1. **Explain the principles of prestressing?**
   Prestressed concrete is basically concrete in which internal stresses of a suitable magnitude and distribution are introduced so that the stresses resulting from external loads are counteracted to a designed degree.

2. **What is meant by tendons?**
   The tendon is a stretched element used in a concrete member’s structure to impart prestress to the concrete. Generally high tensile steel wires, bars, cables or strands are used as tendons.

3. **Why high strength is concrete is necessary for prestress?**
   High strength concrete is necessary for prestressed concrete as the material offers high resistance in tension, shear, bond & bearing. High strength concrete is less liable to shrinkage. Cracks and has a higher modulus of elasticity & smaller ultimate creep strain, resulting in a smaller loss of prestress.

4. **What are the various systems of prestressing?**
   1. **Pretensioning:** In this system the tendons are first tensioned between rigid anchors. Blocks, prior to the casting of concrete & then the concrete is poured is to the mould. When the concrete attains sufficient strength the jacking pressure is released. The prestress is imparted to concrete by bond between the steel and concrete.
   2. **Post tensioning:** In this system the concrete units are first cast by incorporating ducts on groves to house the tendons. When the concrete attains sufficient strength. The high tensile steel wires are inserted & tensioned by means of jack bearing on the end face of the members and anchored by wedges or nuts.
   3. **Thermo electric prestressing:** In this system, the method of prestressing by heated tendons, anchored by passing electric current in the high tensile wires.
   4. **Chemical Prestressing:** In this system, the method is made possible by the development of expanding cement (calcium
sulpho aluminates). The expansion of concrete is restrained by high tensile steel wires.

5. **What is meant by anchorage?**
   A device generally used to enable the tendon imparts and maintain prestress in the concrete. The commonly used anchorages are the freyssinet, magnet blaton. Giffordudall, Lcb – Mc, B.B. R.V system etc.

6. **Why mild steel cannot be used for prestressing?**
   The prestressed concrete should have the shrinkage and creep & the negative strain due to the shrinkage and creep of concrete is equal to 0.0008.
   Considering mild steel. \( \Sigma_{st} = 140 \text{N/mm}^2 \) \( E_s = 2 \times 10^5 \) N/mm\(^2\).
   \[
   \text{Strain } \epsilon = \frac{\sigma_{st}}{E_s} = \frac{140}{2 \times 10^5} = 0.0007
   \]
   Since the negative strain of shrinkage and creep is more than the tensile strain permitted is mild steel.
   We cannot use the mild steel for prestressing.
   Considering high tensile steel wires \( \sigma_{st} = 1000 \text{N/mm}^2 \)
   \[
   \text{Strain } \epsilon = \frac{\sigma_{st}}{E_s} = \frac{1000}{2 \times 10^5} = 0.0050
   \]
   Net strain = 0.0050 – 0.0008 = 0.0042
   Net stress = 0.0042 \times 2 \times 10^5 = 840 \text{N/mm}^2
   Loss of prestress 1000 – 840.160 N/mm\(^2\) (16%)
   For prestressed concrete the high tensile wires are only used.

7. **Mention the losses that can occur in prestressed concrete?**
   1. Loss due to elastic shortening of concrete.
   2. Loss due to shrinkage of concrete.
   3. Loss due to creep of concrete.
   4. Loss due to relaxation of stress in steel.
5. Loss due to Anchorage slip.
6. Loss due to friction.

8. **Distinguish between concentric and eccentric prestressing?**
   The concentric or axial prestressing members in which the entire cross section of concrete has a uniform compressive prestress. In this type the centroid of the tendon coincides with that of the concrete section. Where as in eccentric prestressing is a section at which the tendons are eccentric to the centroid, resulting in a triangular or trapezoidal compressive stress distribution.

9. **Brief the term load balancing concept.**
   The concept of load balancing is useful in selecting the tendon profile which can supply the most desirable system of forces in concrete. In general, this requirement will be satisfied if the cable profile in a prestressed member corresponds to the shape of the bending moment diagram resulting from the external loads.

