tensile edge to compression edge

(*c*) neutral axis to compression edge

(*d*) compression edge to the centre of tensile reinforcement

31. The bending resistance of an RCC beam is proportional to

(*a*) b^2 (*b*) d^2b

(*c*) b^2d (*d*) d

where b = width

d = depth of steel from the compression fibre

32. Maximum allowable percentage of tension reinforcement in R.C.C beam is

(*a*) $85/f_y$ (*b*) 0.4

(*c*) $40/f_y$ (*d*) 4

33. Percentage of nominal reinforcement provided in beams of depth greater than 750 mm is

(*a*) 0.4 (*b*) 0.3

(*c*) 0.2 (*d*) 0.1

34. Maximum diameter of bars in beams is limited to

(*a*) 25 mm

(*b*) 40 mm

(*c*) one eighth of the least dimension of the beams

(*d*) one tenth of the depth

35. In R.C.C beams, the tension reinforcement can be cut off at a point when it is no longer needed if

(*a*) enough bond length is available

(*b*) the shear at cut off point does not exceed two thirds of permissible at that section

(*c*) bending moment is zero

(*d*) None of the above

36. Number of tension reinforcement bars in R.C.C beam that can be spliced at any section should not exceed

(*a*) one third of the total

(*b*) one fourth of the total

(*c*) zero

(*d*) half of the total

37. Slicing of the reinforcement bars in R.C.C beam can be done at a section, where

(*a*) bending moment is less than the maximum bending moment

(*b*) bending moment is less than the 1/2 of the maximum bending moment

(*c*) bending moment is zero

(*d*) shear force is zero

38. Increased depth of a beam causes

(*a*) economy in steel

(*b*) economy is concrete

(*c*) increased stiffness of the section

(*d*) All of the above

39. In a rectangular R. C. C beam, the ratio of maximum shear stress to average shear stress is

(*a*) 1.25

(*b*) 1.33

(*c*) 1.43

(*d*) 1.53

40. In a singly reinforced beam, subjected to shear force F, if d is the depth and b is the width of the section them maximum shear stress is

(*a*) $\frac{F}{b \times d}$ (*b*) $\frac{F}{b\,d^2}$

(*c*) $\frac{F}{b^2\,d}$ (*d*) All of these

41. Minimum vertical spacing of the main bars in R.C.C beam should be

(*a*) Dia of the bar or (maximum size of the aggregate +5 mm)

(*b*) Maximum size of the bar

(*c*) Maximum size of the bar or (2/3 maximum size of the aggregate)

(*d*) None of the above

42. Main reason for providing number of reinforcing bars at a support in a simply supported beam is to resist in that zone

(*a*) tensile stress (*b*) compressive stress

(*c*) shear stress (*d*) bond stress

43. A doubly reinforced beam is used

(*a*) when extra safety factor is required

(*b*) when the depth and width of beam have to be restricted

(*c*) when depth of beam is more than the with

(*d*) a large moment of resistance in desired

44. A doubly reinforced beam is economical as compared to a singly reinforced beam, because

(*a*) the size of the section is small

(*b*) the depth of the section is small

(*c*) compressive steel is under stressed

(*d*) concrete is not stressed to its full value

45. For a cantilever of effective depth of 50 cm, the maximum span to satisfy vertical deflection is

(*a*) 3.0 m (*b*) 2.5 m

(*c*) 3.0 m (*d*) 4.5 m

46. The development length of bars as per I.S 456 is given by

(*a*) $\frac{4 \varnothing \sigma_s}{\tau_{bd}}$ (*b*) $\frac{\varnothing \sigma_s}{4\tau_{bd}}$

(*c*) $\frac{2 \varnothing \sigma_s}{3\tau_{bd}}$ (*d*) $\frac{\varnothing \sigma_s}{3\tau_{bd}}$

47. Due to shrinkage stresses, a simply supported beam having reinforcement only at bottom tends to

(*a*) deflect downward

(*b*) deflect upward

(*c*) deflect upward or downward

(*d*) None of the above

48. A beam curved in plan is designed for

(*a*) bending moment and shear

(*b*) bending moment and torsion

(*c*) shear and torsion

(*d*) bending moment, shear and torsion

49. Economical depth of a T beam is given by the formula

(*a*) $\sqrt{\dfrac{M \times b_r}{\sigma_{st} \times r}}$ (*b*) $\sqrt{\dfrac{M \times b_r}{\sigma_{st} \times b_r}}$

(*c*) $\sqrt{\dfrac{M \times \sigma_{st}}{b_r \times r}}$ (*d*) $\sqrt{\dfrac{M \times \sigma_{st} \times b_r}{r}}$

where M is the applied moment, b_r is width of web, σ_{st} is the tensile stress in the steel and r is ratio of cost of steel to cost of concrete per cubic metre.

