DEPARTMENT OF CIVIL ENGINEERING

DESIGN OF STEEL STRUCTURES

(LIMIT STATE DESIGN)

(FOR VI – SEMESTER)

QUESTION BANK

UNIT I - INTRODUCTION
UNIT II – TENSION MEMBERS
UNIT III - COMPRESSION MEMBERS
UNIT IV – BEAMS
UNIT V – ROOF TRUSSES & INDUSTRIAL STRUCTURES

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OBJECTIVE

This course covers the design of structural steel members subjected to compressive, tensile and bending loads, as per current codal provisions including connections. Design of structural systems such as roof trusses, gantry girders are included.

1. INTRODUCTION


2. TENSION MEMBERS

Types of sections – Net area – Net effective sections for angles and Tee in tension – Design of connections in tension members – Use of lug angles – Design of tension splice – Concept of shear lag

3. COMPRESSION MEMBERS

Types of compression members – Theory of columns – Basis of current codal provision for compression member design – Slenderness ratio – Design of single section and compound section compression members – Design of lacing and battening type columns – Design of column bases – Gusseted base

4. BEAMS

Design of laterally supported and unsupported beams – Built up beams – Beams subjected to biaxial bending – Design of plate girders riveted and welded – Intermediate and bearing stiffeners – Web splices – Design of beam columns

5. ROOF TRUSSES AND INDUSTRIAL STRUCTURES

Roof trusses – Roof and side coverings – Design loads, design of purlin and elements of truss; end bearing – Design of gantry girder

TEXT BOOKS


REFERENCES

UNIT – I

INTRODUCTION


TWO MARKS QUESTIONS AND ANSWERS

1. What are the various types of connections used for connecting the structural members?
   - Riveted connections
   - Bolted connections
   - Pin connections
   - Welded connections

2. Define riveting.
   Riveting is a method of joining two or more structural steel components by inserting ductile metal pins, called rivet.

3. Define nominal diameter of rivet.
   It is the diameter of the unheated rivet measured before driving. It is the stated diameter of the rivet, available in the market.

4. Define gross diameter of rivet.
   It is the diameter of the rivet in the hole, measured after driving. It is taken equal to the diameter of the rivet hole.

5. What is meant by pitch of rivet?
   The pitch of the rivets is the distance between centres of two adjacent rivets in a row.

6. Define gauge line.
   It is the line of rivets, which is parallel to the direction of stress.
7. *What is meant by gauge distance and edge distance?*

Gauge distance is the perpendicular distance between two adjacent gauge lines. This is also called as back pitch.

Edge distance is the distance of the edge of the member or the cover plates from the centre of extreme rivet hole.

8. *Define staggered pitch.*

It is also called as alternate pitch or reeled pitch. The staggered pitch is defined as the distance measured along one rivet line from the centre of a rivet to the centre of the adjoining rivet on the adjacent parallel rivet line.


It is the distance normal to the joint between edges of the overlapping plates in a lap joint or between the joint and the end of cover plates in a butt joint.

10. *What is meant by tensile stress?*

When a structural member is subjected to direct axial tensile load, the stress is known as tensile stress (\( \sigma_{at} \)). The tensile stress is calculated on net cross-sectional area of the member.

\[
\sigma_{at} = \frac{P_t}{A_n}
\]

Where, \( P_t \) is the direct axial tensile load and \( A_n \) is the net cross-sectional area of the member.

11. *What is meant by compressive stress?*

When a structural member is subjected to direct axial compressive load, the stress is known as compressive stress (\( \sigma_{ac} \)). The compressive stress is calculated on gross cross-sectional area of the member.

\[
\sigma_{ac} = \frac{P_c}{A_g}
\]

Where, \( P_c \) is the direct axial compressive load and \( A_g \) is the gross-sectional area of the member.

When a load is exerted or transferred by the application of load through one surface for another surface in contact, the stress is known as bearing stress (\( \sigma_p \)). The bearing stress is calculated on net projected area of contact.

\[
\sigma_p = \frac{P}{A}
\]

Where, \( P \) = load placed on the bearing surface.
\( A \) = net projected area of contact.

13. What is working stress?

The working stress is also termed as allowable stress or permissible stress. The working stress is evaluated by dividing yield stress by factor of safety. For the purpose of computing safe load carrying of a structural member, its strength is expressed in terms of working stress. The actual stresses resulting in a structural member from design loads should not exceed working stress.


The factor of safety is defined as the factor by which the yield stress of the material is divided to give the working stress (permission stress) in the material.

15. What are the methods employed for the design of the steel framework?

- Simple design
- Semi-rigid design
- Fully rigid design
- Plastic design.

16. What are the assumptions made in simple design?

- The beams are simply supported.
All connections of beams, girders, or truss are virtually flexible and are proportioned for the reaction shears applied at the appropriate eccentricity.