10. **What is Young’s modulus of M35 grade concrete?**
    \[ E_C = 5700 \sqrt{F_{CK}} = 5700 \sqrt{35} = 33721\text{N/mm}^2 \]

11. **What is the shrinkage of post tensioned concrete at 28 days?**
    \[
    \text{Shrinkage strain} = \frac{0.0002}{0.000135} = 0.0002 = \log_{10}(k + 2) = \log_{10}(28 	imes 2)
    \]

12. **Name the hoo effects due to which friction loss occur?**
    (i) Loss of stress due to the curvature effect
    (ii) Loss of stress due to the wobble effect.

13. **What is the maximum strain permitted in concrete at collapse in flexure?**
The maximum strain in concrete at the outermost compression fibre is having as 0.0035 is bending.

14. **Brief application of post tensioned system.**
   (i) Post tensioning is ideally suited for medium to long span in situ nook & hence it is more economical.
   (ii) It allows the use of curved and shopped off cables which helps the designer to vary the prestress distribution at will from section to section so as to counter the external loads more efficiently.
   (iii) It is invariably used in strengthening concrete dams.
   (iv) It is ideally suited for the work involving stage prestressing.

15. **How prestressed concrete structures are classified under limit state of severability?**
   **Class – I:** No tensile stresses are permitted under service & hence the structure is crack free.
   **Class – II:** Limited tensile stresses are permitted not exceeding the modulus of rupture of concrete & no visible flexural cracks are permitted.
   **Class – III:** Tensile stresses of magnitude exceeding the modulus of rupture of concrete and visible cracking of limited with a permitted.

16. **Mention any four factors affecting the deflection of the prestressed concrete beam?**
   (i) Imposed load & self weight
   (ii) Magnitude of the prestressing force.
   (iii) Second moments of area of cross section
   (iv) Shrinkage, creep & relaxation of steel stress.
   (v) Modulus of elasticity of concrete
   (vi) Cable profile
   (vii) Span of the member
   (viii) Rigidity condition

17. **Sketches the different cable profiles used in S.S.B**
18. What are the ways of improving the shear resistance a prestressed concrete beam.

Prestressed concrete beam:
(i) Horizontal or axial prestressing
(ii) Prestressing by inclined or sloping cables and
(iii) Vertical (or) transverse prestressing.

19. Sketch the stress strain curve for high tensile wires

![Stress Strain Curve]

20. What are the advantages of prestressed concrete over R.C.C concrete?

(i) The use of high strength concrete and steel in prestressed members results in lighter and slender members than is possible with reinforced concrete.
(ii) The effectiveness of carrying external loads is only by the section above the neutral axis is reinforced concrete but the entire cross section is effective is prestressed concrete.
(iii) The reinforced concrete sections are heavy and shear reinforcement is essential where as in prestressed concrete the section is smaller & curved tendons helps to resistance.
(iv) Do the long span structures the prestressed concrete is generally more economical than reinforced concrete & also prestressed members are decrease in weight reduces the design loads and the cost of construction.
(v) Due to utilization of concrete in the tension zone a savings of 15 to 30% in concrete 60 to 80% savings in steel.

21. What is meant by cracking moment?
The bending moment at which visible cracks develop in prestressed concrete members is generally referred to as the ‘cracking moment’.

22. How the loss of stress due to friction is calculated?
The value of the prestressing force
\[ P_2 = P_0 e^{(\mu + \alpha + kx)} \]
\( P_0 \) = Prestressing force at the jacking end.
\( \mu \) = coefficient of friction between cable and duct.
\( \alpha \) = cumulative angle in radians between any two tangents drawn from the cable profile under consideration.
\( K \) = friction coefficient for wave effect
\( e = 8.7183 \) (exponential)

23. What is meant by loss due to elastic shortening?
This type of loss occurs when the prestressing tendons upon released from tensioning devices causes the convert to be compressed. This loss is proportional to the modular ratio and initial prestressing force in the concrete.
(i.e.) Loss of stress due to elastic shortening mfc
\[ M = \text{modular ratio} = \frac{E_S}{E_C} : f_c = \text{prestress in concrete at the level of steel} \]