50. Which of the followings does not affect the development length ?

(*a*) Deflection of element
(*b*) Bar diameter
(*c*) Stress in bar
(*d*) Design bond stress

51. Characteristic strength of cold worked deformed bars is determined at

(*a*) 0.1% strain (*b*) 2% strain
(*c*) ultimate strain (*d*) None of the above

52. In the limit state design for flexure, the area of the stress block for concrete is taken as

(*a*) $0.36 f_{ck} X_n$
(*b*) $0.42 f_{ck} X_n$
(*c*) $0.53 f_{ck} X_n$
(*d*) None of the above

53. When mild steel is cold twisted, its yield strength increases due to

(*a*) Work-hardening effect
(*b*) Increased bond between concrete and steel
(*c*) formation of ribs on surface bars
(*d*) None of the above

54. The compression reinforcement in a beam design by limit state method is provided for

(*a*) M_u (*b*) $M_u - M_{u,lim}$
(*c*) $M_{u,lim}$ (*d*) None of the above

55. Modulus of rupture of concrete is considered in the design of

(*a*) Multi-storey buildings
(*b*) Liquid retainings
(*c*) Aerodromes
(*d*) Bridge decks

56. Ultimate strength design of R.C.C. structures is also known as

(*a*) modular ratio method
(*b*) elastic stress method
(*c*) load factor method
(*d*) load and resistance factor method

57. Shrinkage deflection in RCC beam can be reduced by providing

(*a*) Compression steel (*b*) Tension steel
(*c*) Stirrups (*d*) Distribution steel

58. Composite construction provides monolithic action between

(*a*) prefabricated steel beam and precast reinforced concrete beams
(*b*) precast reinforced concrete and prestressed concrete beams
(*c*) prefabricated steel beam and cast-in-situ concrete beam
(*d*) cast-in-situ concrete beam and cast-in-situ concrete slab

59. In a double reinforced beam, the bond stress for bars in compression is increased over that for bars in tension by

(*a*) 100% (*b*) 25%
(*c*) 33% (*d*) None of the above

60. For splicing tension reinforcement in flexural members, the most suitable location is

(*a*) point of inflection
(*b*) point of maximum bending moment
(*c*) at the supports
(*d*) None of the above

61. Effective cover in tension reinforcement is measured from

(*a*) bottom of reinforcing bar
(*b*) centre of compression steel
(*c*) top of beam
(*d*) None of the above

62. Requirements of minimum shear reinforcement elements

(*a*) cantilever beam (*b*) lintel
(*c*) continuous beam (*d*) None of the above

63. Effective width of flange for a simply supported beam, can be calculated by formula, which uses the following three terms

(*a*) span, breadth of web, flange thickness
(*b*) span, thickness of web, flange thickness
(*c*) span, thickness of web, width of flange
(*d*) None of the above

64. For the same cross-sectional area which beam will deflect least

(*a*) T-beam
(*b*) Rectangular beam
(*c*) Circular beam
(*d*) I-beam

65. Reinforcement or torsion is provided in the beam in the form of

(*a*) longitudinal reinforcement only

(*b*) shear reinforcement only

(*c*) both longitudinal and shear reinforce ments

(*d*) None of the above

66. Splices in reinforcement of flexural members will be governed by which one of the following considerations ?

(*a*) Where bending moment is less than 50% of moment of resistance

(*b*) Where bending moment is zero

(*c*) Where shear force is zero

(*d*) Where bending moment is 10% of the moment of resistance

67. Portion of the slab, that acts with the beam in resisting compression depends upon

(*a*) the slab thickness

(*b*) the spacing of beam

(*c*) the span of the beam

(*d*) All of the above

68. Distribution reinforcement in a simply supported slab is provided to distribute

(*a*) load

(*b*) shrinkage stress

(*c*) temperature stress

(*d*) None of the above

69. For a slab, supported on its four edges with corners held down and loaded uniformly, the Marcus correction factor to the moments obtained by Grashoff Rankine theory is