The members in compression are subjected to forces applied at the appropriate eccentricities.

The members in tension are subjected to longitudinal forces applied over the net area of the sections.

17. Define Modulus of Elasticity
The modulus of elasticity is defined as the ratio of longitudinal stress to the longitudinal strain within the elastic region, it is denoted by ‘E’.

18. Define Poisson’s Ratio.
The Poisson’s ratio is defined as the ratio of transverse strain to the longitudinal strain under an axial load. It is denoted by ‘μ’ or 1/m. the value of Poisson’s ratio for steel within the elastic region ranges from 0.25 to 0.33.

19. What are the types of riveted joints?
   i. Lap joint
      (a) Single riveted lap joint
      (b) Double riveted lap joint
   ii. Butt joint
      (a) Single cover butt joint
      (b) Double cover butt joint

20. Define Lap joint and Butt Joint.

Lap joint:
When one member is placed above the other and these two are connected by means of rivets, then the joint is known is lap joint.
**Butt Joint**

When the plates are placed end-to-end and flushed with each other and are joined by means of cover plates, the joint is known as Butt joint.
21. What are the types of failures occur in riveted joint?

- Shear failure of rivets
- Shear failure of plates
- Tearing failure of rivets
- Bearing failure of plates
- Splitting failure of plates at the edges
- Bearing failure of rivets.

22. What are the assumptions made for designing riveted joint?

- The load is assumed to be uniformly distributed among all the rivets.
- The shear stress on a rivet is assumed to be uniformly distributed over its gross area.
- The bearing stress is assumed to be uniform between the contact surfaces of plate and rivet.
- The bending stress in a rivet is neglected.
- The rivet hole is assumed to be completely filled by the rivet.
- The stress in plate is assumed to be neglected.
- The friction between plates is neglected.
23. Write about minimum pitch and maximum pitch.

**Minimum pitch:** The distance between centres of adjacent rivets should not be less than 2.5 times the gross diameter of the rivet.

**Maximum pitch:**
- The maximum pitch should not exceed 12t or 200 mm whichever is less in case of compression member, and 16t or 300 mm whichever is less in case of tension member.
- The distance between centres of any two consecutive rivets in a line adjacent and parallel to an edge of an outside plate shall not exceed (100mm + 4t) or 200 mm, whichever is less in compression or tension members.
- If the line of rivets (including tacking rivets) does lie in the direction of stress, the maximum pitch should not exceed 32 t or 300 mm whichever is less, where t is the thickness of the thinner outside plate.

24. What is edge distance?

A minimum edge distance of approximately 1.5 times the gross diameter of the rivet measured from the centre of the rivet hole is provided in the rivet joint.

25. What is meant by limit state design? *(IS800:2007-Pg: 28)*

Limit state design method is technologically sound method which results in significant economy in design of structures. The design of a structure to satisfy all appropriate requirements derived from probability considerations is referred to as a limit state design.

26. State the different limit states. *(IS800:2007-Pg: 28)*

The limit states are broadly grouped in to two major types, namely:
- Limit state of strength
- Limit state of serviceability.

27. What are the four types of serviceability limit states applicable to steel structures? *(IS800:2007-Pg: 28)*
28. **Define durability. (IS800:2007-Pg: 2)**

It is defined as ability of the structure to maintain its level of reliability and performing the desired function in the working environment under exposure conditions, without deterioration of cross sectional area and loss of strength due to corrosion during its life span.

29. **How the loads are classified? (IS800:2007-Pg: 4)**

- Dead load
- Live load
- Earthquake load
- Wind load
- Dynamic loads.

30. **What is a partial safety factor? (IS800:2007-Pg: 4)**

The safety of the structure depends on each of the two principal design factors namely, load and material strength, which are not the functions of each other. Each of the two factors contributes partially to safety and they are termed as partial safety factors.

31. **Define design load.**

The partial safety factor for loads is a load factor which is multiplied to characteristic load, gives the design load.

\[ \text{Design load} = y_f \times \text{characteristic load} \]

32. **Define bolt.**

A bolt is a metal pin with a head formed at one end and the shank threaded at the other end in order to receive a nut.
33. What are the advantages of bolted connections? (May / June 2007)

- There is silence in preparing bolted connection. In riveting, hammering is done. The hammering causes noise in the riveting.
- There is no risk of fire in bolted connection. The rivets are made red hot in riveting and there is risk of fire.
- The bolted connections may be done quickly in comparison to the riveting.
- Though the cost of bolts is more than the cost of rivets, the bolted connections are economical to use because less persons are required for installation, and the work proceeds quickly.
- Noiseless
- Easy to dismantle and reuse the materials.

34. What are the various types of bolts used for structural purposes? (May / June 2007)

- Unfinished bolts
- Turned bolts
- Black bolts
- High strength bolts

35. What are the advantages of HSFG bolts?

- Do not allow slip between the connected members.
- Loads are transferred by friction only.
- Due to high strength less number of bolts are required.
- No noise pollution
- Deformation is minimized.