24. How the loss due to anchorage slip is calculated?
In most post tensioned systems when the cable is tensioned and the jack is released to transfer the prestress to the
concrete the friction wedges employed to grip the wires, slip over a small distance before the wires are finally her erect. This magnitude of loss is computed as:

\[ \text{Loss due to anchorage slip} = \Delta L = E_s \]

\[ \Delta = \text{Slip in anchorage} \quad L = \text{Length of the beam} \]

\[ E_s = \text{Young's modulus of steel.} \]

25. State Mohr’s theorems.

Theorem I: The change in slope between tangents drawn to the elastic curve at any two points A & B is equal to the products of 1/ EI and the area of moment diagram between the points A & B.

\[ \theta_{AB} = \frac{1}{EI} \text{(Area)}_{AB} \]

Theorem II: The horizontal deviation of any point ‘B’ relative to a tangent drawn to the elastic curve at any other point ‘A’ in a direction perpendicular to the original axis of the beam is equal to the product of 1/ EI and the moment of area about B of part of the B.M.D between the points A & B.

\[ C_{BA} = \frac{1}{EI} \text{(Area)}_{AB} \cdot XB \]

26. What is meant by shrinkage of concrete?
The shrinkage of concrete is prestressed members due to the gradual loss of resistance which result in change volume. The value of shrinkage for design is
(i) Pretensioning 0.0003 (ii) Post tensioning = 0.0002 / \log_{10}(k \times 2)
(Where k = age of concrete in days)

27. What is the minimum grade of concrete used for prestress?
The minimum 28 day cube compressive strength prescribed in the Indian standard code Is 1343 – 1980 is 40N/mm² (M40) for pretensioned members & 30N/mm² (M30) for post tensioned members.

28. Why a parabolic tendon preferred in prestressed concrete?
When the cable is provided with a parabolic profile the tendons will erect an uniform upward pressure on the concrete beam & counter act a pass of the external downward loading. If the tendon should follow the shape of the bending moment diagram for the external loads in order it may offer considerable and effective upward pressure. For instance if the loading on the beam is ‘udl’ the tendon may be provided along a parabolic profile.

29. What are equations used a parabolic profile?

(i) Uniformly eccentricity = \frac{-PEL^2}{8EI}

(ii) Trapezoidal Tendons with eccentricity ‘e’
= - Pe \( \frac{(2l^2 + 6l_1l_2 + 3l_2^2)}{6EI} \)

(iii) Parabolic Tendons (central anchors)
\[ = - \frac{5Pe{l^2}}{48EI} \]

(iv) Parabolic Tendons (eccentric anchors)
\[ = pl^2 \left( - 5e1 + e2 \right) / 48EI \]

30. What are the permissible limits for deflection?
(i) The final deflection due to all loads including the effects of temperature, creep & shrinkage should not normally exceed span / 250.
(ii) Deflections including the effects of temperature, creep & span / 350 or 20mm whichever is less
(iii) If finishes are to be applied to prestressed concrete members the total upward deflections should not exceed span.

31. Explain partial prestressing.
Under the working load, if the cross section is subjected to no tension after prestressing then it is known as fully prestressed. Ill\(^{\text{th}}\) under working loads even after the prestress is apply. If there is some tension. It is known as partial prestressing. Normally the tension portion is reinforced with mild steel reinforcement. This untensioned reinforcement is required so as to resist differential shrinkage temperature effects and handling stresses.

32. When circular prestressing is done?
Liquid retaining structures, such as circular pipes, tanks and pressure vessels are having hoop tension developed due to the initial fluid pressure. A reinforced concrete pressure
pipe requires a large amount of reinforcement to ensure low tensile stresses. But the circumferential hoop compression induced in concrete by prestressing counter balances, the hoop tension developed. In addition, circular prestressing safe guard against shrinkage cracks is liquid retaining structures provide economical use of the materials.

33. Why reinforcement is necessary in anchorage zone or end block?
In mpre post tensioned members, the prestressing wires are introduced in cables holes or ducts. Pre – formed in the members & then stressed & anchored at the end forces. Large forces concentrated over relatively small areas are applied on the end blocks. It is linearly distributed & develop transverse and shear stresses. So that an adequate amount of steel is properly distributed to sustain the transverse tensile stresses.