(*a* more than 1 (*b*) less than 1

(*c*) equal to 1 (*d*) None of the above

70. Ratio of the diameter of reinforcing bars and the slab thickness is

(*a*) $\frac{1}{5}$ (*b*) $\frac{1}{6}$

(*c*) $\frac{1}{7}$ (*d*) $\frac{1}{8}$

71. In a two-way slab the lifting of corners occurs due to

(*a*) Zero moment at the centre

(*b*) Torsional moments on the slab

(*c*) Unbalanced moments on the slab

(d) none of the above

72. Marcus correction factor is applicable to

(*a*) Deflection of simply supported beam

(*b*) Bending moment in both directions, applicable to slabs supported

(*c*) Modular ratio for slabs supported at four edges

(*d*) all of the above

73. In the formula $M_0 = WL_n/8$ for the flat slab, L_n is defined as

(*a*) normal span (*b*) clear span

(*c*) effective span (*d*) None of the above

74. Critical section for shear in a flat slab is taken at

(*a*) a distance for the face of support

(*b*) a distance $d/2$ from the face of support

(*c*) at the face of support

(*d*) none of the above

where d is effective depth of slab.

75. Which of the following is generally not designed for shear

(*a*) a slab (*b*) a cantilever beam

(*c*) a footing (*d*) None of the above

76. Wire mesh provided at the corners of a two-way slab

(*a*) prevents corners from lifting

(*b*) distributes bending moments uniformly

(*c*) controls cracking of corners

(*d*) None of the above

77. For a cantilever of effective depth of 50 cm the maximum span to satisfy the vertical deflection limit is

(*a*) 3.5 m (*b*) 4.0 m

(*c*) 4.2 m (*d*) 4.5 m

78. For a two-way slab, the main reinforcement is provided along the

(*a*) length of the slab

(*b*) breadth of the slab

(*c*) diagonal of the slab

(*d*) None of the above

79. The permissible direct compressive stress on concrete in RCC columns is

(*a*) equal to that in compression in bending

(*b*) less than that in compression in bending

(*c*) greater than in compression in bending

(*d*) none of the above

80. Minimum diameter of longitudinal bars in column is

(*a*) 8 mm (*b*) 10 mm

(*c*) 12 mm (*d*) 16 mm

81. Minimum cover to the ties or spiral should not be less than

(*a*) 15 mm (*b*) 20 mm

(*c*) 25 mm (*d*) 30 mm

82. Design of uncracked reinforced column subjected to combined compression and bending is

(*a*) $\frac{\sigma_{cc}}{\sigma_{acc}} + \frac{\sigma_{cb}}{\sigma_{acb}} \leq 1$ (*b*) $\frac{\sigma_{cc}}{\sigma_{cc}} + \frac{\sigma_{cb}}{\sigma_{acb}} < 1$

(*c*) $\sigma_{cc} + \sigma_{cb} \leq 1$ (*d*) none of these

where σ_{cc} = axil compressive stress

σ_{acc} = allowable compressive stress

σ_{cb} = bending compressive stress

σ_{acb} = allowable bending compressive stress

83. As per I.S 456 minimum reinforcement in a column shall not apply if the slenderness ratio is less than

(*a*) 12 (*b*) 16

(*c*) 18 (*d*) 20

84. A column is considered as a long column if its slenderness ratio is more than

(*a*) 15 (*b*) 20

(c) 24 (*d*) 28

85. As per IS:456 the column is considered as a short column if its slenderness ratio is less than

(*a*) 12 (*b*) 15

(*c*) 18 (*d*) 24

86. For a longitudinal reinforcing bar in a column, the minimum cover shall neither be less than the dia of bar nor less than