36. Define nominal diameter and gross diameter of bolt.

**Nominal diameter of bolt**: The nominal diameter of a bolt is the diameter of unthreaded shank of bolt.
**Gross diameter of bolt:** The gross diameter of a bolt is the nominal diameter of the bolt.

37. **Define slip factor.**
   The slip factor is defined as the ratio of the load per effective interface, required to produce slip in a pure shear joint, to the total shank tension induced in the bolts.

38. **Define weld.**
   The welding is one of the methods of connecting the structural members. In the welding, a metallic link is made between the structural members. The weld is defined as a union between two pieces of metal at faces rendered plastic or liquid by heat or by pressure or both.

39. **Write about the advantages of welding.**
   - There is silence in the process of welding.
   - There is safety of welding operator in the welding.
   - The welding may be done quickly in comparison to the riveting.
   - The welded joints have better appearance than riveted joints.
   - The welded joints are more rigid than the riveted joints.

40. **List the various types of welded joints.**
   - Butt weld
   - Fillet weld
   - Slot weld and plug weld
   - Spot weld
   - Seam weld
   - Pipe weld

41. **Write about the disadvantages of welding.**
   - The members are likely to distort in the process of welding.
- A welded joint fails earlier than riveted joint, if the structure is under fatigue stresses.
- There is a greater possibility of brittle fracture in welding than the rivet.
- The inspection of welded joint is more difficult and more expensive than the riveted joint.
- More skilled person is required in the welding than in the riveting.

**42. What is the effective area of butt weld?**

The effective area of a butt weld is taken as the product of the effective throat thickness and the effective length of butt weld.

**43. How the length of bolt is calculated?**

The length of bolt is equal to the distance from the underside of the bolt head to the extreme end of the shank, including any camber or radius.

**44. What are the types of failures occur in riveted joint?**

- Shear failure of bolt
- Shear failure of plates
- Tension failure of bolt or tension failure of plate
- Bearing failure of bolt or Bearing failure of plate

**45. What is meant by stiffened & unstiffened seat connection?**

The simple seat connection consists of an angle with its horizontal leg at its top, to receive the reaction from the beam and transfer it to the column or beam. The seat connection requires more space in the vertical direction.

When the beam reaction is large (>100 KN) the angle alone cannot support it. In such case the horizontal leg of an angle is stiffened (strengthened) by means of one or two tight fitting angles. Such connection is called as stiffened seat connection.
46. What are the types of welding process?

- Electric arc welding
- Gas welding
- Thermite welding
- Forged welding
- Resistance welding.

47. Write the equation for calculating the effective throat thickness of weld.

It is the perpendicular distance from the root of fillet on the hypotenuse i.e., distance BD. The effective throat thickness shall not be less than 3 mm and generally not to exceed 0.7t or 1.0t, where t is the thickness of thinner plate of elements being welded.

48. Draw a neat sketch of ISMB 400 and mention its properties.
49. Define the terms gauge, pitch, edge and end distance of bolt joint.  
(IS800:2007-Pg: 2,3 &4)

1.3.55 **Gauge** — The spacing between adjacent parallel lines of fasteners, transverse to the direction of load/stress.

1.3.72 **Pitch** — The centre-to-centre distance between individual fasteners in a line, in the direction of load/stress.

1.3.33 **Edge Distance** — Distance from the centre of a fastener hole to the nearest edge of an element measured perpendicular to the direction of load transfer.
50. How to calculate the efficiency of a joint?

The efficiency of the joint is the ratio of actual strength of connection to the gross strength of connected member, expressed in % as,

\[
\text{Efficiency of joint} = \frac{\text{least actual strength of the joint}}{\text{Gross strength of solid plate member}} \times 100
\]

PART - B

12 MARK QUESTIONS

1. Determine the strength of a double cover butt cover butt joint used to connect two flats 200 F 12. The thickness of each cover plate is 8 mm. flats have been joined by 9 rivets in chain riveting at a gauge of 60 mm. What is the efficiency of the joint?

2. A load of 150 kN is applied to a bracket plate at an eccentricity of 300 mm. sixteen rivets of 20 mm nominal diameter are arranged in two rows with 8 rivets per row. The two rows are 200 mm apart and the pitch is 80 mm. if the bracket plate is 12.5 mm thick, investigate the safety of the connection. Given, \( s = 100 \text{ N/mm}^2 \), \( f_b = 300 \text{ N/mm}^2 \) and \( f_t = 150 \text{ N/mm}^2 \).

