14
CHAPTER

Prestress Concrete

Q.1 If a simply supported concrete beam prestressed with a force of 2500 kN is designed by load balancing concept for an effective span of 10 m and to carry a total load of 40 kN/m, then the central dip of the cable profile should be

(a) 100 mm (b) 200 mm
(c) 300 mm (d) 400 mm

Q.2 In a load-balanced prestressed concrete beam, the cross-section is subjected to

(a) axial stress.
(b) bending stress.
(c) axial and shear stress.
(d) axial and bending stress.

Q.3 A prestressed concrete beam 150 mm × 300 mm supprots a live load of 5 kN/m over a simple span of 8 m. It has a parabolic cable having an ecentricity of 75 mn at midspan and zero at ends. The prestressing force required to maintain the net resultant stress at the bottom fibre at mid-span as zero under the action of DL + LL + prestress is

(a) 239 kN (b) 293 kN
(c) 302 kN (d) 392 kN

Q.4 For a pretensioned rectangular plank, the uplift at centre on release of wires from anchors due to pretensioning only (force P, ecentricity e) will be

(a) $\frac{PeL^2}{6EI}$ (b) $\frac{Pe^2L}{6EI}$

(c) $\frac{PeL^2}{8EI}$ (d) $\frac{Pe^2I}{8EI}$

Q.5 At the time of initial tensioning, the maximum tensile stress in tendon immediately behind the anchorage shall NOT exceed

(a) 50% of the ultimate tensile strength of the wire or bar or stand.
(b) 80% of the ultimate tensile strength of the wire or bar or stand.
(c) 40% of the ultimate tensile strength of the wire or bar or stand.
(d) 60% of the ultimate tensile strength of the wire or bar or stand.

Q.6 For a prestressed concrete bridge beam, a minimum clear spacing of the cable or group of cable should be

(a) 25 mm
(b) 25 mm or 6 mm plus the largest size of the aggregate.
(c) 40 mm
(d) 50 mm

Q.7 In the design of prestressed concrete structure, which of the following limit states will come under the limit states of serviceability?

1. Flexure 2. Shear
3. Deflection 4. Cracking

Select the correct answer using the codes given below

(a) 1 and 4 (b) 3 and 4
(c) 2, 3 and 4 (d) 2 and 3

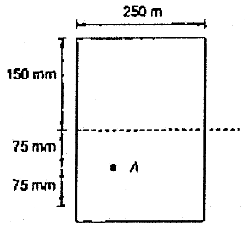
Q.8 In the conventional prestressing, the diagonal tension in concrete

(a) increases.
(b) decreases.
(c) does not change.
(d) may increase or decrease.

Q.9 The ultimate strength of the steel used for prestressing is nearly

(a) 250 N/mm^2 (b) 415 N/mm^2
(c) 500 N/mm^2 (d) 1500 N/mm^2

Q.10 A prestressed concrete beam section is shown in the given figure. (all dimensions are in mm). If the net losses are 15% and final prestressing force applied at 'A' is 500 kN, then the initial extreme fibre stresses at top and bottom will be respectively



(a) −3.40 N/mm² and 16.70 N/mm²
(b) −3.40 N/mm² and 19.60 N/mm²
(c) −4.0 N/mm² and 16.70 N/mm²
(d) −4.0 N/mm² and 19.60 N/mm²

Q.11 When the tendon of a rectangular prestressed beam of cross-sectional area A is subjected to a load W through the centroidal longitudinal axis of beam (where M = maximum bending moment and Z = section modulus) then the maximum stress in the beam section will be

(a) $\frac{W}{A}-\frac{M}{Z}$ (b) $\frac{W}{A}+\frac{M}{Z}$
(c) $\frac{A}{W}-\frac{Z}{M}$ (d) $\frac{A}{W}+\frac{Z}{M}$

Q.12 The losses in prestress in pre-tensioning system are due to
1. elasticity deformation of concrete when wires are tensioned successively.
2. friction.
3. Shrinkage and creep of concrete.