34. What is meant by transmission length. Sketch Hoyer effect.
In a pretensioned system, when a wire is released, the transmission of prestressing force from steel to concrete in through a bond comprising of (i) adhesion (ii) friction (iii) Shearing resistance. At intermediate points along the length
of the beam, the bond stress due to the friction and shearing resistance developed. The distribution of bond stress. Stress in steel and concrete in the transmission zone are shown. When the bond stress is zero values, and uniform stress distribution is prevalent from the section. The length for achieving this is termed as transmission length.

35. Give an expression for brashing tensile force in anchorage zone of prestressed concrete members.

\[ F_{bst} = 0.3P \left( 1 - \frac{Y_{po}}{Y_o} \right) \]

\( P \) = anchorage force

\( Y_{po} \) = depth of the anchorage

\( Y_o \) = depth of the equivalent prism

36. What is load friction against cracking & collapse is tensioned members.

Load factor against cracking = \( N_{cr} \)
\[ N_d \]

\[ N_{cr} = \text{Cracking load} \]
\[ N_d = \text{design tensile load}. \]

For ordinary tensioned members, minimum load factor of 1.5 to \( R \).

37. **What are the failure modes of prestressed concrete columns?**

(i) Compression failure (Concentric loading)

Small eccentricity

(ii) Balanced failure (Balanced eccentricity)

(iii) Initial tension failure (Large eccentricity)

38. **What is the empirical formulae for transmission length:**

\[
L_t = \sqrt{f_{cu}} \times 10^3 \beta
\]

\( f_{cu} = \text{cube strength of concrete transfer} \)
\( \beta = \text{constant depending upon the details of stand wire}. \)

39. **What are the methods used for obtaining shear bond.**

(i) The surface of the drawn round wires is roughened by picking to procedure fine irregularities which inert lock with the concrete.

(ii) Twisting of round wires into strands.

(iii) Cold rolling of elliptical or rhombic shallow indentations on the surfaces of wires.
(iv)Hot rolling & oblique transverse ribs on wires which are subsequent by heat treated.

40. **What is meant by primary moment, secondary moment?**

**Primary moment:** The primary moment is the apparent bending moment at a section in a statically indeterminate structure due to the ahead eccentricity of the tendons from the additional moments.

**Secondary moment:** Secondary moments are additional moments induced at a section due to the redundant reactions developed as a consequence of prestressing the structure.

**Resultant moment:** The resultant moment at a section of an indeterminate prestressed structure is the sum of primary & secondary moments (i.e) \( R.M = (P.M + S.M) \)

41. **What is the effect of prestressing a indeterminate structure?**

When an indeterminate structure is prestressed the redundant reactions will develop due to the redundancies exercising a restraint at the supports. The redundant reactions develop consequence of prestressing & secondary moment.

42. **State Guyon’s theorem?**

In a continuous prestressed beam, if the tendon profiled is displaced vertically any of the intermediate supports by any amount, but without altering its intrinsic shape between the support, the resultant line of the thrust is unchanged.

43. **What is meant by linear transformation of the cable?**

The operation of \( d \) is placing the cable at interned supports while holding the positions of the end anchorage constant without changing the intrinsic shape (in curvature & bends) is referred as the linear transformation of the cable.

44. **What is the meant by line of prestress (or) CGS line?**
The locus of the centroid of the prestressing force along the structure is the line of prestress or centre of gravity of the steel line.

45. **What is concordant cable?**
   A tendon profile in which the eccentricity is proportional at all cross sections to the bending moment caused by any loading on a rigidity supported statically indeterminate structure is a concordant profile.

46. **What is meant by vertical or transverse prestresisng?**
   Besides the longitudinal prestressing sometimes it may be desirable to provide vertical prestresisng to reduce or eliminate the principal tensile stress. Vertical prestressing is done by providing high tension vertical steel wires of small diameter at suitable pitch & stressed adequately.