3. What are the types of load to be account for steel design?

4. A bridge truss carries an axial pull of 400 KN. It is to be a gusset plate 22mm thick by a double cover butt joint with 22 mm diameter power driven rivets. Design an economical joint. Determine the efficiency of the joint.
5. Two plates 12 mm and 10 mm thick are joined by a triple riveted lap joint, in which the pitch of the central row of rivets is 0.6 times the pitch of rivets in the outer rows. Design the joint and find its efficiency. Take $\sigma_{ut} = 150 \text{ N/mm}^2$ & $\sigma_{pt} = 250 \text{ N/mm}^2$. (May / June 2007)

6. A double riveted double cover butt joint is used to connect plates 12 mm thick. Using Unwin’s formula, determine the diameter of rivet; rivet value, gauge and efficiency of joint. Adopt the following stresses:
   - Working stress in shear in power driven rivets = 100 N / mm$^2$ (Mpa)
   - Working stress in bearing in power driven rivets = 300 N / mm$^2$ (Mpa)
   - Working stress in axial tension in plates = 0.6 $f_y$

7. A bracket carrying a load of 100 kN is connected to column by means of two horizontal fillet welds, of 130 mm effective length and 10 mm thick. The load acts at 70 mm from the face of the column as shown. Find the throat stress. (May / June 2007)

8. A tie member 75 mm X 8mm is to transmit a load of 90 kN. Design the fillet weld and calculate the necessary overlap. (Nov / Dec 2007)

9. A single bolted double cover butt joint is used to connect two plates 8mm thick. Assuming 20mm bolts at 50mm pitch calculate the efficiency of the joint. The thickness of cover plate is 4mm.
10. The figure shows the joint in the bottom chord continuous member of the truss. Design the connection using M16 black bolt of property class 4.6 and grade Fe410 steel. Assume edge distance of 35 mm and minimum pitch.

11. Design the seat angle connection between the beam ISMB 250 and column ISHB 250 for a reaction from beam equal to 85 KN. Use M16 black bolt of property class 4.6 and grade Fe410 steel with $f_y = 250$ MPa.

12. A beam ISWB 550 having equal flange width to that of column, transfers a factored end reaction of 275 KN to the flange of the column ISSC 250. Design the stiffened seat angle connection using 20 mm bolts of grade 4.6, $f_y = 250$ MPa.
UNIT - II
TENSION MEMBERS

Types of sections – Net area – Net effective sections for angles and Tee in tension – Design of connections in tension members – Use of lug angles – Design of tension splice – Concept of shear lag

PART – A

TWO MARK QUESTIONS AND ANSWERS

1. Define tension member.

A tension member is defined as a structural member subjected to tensile force in the direction parallel to its longitudinal axis. A tension member is also called as a tie member or simply a tie.

2. What are the various types of tension members?

- Wires and cables
- Rods and bars
- Single structural shapes and plates
- Built-up members

3. What is meant by built-up members? (IS800:2007-Pg: 1)

Two or more than two members are used to form built-up members. The built-up sections may be made more rigid and more stiff than the single structural shapes. A built-up section may be made of two channels placed back to back with a gusset plate in between them.

4. Define slenderness ratio. (IS800:2007-Pg: 4)
The slenderness ratio of a tension member is the ratio of its unsupported length (l) to its least radius of gyration (r).

\[ \text{Slenderness ratio, } \lambda = \frac{l}{r}. \]

5. What is net sectional area? (Nov / Dec 2007)

The net sectional area of a tension member is the gross-sectional area of the member less the maximum deduction for holes.

\[ A_{\text{net}} = A_{\text{gross}} - \text{sectional areas of holes} \]

6. How to calculate net area in (a) chain bolting (b) zigzag bolting.

(IS800:2007-Pg: 33)

a) Chain bolting

Net area, \( A_n = (b - n d_h) t \)

b) Zigzag bolting

\[
A_n = b - nd_h + \sum_i \frac{P_{si}^2}{4g_i} t
\]

\( b, t = \text{width and thickness of the plate, respectively,} \)

\( d_h = \text{diameter of the bolt hole (2 mm in addition to the diameter of the hole, in case the directly punched holes),} \)

\( g = \text{gauge length between the bolt holes, as shown in Fig. 5,} \)


7. What is a Lug angle?

In order to increase the efficiency of the outstanding leg in single angles and to decrease the length of the end connections, sometimes a short length angle at the ends are connected to the gusset and the outstanding leg of the main angle directly, as shown in Fig. Such angles are referred to as lug angles. It also reduces shear lag.
8. Write any two specifications for designing of lug angle. 
(IS800:2007-Pg: 83)

10.12.2 In the case of angle members, the lug angles and their connections to the gusset or other supporting member shall be capable of developing a strength not less than 20 percent in excess of the force in the outstanding leg of the member, and the attachment of the lug angle to the main angle shall be capable of
developing a strength not less than 40 percent in excess of the force in the outstanding leg of the angle.