Select the correct answer using the codes below
(a) 1, 2 and 3 (b) 2 and 3
(c) 1 alone (d) 3 alone

Q.13 In the limit state design of prestressed concrete structure, the strain distribution is assumed to be
(a) Linear
(b) Non-linear
(c) Parabolic
(d) Parabolic and rectangular

Q.14 A simply supported post-tensioned prestressed concrete beam of span L is prestressed by straight tendon at a uniform eccentricity 'e' below the centroidal axis. If the magnitude of prestressing force is P and flexural rigidity of beam is EI, the maximum central deflection of the beam is

(a) $\frac{Pel^2}{8EI}$ (downward) (b) $\frac{Pel^2}{48EI}$ (upward)
(c) $\frac{Pel^3}{8EI}$ (upward) (d) $\frac{Pel^2}{8EI}$ (upward)

Q.15 M40 concrete is preferred over M20 concrete for prestressed concrete to
(a) overcome bursting stresses at the ends.
(b) avoid brittle failure of concrete.
(c) eliminate the effect of shrinkage.
(d) economize the use of cement.

Q.16 Which of the following system of prestressing is suitable for pretensioned members?
(a) Freyassinet system.
(b) Magnel-Blaton system.
(c) Hoyer system.
(d) Gifford-Udall system.

Q.17 The profile of the centroid of the tendon is parabolic with a central dip 'h'. Effective prestressing force is P and the span is L. What is the equivalent upward acting uniform load?

(a) $\frac{8hL}{P}$ (b) $\frac{8hP}{L^2}$
(c) $\frac{8h^2L}{P}$ (d) $\frac{8h^2P}{L}$

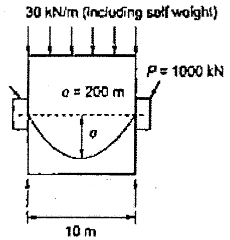
Q.18 An ordinary mild steel bar has been prestressed to a working stresses of 200 MPa. Young's modulus of steel is 200 GPa. Permanent negative strain due to shrinkage and creep is 0.008. How much is the effective stress left in steel?
(a) 184 MPa (b) 160 MPa
(c) 40 MPa (d) 16 MPa

Q.19 What is the limiting principal tensile stress uncracked concrete member of M25 grade?
(a) 1 MPa (b) 21.5 MPa
(c) 2 MPa (d) 2.5 MPa

Q.20 High strength steel used in prestressed concrete can be take how much maximum strain?
(a) 2% (b) 3%
(c) 4% (d) 6%

Q.21 IS : 1343-1980 limits the minimum characteristic strength of pre-stressed concrete for post tensioned work and pretension work as
(a) 25 MPa, 30 MPa (b) 25 MPa, 35 MPa
(c) 30 MPa, 35 Mpa (d) 30 MPa, 40 MPa

Q.22 What is the net downward load to be considered for the analysis of the prestressed concrete beam provided with a parabolic able as shown in the figure below?



(a) 12 kN/m (b) 13 kN/m
(c) 14 kN/m (d) 15 kN/m

Q.23 A concrete beam of rectangular cross section of 200 mm × 400 mm is prestressed with a force of 400 kN at an ecentricity of 100 m. The maximum compressive stress in the concrete is
(a) 12.5 N/mm² (b) 7.5 N/mm²
(c) 5.0 N/mm² (d) 2.5 N/mm²

Q.24 The percentage loss of prestress due to anchorage slip of 3 mm in a concrete beam of length 30 m which is post-tentioned by tendons with an initial stress of 1200 N/mm² and modulus of elasticity equal to 2.1 × 10⁵ N/mm² is
(a) 0.0175 (b) 0.175
(c) 1.75 (d) 17.5

Q.25 The purpose of prestressing the concrete is
(a) to impart the initial compressive stress in concrete.
(b) to provide adequate bond stress.
(c) both (a) and (b).
(d) none of the above.

Q.26 Study the following statements:
1. In pre-tensioned work, the cover of concrete measured from the outside of the pre-stressing tendon shall be at least 20 mm.
2. In post-tensioned work, the minimum clear cover from the duct shall be atleast 30 mm or the size of the cable or bar whichever is large.
3. Where prestressed concrete members are located in aggressive environment, the cover shall be increased by 10 mm over the normal one.