(*a*) 15 mm

(*b*) 20 mm

(*c*) 25 mm

(*d*) 40 mm

87. Maximum reinforcement in a column is

(*a*) 4% (*b*) 5%

(*c*) 6% (*d*) 8%

88. If the effective length of a 32 cm dia column is 4.40 mts, slenderness ratio is

(*a*) 45 (*b*) 50

(*c*) 55 (*d*) 60

89. Equivalent concrete area of R.C.C given by $[A_{st} + (m - 1)A_{sc}]$ is given by

(*a*) load factor method

(*b*) modular ratio method

(*c*) working stress method

(*d*) None of the above

90. Diameter of ties in a column should be greater than

(*a*) or equal to 5 mm

(*b*) or equal to 1/4 of dia of main bar

(*c*) 5 mm but less than 1/4 of main bar

(*d*) 5 mm and more than 1/4 of main bar

91. Due to circumferential action of the spiral in a spirally reinforced column

(*a*) capacity of column decreases

(*b*) capacity of column increases

(*c*) ductility of column increases

(*d*) both (*a*) and (*b*) increases

92. Which of the following member should have maximum cover ?

(*a*) Interior column in a building

(*b*) Exterior column in a building

(*c*) Column party submerged in sea water

(*d*) Column fully submerged in sea water

93. In a RCC column if ties are not provided, the column is likely to

(*a*) fail by buckling (*b*) fail by crushing

(*c*) behave like a beam (*d*) none of the above

94. For the same cross-sectional area spiral tied column shows more strength than rectangular tied column because

(*a*) spiral confines concrete in case

(*b*) spiral consumes more steel

(*c*) spacing of rectangular ties can be varied more easily

(*d*) none of the above

95. If a column has more cross-sectional area than that required to carry the load, then minimum per cent of steel is calculated based on

(*a*) Actual area

(*b*) Area required to carry the load

(*c*) Area excluding clear cover

(*d*) none of the above

96. The corner bars in a square column must be tied in two perpendicular directions because

(*a*) otherwise each bar will behave independenly

(*b*) load carrying capacity of one bar depends on how it is tied to other

(*c*) the failure can be in any mutually perpendicular directions

(*d*) none of the above

97. Effective height of a column is

(*a*) twice the actual height for a hinge column

(*b*) same as actual height for a free standing column

(*c*) the distance between two consecutive point of contraflexures

(*d*) none of the above

98. Limiting strain in concrete for axially loaded columns is normally taken as

(*a*) 0.2% (*b*) 0.35%

(*c*) Zero (*d*) None of the above

99. Interaction diagrams may be used to design columns subjected to

(*a*) axial force only

(*b*) axial force and torsion

(*c*) bending moment and torsion

(*d*) none of the above

100. When a number of columns are constructed in a row, the type of foundation generally provided is

(*a*) Raft foundation

(*b*) Pile foundation

(*c*) Grillage foundation

(*d*) Strip foundation

101. Critical section for footing under masonary load for maximum B.M is

(*a*) at the centre of wall

(*b*) at the extreme edge of wall

(*c*) half way between centre and extreme edge

(*d*) at a distance equal effective depth of footing from the edge of wall

102. In a combined footing for two columns carrying unequal loads, the maximum hogging bending moment occurs at

(*a*) less loaded column

(*b*) more loaded column

(*c*) centre of two columns

(*d*) a point where shear force is zero

103. A foundation is called shallow foundation if

(*a*) the depth of foundation is less than 1 mt

(*b*) the depth is equal to the width of foundation

(*c*) the depth is half of the width of foundation

(*d*) None of the above

104. Ensure uniform pressure distribution, the thickness of foundation is kept

(*a*) uniform throughout

(*b*) decreased towards the edges

(*c*) increased towards the edges

(*d*) None of the above

105. Raft foundation is type of

(*a*) deep foundation

(*b*) shallow foundation

(*c*) foundation under water

(*d*) none of the above

106. While designing pile as column, the end conditions are taken as

(*a*) Both ends fixed

(*b*) Both ends hinged

(*c*) One end fixed and other end hinged

(*d*) None of the above

107. In pile load test for a safe pile the net settlement per tonne of test load should not exceed

(*a*) 10 mm (*b*) 15 mm

(*c*) 20 mm (*d*) 25 mm

108. R.C retaining wall suitable for heights above 6 m is

(*a*) cantilever (*b*) counterfort

(*c*) T-shaped wall (*d*) L-shaped wall

109. In a counterfort type retaining wall, the toe can be designed as a cantilever, if

(*a*) size of front ana rear counterforts is the same

(*b*) front counterforts are absent

(*c*) rear counterforts are absent

(*d*) none of the above

110. A retaining wall can overturn if the resultant of the earth pressure and weight of wall strikes the base at

(*a*) middle third of the base width

(*b*) middle half of the base width

(*c*) outer third of the base width

(*d*) none of the above

111. Minimum depth of foundation for a retaining wall does not depend on

(*a*) weight of the wall

(*b*) area of the base

(*c*) unit weight of the soil

(*d*) none of the above

112. In a cantilever retaining wall the toe projection is usually kept

(*a*) equal to the heel projection.

(*b*) less than heel projection

(*c*) twice the heel projection

(*d*) None of the above

113. A counter for retaining wall is preferred over the cantilever type when

(*a*) height of wall is more

(*b*) tension develops at the wall base

(*c*) adequate factor of safety against turning is not available

(*d*) None of the above