10.12.3 In the case of channel members and the like, the lug angles and their connection to the gusset or other supporting member shall be capable of developing a strength of not less than 10 percent in excess of the force not accounted for by the direct connection of the member, and the attachment of the lug angles to the member shall be capable of developing 20 percent in excess of that force.

10.12.4 In no case shall fewer than two bolts, rivets or equivalent welds be used for attaching the lug angle to the gusset or other supporting member.

9. Write note on tension member splice. (May / June 2007)

A tension member is spliced when the available length is less than the required length of the tension member. A tension member is also spliced when the members of different thickness are required to be connected. In such a case packing is required to fill up the gap.

Total area of cross section which can be taken as equal weight of the member per unit length divided by density of the material is called Gross area. The sectional area given by the manufacturer is taken as the gross area.

12. Explain shear lag effect. (IS800:2007-Pg: 4)

The tensile force is transferred from gusset to the tension member (such as angles, channels or T-sections) through one leg by bolts or welds. In this process initially the connected leg may be subjected to more stress than the outstanding leg and finally the stress distribution becomes uniform over the section away from the connection. Thus one part lags behind the other; this is referred to as shear lag.

1.3.88 Shear Lag — The in plane shear deformation effect by which concentrated forces tangential to the surface of a plate gets distributed over the entire section perpendicular to the load over a finite length of the plate along the direction of the load.
13. Give the sketches of steel sections?

Channel, Angle, T and Solid Sections

PART - B

12 MARK QUESTIONS

1. Using a lug angle, design a suitable joint for 100 mm * 65mm * 10 mm angle, used as a tension member. Use 20 mm diameter rivets and thickness of gusset plate 8 mm.

2. The bottom tie of roof truss is 4m long. In addition to an axial tension of 1000 kN, it has to support at its centre a shaft of load of 3600N. The member is composed of two angles 100 mm * 75 mm * 10 mm with the longer legs turned down and placed back to back on either side of 10 mm gusset plate. The angles are tack riveted at 92 cm centres with 20 mm diameter rivets.
3. Design a horizontal tension member carrying a load 600 KN. The length of the member is 3 mm. The member is connected to 4.5 cm thick gusset plate 20 mm rivets.

4. Design the tension strength of a roof truss diagonal 100 X 75 X 10 mm connected to the gusset plate by 20 mm diameter power driven rivets in one row along the length of the member. The short leg of the angle is kept outstanding. (NOV/DEC 2007)

5. A bridge truss diagonal carries an axial pull of 300 KN. Two mild steel flats 250 ISF 10 and ISF 18 of the diagonal are to be jointed together. Design a suitable splice.

6. Design a double angle tension member carrying axial tensile force of 300 kN in addition to this, it is also subjected to a uniformly distributed load of 0.4 kN/m throughout its length, including self weight. The centre to centre distance between the end connection is 2.7 m. (MAY/JUNE 2007)

7. Design a tension splice to connect two plates of size 220 mm X 20 mm and 200 mm X 10 mm, for a design load of 220 kN. Also sketch the details of the riveted joint. (MAY/JUNE 2007)

8. The main tie of a roof truss consists of ISA 150 X 115 X 8 mm and is connected to a gusset plate by 18 mm diameter rivets. Find out the maximum load it can carry.
UNIT - III

COMPRESSION MEMBERS

Types of compression members – Theory of columns – Basis of current codal provision for compression member design – Slenderness ratio – Design of single section and compound section compression members – Design of lacing and battening type columns – Design of column bases – Gusseted base

PART – A

TWO MARK QUESTIONS AND ANSWERS

1. What is meant by strut? *(IS800:2007-Pg: 5)*

A strut is defined as a structural member subjected to compression in a direction parallel to its longitudinal axis. The term strut is commonly used for compression members in roof trusses.
2. Draw the diagram of buckling of column.

3. What are the assumptions made in Euler’s analysis?

1. The material is homogeneous and linearly elastic (i.e. it obeys Hooke’s Law).
2. The strut is perfectly straight and there are no imperfections.
3. The loading is applied at the centroid of the cross section at the ends.

4. What is meant by effective sectional area?
   The effective sectional area of a compression member is the gross cross sectional area of the member. The deduction is not made for members connected by rivets, bolts and pins.

5. Define slenderness ratio of compression member.
   The slenderness ratio of a compression member is the ratio of effective length of compression member \((l)\) to approriate radius of gyration \((r)\).

6. What are the buckled modes for different end conditions?

7. Define buckling load. \((IS800:2007-Pg: 1)\)
   The buckling load is defined as the load at which a member or a structure as a whole collapses in service (or buckles in a load test). The
buckling is defined as the sudden bending, warping, curling or crumpling of the elements or members under compressive stresses.

8. What is meant by built-up compression members?

The built-up compression members are needed when the single rolled steel sections are not sufficient to furnish the required cross-sectional area.