Which of these statements are correct?
(a) both 1 and 2 (b) both 2 and 3
(c) both 1 and 3 (d) 1, 2 and 3

Q.27 The breakage of wires in any prestressed concrete member shall not exceed
(a) 5 per cent during tensioning.
(b) 3 per cent during tensioning.
(c) 2.5 per cent during tensioning.
(d) 6 per cent during tensoining.

Q.28 In prestressed concrete members, the final deflection, due to all loads including the effects of temperature, creep and shrinkage shall not exceed
(a) span/350 (b) span/250
(c) span/300 (d) span/180

Q.29 Study the following statements:
1. The sudden failure of a prestressed member without any warning is generally due to the fracture of steel in the tension zone.
2. BIS 1343-1980 prescribes a minimum longitudinal reinforcement of 0.02 per cent of the cross-sectional area, when high yield strength steel is used.
3. The deflection including the effects of temperature, creep and shrinkage occurring

after erection of partitions and the application of finishes should not normally exceed span/ 350 or 20 mm which ever is less.

Which of these statement/s is/are correct?

(a) Only 3 (b) Both 1 and 2
(c) Both 1 and 3 (d) 1, 2 and 3

Q.30 The effective prestress after all losses should not be less than

(a) $0.45f_p$ (b) $0.75f_p$
(c) $0.60f_p$ (d) $0.55f_p$

Q.31 The maximum ultimate moment of resistance of a prestressed rectangular section is

(a) $0.36\,f_{ck}bd^2$ (b) $0.21\,f_{ck}bd^2$
(c) $0.32\,f_{ck}bd^2$ (d) $0.24\,f_{ck}bd^2$

Q.32 Match List-I with List-II and select the correct answer:

List-I
A. Loss of pre-stress
B. End block
C. Transmission length
D. Partially pre-stressed structures

List-II
1. Class 3
2. Predetermined members
3. Bursting tension
4. Elastic shortening

Codes:

	A	B	C	D
(a)	3	4	1	2
(b)	4	3	1	2
(c)	3	4	2	1
(d)	4	3	2	1

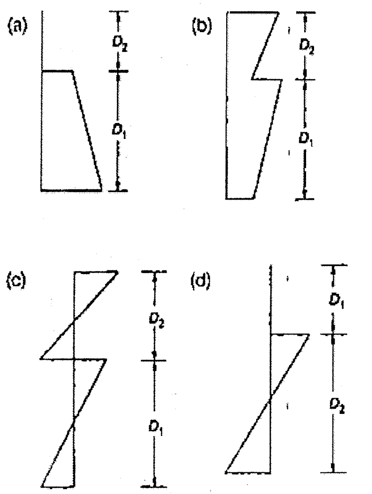
Q.33 Consider the following factors:

1. Initial prestress
2. Losses in prestress
3. Depth of cable from extreme compression fibre

Factor/s which affect the ultimate moment capacity of a prestressed concrete beam is/are:

(a) 1 and 2 (b) 1 and 3
(c) 1 alone (d) 3 alone

Q.34 A pretensioned plank (depth D_1) is placed over simply supported beam and additional in-situ concrete (depth D_2) is laid on top. What is the probable shape of stress block on hardening of in-situ concrete?



Q.35 In the case of a P.S.C. beam, to satisfy the limit state of serviceability in cracking, match List-I with List-II and select the correct answer using the codes given below the lists:

List-I
A. Class 1 structure
B. Class 2 structure
C. Class 3 structure

List-II
1. No visible cracking; $\sigma_t < 3$ N/mm².
2. Concrete section uncracked; crack width to be calculated and checked.
3. No cracking under service loads.

Codes:

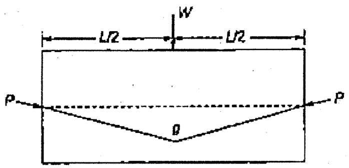
	A	B	C
(a)	1	2	3
(b)	2	1	3
(c)	3	1	2
(d)	3	2	1

Q.36 Assertion (A) : Losses in prestress of pretensioned beams are more than the losses in post-tensioned beams.