47. **What are the advantages of statically indeterminate prestressed concrete structures?**
   (i) The bending moments are more evenly distributed between the centre of span and the supports of members.
   (ii) Reduction in the sizes of members results in lighter structure.
   (iii) The ultimate load carrying capacity in higher than the statically determinate structure due to the redistribution of moment
   (iv) Continuity of the members in framed by segmental construction using precast units connected by prestressed cables.
   (v) In continuous post tensioned guides, the curved cables can be suitably positioned to resist the span & support moments.

48. **What are the disadvantages of prestressed continuous beams?**
   (i) Loss of prestress due to friction is more in long cables.
(ii) Secondary stresses due to prestressing, creep, shrinkage, temperature & settlement of supports may induce very high stresses unless they are controlled.
(iii) Cable positioned to cater for secondary moments are generally no suitable to provide the required ultimate moment under a given system of loads.
(iv) The computation of collapse (or) ultimate load is influenced by the degree of redistribution of moments.

49. Sketch the shape of pressure line for a span continuous beam with straight tendon as constant eccentricity prestress.

50. What is the value of secondary moment in a continuous beam with concordant cable profile?
   Zero

51. What are the assumptions made for the analysis of secondary moment
   (i) The effect of change in length of members due to the prestressing force & external loading in negligible.
   (ii) The cable friction is considered to be negligible so that the prestressing force is constant at all points of the cable.
52. Show the resultant thrust line in a two span continuous beam. Prestressed by a parabolic cable with zero eccentricity at all the support.

53. What is meant by composite construction is prestressed concrete?
   In a composite construction, precast prestressed members are used in conjunction with the concrete cast in site. So that the members behave as a monolithic unit under service loads.

54. What are the advantages of composite constructions?
   (i) Appreciable savings in the cost of steel in a composite member compared with a R.C.C. or prestressed concrete members.
   (ii) Sizes of the precast prestressed units can be reduced due to the effect of composite action.
   (iii) Low ratio of size of precast unit to that of the composite member & in many cases precast prestressed units serves as supports & dispenses with the form work for the placement of in situ concrete.
(iv) Composite constructions are ideally suited for the constructions of bridge decks without disturb the normal traffic.
(v) Efficient utilization of materials in a composite section results in reduced dead loads & leading to overall economy.

55. Explain the most common type of composite construction?
The most common type of composite construction consists of a number of precast prestressed inverted ‘T’ beam placed side by side and connected by a continuous top slab of in-situ concrete. This type of construction is widely used in the construction of bridge decks.

56. Sketch the typical cross section of composite section.

[Sketch of composite section]

57. Sketch the stress across the mid span section as various stages of loading in propped composite flexure members.
58. Why is transverse prestressing done for bridge decks?
Transverse prestressing is used to develop monolithic action is lateral direction.

59. What is meant by shear connectors?
Effective bonding between the hoo parts of a composite beam may be developed by providing castellation in the precast unit or by projecting reinforcements from the precast unit is a sieve as shear connectors. Type as follows.

60. Why shrinkage stresses are developed in composite construction?
In composite members, a considerable proportion of the total shrinkage will have already taken place in the precast prestressed beam before the casting and inawiening of in
situ concrete. Due to the high water / cement ratio used in the insitu concrete, there will be considerable shrinkage of this part in composite section. Consequently the differential shrinkage between the precast and insitu cast results in shrinkage stresses.

61. What is meant by propped & unpropped construction?

**Propped construction:** The dead load stresses developed in the precast prestressed units can be minimized by propping them while casting the concrete in situ.

**Unpropped construction:** If the precast units are not propped while placing the insitu concrete, stresses are developed in the unit due to the self weight of the members & the dead weight of the in situ concrete. This method of construction is unpropped construction.

62. What are the assumptions used in calculation of differential shrinkage?

(i) The shrinkage is uniform in situ part of the section.

(ii) Effect of creep & increase is modulus of elasticity with age and the component of shrinkage which is common to both the units is negligible.

63. What are the various methods of achieving continuity in continuous beam.

1. Curved or Straight cable
2. Cap cable
3. Short, straight tendons.
64. Sketch the end block when stress distribution in a post tensioned system.

65. Sketch the typical reinforcement provided in Anchorage zone?