A built-up compression member may consist of two or more rolled structural steel sections connected together effectively and acts as one compression member.


In position restraint end of the column is not free to change its position but rotation about the end of eth column can take place e.g., hinged end of column.

10. What are the different effective lengths for different boundary condition?
11. Define effective length.

The effective length of a compression member is the distance between the points of contra flexures of a buckled column. It depends on the actual length and the end conditions in regards to restraint against rotation and transverse displacement.
12. What is meant by actual length?
The actual length is taken as the length from centre-centre of intersections with the supporting members.

13. How the effective length of column is determined?
The effective length of columns in framed structures may be obtained by multiplying the actual length of the column between the centres of laterally supporting members (beams) given with the effective length factor K.

Effective length = KL


7.6.1.4 Single laced systems, on opposite faces of the components being laced together shall preferably be in the same direction so that one is the shadow of the other, instead of being mutually opposed in direction.

Double laced system, on opposite faces of the components being laced together shall preferably be in mutual opposed in direction.

15. What are the forces acting on lacing system?
The forces acting on lacing system are transverse shear force and axial force.

16. Draw the column base plate diagram. *(Nov / Dec 2005)*
17. Which column formula is recommended in IS 800:2007? (Pg: 34)

7.1.2.1 The design compressive stress, $f_{cd}$, of axially loaded compression members shall be calculated using the following equation:

$$ f_{cd} = \frac{f_y / \gamma_m}{\phi + \left[ \phi^2 - \lambda^2 \right]^{0.5}} = \frac{\chi f_y / \gamma_m}{\gamma_m} \leq f_y / \gamma_m $$
where

\[
\phi = 0.5 \left[ 1 + \alpha (\lambda - 0.2) + \lambda^2 \right] \\
\lambda = \text{non-dimensional effective slenderness ratio} \\
= \sqrt{\frac{f_y}{f_{cc}}} = \sqrt{f_y} \left( \frac{KL/r}{\pi^2 E} \right)^2 \\
f_{cc} = \text{Euler buckling stress} = \frac{\pi^2 E}{(KL/r)^2}
\]

where

\( KL/r \) = effective slenderness ratio or ratio of effective length, \( KL \) to appropriate radius of gyration, \( r \);
\( \alpha \) = imperfection factor given in Table 7;
\( \chi \) = stress reduction factor (see Table 8) for different buckling class, slenderness ratio and yield stress

\[
1 = \left[ \phi + \left( \phi^2 - \lambda^2 \right)^{0.5} \right]
\]

\( \lambda_{m0} \) = partial safety factor for material strength.
18. Where should the splice plate be located in a column? *(IS800:2007-Pg:46)*

7.3.4.1 Where the ends of compression members are prepared for bearing over the whole area, they shall be spliced to hold the connected members accurately in position, and to resist bending or tension, if present. Such splices should maintain the intended member stiffness about each axis. Splices should be located as close to the point of inflection as possible. Otherwise their capacity should be adequate to carry magnified moment.

19. What is the purpose for providing anchors bolt in base plate?

Anchor bolts are provided to stabilize the column during erection and to prevent uplift for cases involving large moments. Anchor bolts can be cast-in-place bolts or drilled-in bolts. The latter are placed after the concrete in set and are not too often used. Their design is governed by the manufacturer’s specifications. Cast-in-place bolts are hooked bars, bolts, or threaded rods with nuts placed before the concrete is set.

20. What are the types of bases provided for connecting the column to the base?

- Slab base
- Gusseted base
- Moment resisting base

21. Under what circumstances gusset base is used?

When the load on the column is large or when the column is subjected to moment along with axial load, gusseted base is provided. It consists of a base plate, gusset plate, connecting angles provided on either side of the column and web cleat angle.
22. Write about batten plates in compression member.

When compression members are required for large structures like bridges, it will be necessary to use built-up sections. They are particularly useful when loads are heavy and members are long (e.g. top chords of Bridge Trusses). The cross section consists of two channel sections connected on their open sides with some type of lacing or latticing (dotted lines) to hold the parts together and ensure that they act together as one unit. The ends of these members are connected with “batten plates” which tie the ends together.

23. What are the three classifications for determination of size of plate?

Class I- will pertain to all base plates the moment on which is so small in proportion to the direct load that there is compression over the entire area between the bottom of the base and its foundation

Class II- will pertain a comparatively small range of base plates which have tension over a small portion - one - third or loss of the area

Class III- will include those which are exposed to a comparatively large moment and which therefore have tension over a large portion - more than one -third of the area between the bottom of the base plate and its concrete footing.

24. What are the functions of providing column bases?

The basic function of bases is to distribute the concentrated load from the column over a larger area. The column load is distributed over the base plate and then to supporting concrete and finally to the soil.
25. What is meant by slab base?