Reason (R) : This is partically due to the effect of elastic shortening.

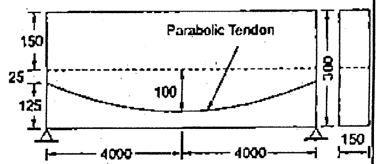
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.37 If 'P' is the prestressing force applied at a maximum eccentricity 'g' at mid-span, to balance the concentrated load "W", the balancing load will be



(a) 2.5 Pg/L (b) 3.0 Pg/L
(c) 3.5 Pg/L (d) 4.0 Pg/L

Q.38



In the P.S.C. beam shown in figure, f_{ck} = 45 MPa and it supports a u.d.l. of 15 kN/m including self weight. It is prestressed by a paraoblic cable carrying an effective prestress of 200 kN. The shear resistance of uncracked section at the support will be

(a) 93.8 kN (b) 94.5 kN
(c) 94.2 kN (d) 95.4 kN

Q.39 A concrete beam is to be post-tensioned in such a way that no tensile stress develops at the time of post-tensioning. The distance of the tendon from the nearest face must be

(a) between $d/5$ and $d/4$
(b) $> d/6$
(c) Between $d/4$ and $d/3$
(d) $> d/3$

Q.40 Match List-I (Post-tensioning system) with List-II (Type of anchorage) and select the correct answer using the codes given below the lists:

List-I
A. Freyssinet
B. Gifford-Udall
C. Lee-McCall
D. Magnel Blaton

List-II
1. Flat steel wedges in sandwich plates
2. High strength nuts
3. Split conical wedges
4. Conical serrated concrete wedges

Codes:

	A	B	C	D
(a)	2	1	4	3
(b)	4	3	2	1
(c)	2	3	4	1
(d)	4	1	2	3

Q.41 An ordinary mild steel bar has been prestressed to a working stress of 200 MPa. Young's modulus of steel is 200 GPa. Permanent negative strain due to shrinkage and creep is 0.0008. How much is the effective stress left in steel?

(a) 184 MPa (b) 160 MPa
(c) 40 MPa (d) 16 MPa

Q.42 A prestressed concrete beam has a cross-section with the following properties:

A = 46,400 mm², I = 75.8 × 10⁷ mm⁴,

y_{bottom} = 244 mm, y_{top} = 156 mm.

It is subjected to a prestressing force at an eccentricity 'e' so as to have a zero stress at the top fibre. The value of 'e' is given by

(a) 66.66 mm (b) 66.95 mm
(c) 104.72 mm (d) 133.33 mm

Q.43 For prestressed structural elements, high strength concrete is used primarily because

(a) both shrinkage and creep are more.
(b) shrinkage is less but creep is more.

(c) modulus of elasticity and creep values are higher.

(d) of high modulus of elasticity and low creep.

Q.44 If percentage gain in stress due to UDL in tendon is zero, then eccentricity will be

(a) $\frac{wl^2}{12P}\frac{E_S}{E_C}$ (b) $\frac{wl^2}{12P}\frac{1}{E_C}$

(c) $\frac{wl^2}{12P}\frac{E_C}{E_S}$ (d) $\frac{wl^2}{12P}$

where P is prestressing force in tendon, w is UDL, E_C - modulus of elasticity of concrete and E_S - modulus of elasticity of steel.

Q.45 A rectangular concrete beam 250 mm wide and 600 mm deep is prestressed by means of 4-14φ high tensile bars located 200 mm from soffit of the beam. If the effective stress in the wires is 700 N/mm², the maximum bending moment that can be applied to the section without causing at soffit of the beam is

(a) 126.22 kNm (b) 118.20 kNm

(c) 106.42 kNm (d) 86.10 kNm

Q.46 A prestressed concrete beam with rectangular section 120 mm wide by 300 mm deep supports a uniformly distributed load of 4 kN/m including its self weight having effective span 6 m. The beam is concentrically prestressed by cable carrying a force of 180 kN. The shift of pressure line in the beam at centre is:

(a) 100 mm (b) 200 mm

(c) 150 mm (d) 250 mm

Q.47 A rectangular prestressed beam 150 mm wide and 300 mm deep is used over an effective span of 10 m. The cable with zero eccentricity at the supports and linearly varying to 50 mm at centre, carries an effective prestressing force of 500 kN. The magnitude of concentrated load Q located at centre of span considering it counteracts bending effect of prestressing force neglecting self weight of beam is:

(a) 10 kN (b) 15 kN

(c) 20 kN (d) 30 kN

Q.48 A prestressed beam, 600 mm × 200 mm supports imposed load of 4 kN/m over effective span of 10 m. It is prestressed with cable with parabolic profile having eccentricity of 100 mm at centre and zero at the ends. The effective prestressing force considering it is nullified by imposed load for mid span section neglecting self weight of the beam is:

(a) 600 kN (b) 500 kN

(c) 800 kN (d) 400 kN

Q.49 The cross-section of prestressed concrete beam used over a span of 6 m is 100 mm wide and 300 mm deep. The initial stress in the tendons located at constant eccentricity of 50 mm is 1000 N/mm² having sectional area of tendons 100 mm². The rotation due to prestress is (E_C = 36 kN/mm², E_S = 210 kN/mm²)

(a) 0.0185 radians (sagging)

(b) 0.00185 radians (hogging)

(c) 0.0360 radians (hogging)

(d) 0.00360 radians (sagging)

Q.50 A pretensioned concrete beam, 100 mm × 300 mm is prestressed by straight wires carrying initial force of 150 kN at an eccentricity of 50 mm. The modulus of elasticity of steel and concrete are 210 kN/mm² and 35 kN/mm² respectively. The percentage loss of stress in steel due to elastic deformation of concrete if area of steel wires is 188 mm² is:

(a) 3% (b) 4%

(c) 5% (d) 6%

Q.51 A concrete beam is prestressed by a cable carrying an initial prestressing force of 300 kN. The cross-sectional area of the wires in the cable is 300 mm². As per IS : 1343 recommendation, the loss of stress in the cable only due to shrinkage of concrete assuming E_S = 210 kN/mm² is: (Assume beam to be pretensioned)

(a) 43 N/mm² (b) 53 N/mm²

(c) 63 N/mm² (d) 83 N/mm²

Q.52 A concrete beam of length 30 m is post-tensioned by a cable carrying an initial stress of 1000 N/mm². The slip at the jacking end was observed to be 5 mm. The modulus of elasticity of steel is 210 kN/mm². The percentage loss of stress due to anchorage slip is:

(a) 2.5% (b) 3.5%

(c) 4.5% (d) 5.5%

Q.53 A concrete beam (300 mm × 500 mm) is prestressed by 2 post-tensioned cables of 600 mm² each initially stressed to 1600 N/mm². The cables are located at constant eccentricity of 100 mm having span length 10 m. The deflection at centre of the span when it is supporting its own weight neglecting all losses is:

(E_S = 210 kN/mm² and E_C = 38 kN/mm²), Y_C = 24 kN/m³

(a) 16.3 mm (upward)

(b) 16.3 mm (downward)

(c) 14.2 mm (downward)

(d) 14.2 mm (upward)

Q.54 A cylinderical concrete tank, 40 m external diameter, is to be prestressed circumferentially by means of high strength steel wire (E_S = 210 kN/mm²) jacked at 4 points, 90 degrees apart. If the minimum stress in the wires immediately after tensioning is to be 600 N/mm² and coefficient of friction is 0.50, the maximum stress to be applied to the wires at the jack is: ($e^{0.79}$ = 2.2)

(a) 1120 N/mm² (b) 1320 N/mm²

(c) 2120 N/mm² (d) 2320 N/mm²

Q.55 Which of the following losses of prestress are encountered in pretensioning systems:

1. Elastic deformation of concrete
2. Relaxation of stress in steel
3. Shrinkage of concrete
4. Friction
5. Anchorage slip
6. Creep of concrete