The slab base as shown in Figure consists of cleat angles and base plate. The column end is faced for bearing over the whole area. The gussets (gusset plates and gusset angles) are not provided with the column with the slab bases. The sufficient fastenings are used to retain the parts securely in plate and to resist all moments and forces, other than the direct compression. The forces and moments arising during transit, unloading and erection are also considered.

26. What is meant by column splice?

A joint in the length of a column provided, when necessary, is known as column splice. It is also described as column joint.

27. List the limiting slenderness ratio of compression member carrying dead load & live load. (April / May 2008)(IS800:2007-Pg: 20)
PART - B

12 MARK QUESTIONS

1. Design a rolled steel beam section column to carry an axial load 1100 KN. The column is 4 m long and adequately in position but not in direction at both ends.

2. A rolled steel beam section HB 350 @ 0.674 kN/m is used as a stanchion. If the unsupported length of the stanchion is 4 m, determine safe load carrying capacity of the section.

3. A double angle discontinuous strut ISA 125 mm * 95 * mm * 10 mm long legs back to back is connected to both sides of a gusset plate 10 mm thick with 2 rivets. The length of strut between centre to centre of intersections is 4 m. determine the safe load carrying capacity of the section.

4. A steel column 12 m long carries an axial load of 1000 kN. The column is hinged at both ends. Design an economical built-up section with double lacing. Design the lacing also.

---

**Table 3 Maximum Values of Effective Slenderness Ratios**

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Member</th>
<th>Maximum Effective Slenderness Ratio $(KL/r)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>i) A member carrying compressive loads resulting from dead loads and imposed loads</td>
<td>180</td>
</tr>
</tbody>
</table>

---

3
5. Design a built-up column consisting of two channels connected by batten to carry an axial load of 800 KN; the effective length of the column is 6 m.

6. Design a built up column 8m long to carry a load of 400kN. The column is restrained in position but not in direction at both the ends. Provide single angle lacing system with riveted connections. (Nov/Dec 2007)

7. Design a built up column 6m long to carry a load of 400kN. The column is provided with Batten system. The ends of the columns are pinned. Design the battens. (Nov/Dec 2007)

8. A discontinues strut consists of two ISA 90X75X10mm placed to the same side of a gusset plate 10mm thick with its longer leg back to back, with one rivet on each angle at the ends. The effective length of the strut is 2.5m. Determine the allowable load. What is the safe load if the strut is continuous? Take $f_y = 250N/mm^2$. The angles are connected with tack rivets along the length. (May/June 2007)

9. A built up column consists ISHB 400@ 77.40 kg/m with one 300mmX12mm flange plate on each side. The column carries an axial load of 2600kN. Design a gusseted base, if the column is supported on concrete pedestal with a bearing pressure of 5N/mm^2. (May/June 2007)
Design of laterally supported and unsupported beams – Built up beams – Beams subjected to biaxial bending – Design of plate girders riveted and welded – Intermediate and bearing stiffeners – Web splices – Design of beam columns

PART - A

TWO MARK QUESTIONS AND ANSWERS

1. What is meant by limit state design?

Designs should ensure that the structure does not become unfit for the use for which it is required. The state at which the unfitness occurs is called a limit state.

2. What are special features of limit state design method?

- It is possible to take into account a number of limit states depending upon the particular instance.
- This method is more general in comparison to the working stress method. In this method, different safety factors can be applied to different limit states, which is more rational than applying one common factor (load factor) as in the plastic design method.
- This concept of design is appropriate for the design of structures since any new knowledge of the structural behavior, loading and materials can be readily incorporated.

3. Explain the behavior of steel beams?

Laterally stable steel beams can fail only by (a) Flexure (b) Shear or (c) Bearing, assuming the local buckling of slender components does not occur. These three conditions are the criteria for limit state design of steel beams. Steel beams would also become unserviceable due to excessive deflection and this is classified as a limit state of serviceability. The factored design moment, M at any section, in a beam due to external actions shall satisfy

\[ M < M_d \]
4. Write Short notes on compact sections

When the lateral support to the compression flange is adequate, the lateral buckling of the beam is prevented and the section flexural strength of the beam can be developed. The strength of I-sections depends upon the width to thickness ratio of the compression flange. When the width to thickness ratio is sufficiently small, the beam can be fully plastified and reach the plastic moment, such sections are classified as compact sections.

5. What is meant by slenderness sections?

When the width to thickness ratio of the compression flange is sufficiently large, local buckling of compression flange may occur even before extreme fibre yields. Such sections are referred to as slender sections.

7. Draw the curvature for flexural member performance and the classification of cross sections.
8. List the various factors affecting the lateral-torsional buckling strength.
   • Distance between lateral supports to the compression flange.
   • Restraints at the ends and at intermediate support locations (boundary conditions).
   • Type and position of the loads.
   • Moment gradient along the length.
   • Type of cross-section.