(a) 1, 2, 3 and 4 only

(b) 1, 2, 3 and 6 only

(c) 1, 2, 3 and 5 only

(d) All of the above

■■■■

Answers Prestress Concrete

1. (b)	2. (a)	3. (d)	4. (c)	5. (b)	6. (c)	7. (b)	8. (b)	9. (d)	10. (d)
11. (b)	12. (d)	13. (a)	14. (d)	15. (a)	16. (c)	17. (b)	18. (c)	19. (a)	20. (c)
21. (d)	22. (c)	23. (a)	24. (c)	25. (a)	26. (d)	27. (c)	28. (c)	29. (b)	30. (a)
31. (b)	32. (b)	33. (d)	34. (b)	35. (b)	36. (a)	37. (d)	38. (b)	39. (d)	40. (b)
41. (c)	42. (c)	43. (d)	44. (d)	45. (d)	46. (a)	47. (a)	48. (b)	49. (b)	50. (c)
51. (c)	52. (b)	53. (a)	54. (b)	55. (b)					

Explanations Prestress Concrete

1. (b)

For a simply supported beam,

$$\frac{wl^2}{8} = Pe$$

$$\Rightarrow \quad e = \frac{wl^2}{8P} = \frac{40\times10^2}{8\times2500} = 0.2\text{ m} = 200\text{ mm}$$

3. (d)

$$A = 150\times300 = 45000\text{ mm}^2$$

$$I = \frac{150\times300^3}{12} = 3.375\times10^8\text{ mm}^4$$

Self weight = 25 × 0.15 × 0.30 = 1.125 kN/m

Total load = 1.125 + 5 = 6.125 kN/m

$$M = \frac{wL^2}{8} = 6.125\times\frac{8^2}{8} = 49\text{ kN-m}$$

$$\sigma_u = \frac{M}{I}y = \frac{49\times10^6}{3.375\times10^8}\times150$$

$= 21.78\ N/mm^2$

$$\sigma_{cc} = \frac{P}{A} + \frac{P \times e \times y}{I} = 5.56 \times 10^{-5} P$$

$5.56 \times 10^{-5} P = 21.78$

$P = 392\ kN$

10. (d)

Initial prestressing force.

$$P = \frac{500}{0.85} = 588.24\ kN,\ e = 75\ mm$$

Area of beam, $A = 250 \times 300 = 75000\ mm^2$

Top/bottom fiber stress

$$= \frac{P}{A}\left(1 \pm \frac{6e}{d}\right) = -3.92,\ 19.6\ N/mm^2$$

14. (a)

Maximum central deflection

$$\delta = \frac{L^2}{8R}$$

$$\frac{1}{R} = \frac{Pe}{EI}$$

$$\therefore \quad \delta = \frac{PeL^2}{8EI} \text{(Upwards)}$$

22. (c)

$$w_c = \frac{8Pe}{l^2} = \frac{8 \times 1000 \times 200 \times 10^{-3}}{(10)^2}$$

$= 16\ kN/m$

$\therefore$ Net downward loading $= 30 - w_c$

$30 - 16 = 14\ kN/m$

34. (b)

Pretensioned beam (plank) can resist both compressive and tensile stress. However, pretensioning is done to keep compressive stresses throughout the beam.

37. (d)

To balance the concentrated load, the maximum BM due to the concentrated load should be equal to the moment due to the prestressing force 'P'.

$$\therefore \quad \frac{WL}{4} = P \times g \Rightarrow W = \frac{4Pg}{L}$$

38. (b)

Shear resistance of uncracked section

$$V_0 = 0.67 b D \sqrt{\sigma_t^2 + 0.5\sigma_{cp}\sigma_t} + V_p$$

V_p = Vertical component of prestressing force

$$= 200 \sin\alpha = 200 \times \frac{4e}{L} = 7.5\ kN$$

$V_0 = 94.5\ kN$

39. (d)

For no tension

$$\frac{P}{A} = \frac{P \cdot e}{Z}$$

$$e \le \frac{d}{6}$$

Distance of tendon from nearest face

$$\ge \left(\frac{d}{2} - \frac{d}{6}\right) \ge \frac{d}{3}$$

40. (b)

In the Freyssinet system anchorage consists of cylinder of good quality concrete and is provided with corrugations on the outside. It has a central conical hole and is provided with heavy top reinforcement.

In Gifford-Udall system, the wire are stressed and anchored one by one in a separate cylinder using small wedding grip called Udall grips. Each grip consists of two split cones.

In Lee-McCall system anchoring of bars is done by screwing special threaded nuts. The nuts bear against a distribution plate provided at the end of the beam.

In the Magnel Blaton system, the wires are anchored by wedging, two at a time into sandwich plates. The sandwich plates are provided with two wedge shaped grooves on its two faces. The wires are taken into each groove and tightened. Then a steel wedge is driven between the tightened wires to anchor them against the plate.

41. (c)

Loss of stress due to shrinkage and creep

$= 200 \times 10^3 \times 0.0008$

$= 160\ MPa$

Effective stress left

$= 200 - 160 = 40\ MPa$

42. (c)

For zero stress at top fibre

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

$$\Rightarrow \quad \frac{P}{A} = \frac{Pe}{I/y_{top}}$$

$$\Rightarrow \quad e = \frac{75.8 \times 10^7}{156 \times 46400} = 104.72\ mm$$

44. (d)

Net percentage gain due to load

$$= \frac{2e\,\theta_{net}\,E_s}{l}$$

If % gain is zero, then

$$\frac{2e\,\theta_{net}\,E_s}{l} = 0,\ [e \ne 0,\ E_s \ne 0]$$

$$\therefore \quad \theta_{net} = 0$$

$$\Rightarrow \quad \frac{wl^3}{24E_cJ} - \frac{Pel}{2E_cJ} = 0$$

$$\Rightarrow \quad e = \frac{wl^2}{12P}$$

45. (d)

$A = 250 \times 600$

$= 15 \times 10^4\ N/mm^2,$

$$Z = \frac{250 \times 600^2}{6} = 15 \times 10^6\ N/mm^2$$

$$A_S = \frac{\pi}{4} \times 4 \times 14^2 = 616\ mm^2$$

$e = 100\ mm,\ P = 616 \times 70 = 431{,}200\ kN$

$$\Rightarrow \quad \frac{P}{A} = 2.87\ N/mm^2 \text{ and } \frac{Pe}{Z} = 2.87\ N/mm^2$$

Prestress at soffit of the beam $= 2.87 + 2.87$

$= 5.74\ N/mm^2$

If M = maximum moment on the section for zero tension at bottom.

$$\frac{M}{Z} = 5.74\ N/mm^2,$$

or $\Rightarrow$ $M = 5.74 \times 15 \times 10^6$

$= 86.1 \times 10^6\ Nmm = 86.1\ kNm$

46. (a)

Prestressing force, $P = 180\ kN,\ e = 0$

$A = 120 \times 300 = 36 \times 103\ mm^2$

$Z_t = Z_b = 18 \times 10^5\ mm^3$

$$M_{max} = \frac{4 \times 6^2}{8} = 18\ kN/m$$

Direct stress, $\dfrac{P}{A} = \dfrac{180 \times 10^3}{36 \times 10^3} = 5\ N/mm^2$

Bending stress, $\dfrac{M}{Z} = \dfrac{18 \times 10^6}{18 \times 10^5} = 10\ N/mm^2$

Resultant stress at centre of span at top fibre

$= 10 + 5 = 15\ N/mm^2$

(compression)

If N = resultant thrust in the section and e = corresponding eccentricity.

$$\frac{N}{A} + \frac{Ne}{Z} = 15$$

$$\Rightarrow \quad \frac{180 + 10^3}{36 \times 10^3} + \frac{180 \times 10^3 e}{18 \times 10^5} = 15$$

$\Rightarrow$ $e = 100\ mm$

47. (a)

If the inclination of the cable to horizontal is θ.

Q = concentrated load at centre of span for load balancing

$\therefore$ $Q = 2P \sin\theta = 2P \tan\theta$

$$= \frac{2 \times 500 \times 50}{5 \times 1000} = 10\ kN$$

$\Rightarrow$ $Q = 10\ kN$

48. (b)

If P = prestressing force,

$$Pe = \frac{wl^2}{8} \text{ (by moment balancing)}$$

or, $P = \dfrac{wl^2}{8e} = \dfrac{4 \times 10^2}{8 \times 0.1} = 500\ kN$

or, $P = 500\ kN$

49. (b)

Second moment of area,

$$I = \frac{100 \times (300)^3}{12}$$

$= 225 \times 10^6\ mm^4$

Prestressing force,

$$P = (1000 \times 100)$$
$$= 10^5 \text{ N} = 100 \text{ kN}$$

Rotation due to prestress,

$$\theta_P = \frac{P_0 L}{2E_c I} \text{ (hogging)}$$

$$= \frac{100 \times 50 \times 6 \times 10^3}{2 \times 36 \times 225 \times 10^6}$$

$$\Rightarrow \quad \theta_P = 0.0185 \text{ radians (Hogging)}$$

50. (c)

$$P = 150 \text{ kN}$$

$$e = \frac{d}{6} = \frac{300}{6} = 50 \text{ mm}$$

$$A = 100 \times 300 = 3 \times 10^4 \text{ mm}^2$$

$$I = 225 \times 10^6 \text{ mm}^4$$

α_e = modular ratio

$$= \frac{E_s}{E_c} = \frac{210}{35} = 6$$

$$\text{Initial stress in the steel} = \frac{150 \times 10^3}{188}$$

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

Stress in concrete,

$$f_c = \frac{150 \times 10^3}{3 \times 10^4} + \frac{150 \times 10^3 \times 50 \times 50}{225 \times 10^6}$$

$$= 6.66 \text{ N/mm}^2$$

Loss of stress due to elastic deformation of concrete = $\alpha_e f_c$.

$$= 6 \times 6.66 = 40 \text{ N/mm}^2$$

$$\% \text{ Loss of stress in steel} = \frac{40 \times 100}{800} = 5\%$$

51. (c)

As per IS : 1343;

If the beam is pretensioned, total residual shrinkage strain = 300×10^{-6}

$$\therefore \text{ Loss of stress} = e_S \times E_S$$
$$= 300 \times 10^{-6} \times 210 \times 10^3$$
$$= 63 \text{ N/mm}^2$$

52. (b)

$$\text{Loss of stress due to anchorage slip} = \frac{E_s \Delta}{L}$$

For 30 m long beam, loss of stress

$$= \frac{210 \times 10^3 \times 5}{30 \times 1000} = 35 \text{ N/mm}^2$$

$$\therefore \text{ Percentage loss stress} = \frac{35}{1000} \times 100 = 3.5\%$$

53. (a)

Self-weight of the beam,

$$w = 0.3 \times 0.5 \times 24$$
$$= 3.6 \text{ kN/m}$$

Second moment of area,

$$I = \frac{300 \times 500^3}{12}$$
$$= 3125 \times 10^6 \text{ mm}^4$$

Prestressing force,

$$P = 2 \times 600 \times 1600$$
$$= 1920 \times 10^3 \text{N} = 1920 \text{ kN}$$

Net deflection = Downward deflection due to self-weight – Upward deflection due to prestressing force.

$$\Rightarrow \frac{5wl^4}{384 E_c I} - \frac{P_0 l^2}{8 E_c I} = \left[\frac{5 \times 0.0036 \times (10 \times 1000)^4}{384 \times 38 \times 3125 \times 10^6} - \frac{1920 \times 100 \times (10 \times 1000)^2}{8 \times 38 \times 3125 \times 10^6}\right]$$

$$\Rightarrow \quad 3.95 - 20.2 = -16.3 \text{ mm}$$

(upward deflection of beam)

54. (b)

The prestressing force at the farther end, P_x is related to the force at the jacking end, P_0 by the expression,

$$P_x = P_0 e^{-\mu\alpha}$$
$$\Rightarrow \quad 600 = P_0 e^{-(0.5 \times \pi/2)}$$

where $e = 2.7183$

$$\Rightarrow \quad P_0 = 600 \times e^{+0.79}$$
$$= 1320 \text{ N/mm}^2$$

55. (b)

Friction and anchorage slip losses occurs only in post-tensioned system.

■■■■