9. How do you improve the shear resistance in plate girder?
   i. Increasing in buckling resistance due to reduced c/d ratio;
   ii. The web develops tension field action and this resists considerably larger stress than the elastic critical strength of web in shear

10. What are the classifications in Stiffeners?
    a) Intermediate transverse web stiffeners
    b) Load carrying stiffeners
    c) Bearing stiffeners
    d) Torsion stiffeners
    e) Diagonal stiffeners and
    f) Tension stiffeners

11. Write about the Box girders.
The design and detailing of box girders shall be such as to give full advantage of its higher load carrying capacity. Diaphragm shall be used where external vertical as well as transverse forces are to be transmitted from one member to another. The diaphragms and their fastenings shall be proportioned to distribute other force applied to them and in addition, to resist the design transverse force and the resulting shear forces. The design transverse force shall be taken as shared equally between the diaphragms.

12. Write Short notes on Purlin.

Purlins attached to the compression flange of a main member would normally be acceptable as providing full torsional restraint; where purlins are attached to tension flange, they should be capable of providing positional restraint to that flange but are unlikely (due to the rather light purlin/rafter connections normally employed) to be capable of preventing twist and bending moment based on the lateral instability of the compression flange.

13. Write the Special features of limit state design method?

• Serviceability and the ultimate limit state design of steel structural systems and their components.
• Due importance has been provided to all probable and possible design conditions that could cause failure or make the structure unfit for its intended
• The basis for design is entirely dependent on actual behaviour of materials in structures and the performance of real structures, established by tests and long-term observations
• The main intention is to adopt probability theory and related statistical methods in the design.
• It is possible to take into account a number of limit states depending upon the particular instance
14. What is meant by laterally supported beam?

The laterally supported beams are also called laterally restrained beams. When lateral deflection of the compression flange of a beam is prevented by providing effective lateral support, (restraint) the beam is said to be laterally supported. The effective lateral restraint is the restraint which produces sufficient resistance in a plane perpendicular to the plane of bending to restrain the compression flange of a beam from lateral buckling to either side at the point of application of the restraint.

15. Write a note on built up beams.

The built-up beams are also termed as compound beams or compound girders. The built-up beams are used when the span, load and corresponding bending moment are of such magnitudes that rolled steel beam section become inadequate to provide required section modulus. The built-up beams are also used when rolled steel beams are inadequate for limited depth.

16. What are the elements of plate girder?
The vertical plate of the plate girder is termed as **web plate**. The angles connected at the top and bottom of the web plate are known as **flange angles**. The horizontal plates connected with the flange angles are known as flange. Plates or cover plates. The web plate, flange angles and flange plates are shown in Fig. The **bearing stiffeners, intermediate stiffeners and horizontal stiffeners** used with the plate girder are shown in Fig.

17. **Under what circumstances web plates are stiffened and unstiffened?**

A web plate is kept unstiffened when the ratio of clear depth to thickness of web is less than 85. It does not require stiffeners. A web plate is called stiffened, when the ratio of clear depth to thickness of web is greater than 85 and stiffeners are provided to contribute additional strength to web.

18. **What is meant by plastic method of design?**
Steel being a ductile material it can absorb large deformations beyond elastic fracture. Steel processes reserved strength beyond yield strength. The method using this reserved strength is called plastic method of design.

19. **Define shape factor.**

The ratio of plastic moment to elastic moment $M_p / M_y$ is the property of cross sectional area and is not dependent on material properties. This ratio is called as shape factor.

20. **What is meant by plastic hinge?**

Plastic hinge is the yield section of the beam, which acts as if it were hinged, except with a constant restraining plastic moment.

21. **Define yield length.**

The yield length is the length of the beam over which the moment is greater than or equal to the yield moment. It depends upon the type of loading and the cross section of the structural member.

22. **What are the methods of plastic analysis?**

- Static method
- Kinematic method or mechanism method.

23. **What is meant by static and Kinematic method?**

**Static method:** The lower bound theorem states a load computed, on the basis of assumed equilibrium moment diagram, in which moments are not greater than plastic moment $M_p$, is less than or at the best equal to the true collapse load. i.e., $W \leq W_c$ (collapse load)

**Kinematic method:** The upper bound theorem states a load computed, on the basis of assumed mechanism, will always be greater than or at the best equal to the true collapse load. i.e., $W \geq W_c$
24. What are the guide lines to locate the plastic hinges?

The plastic hinges occur,

- At the points of maximum moment
- At the connections involving change in geometry.
- Under the concentrated load
- At the points of zero shear in a span, loaded by udl.

25. Define virtual work.

It states that ‘work done by the load during small motion of collapse mechanism must be equal to the work absorbed in the plastic hinges’.

26. What is meant by complete collapse, partial collapse and over complete collapse?

**Complete collapse:** The number of plastic hinges, \( H \) required to form complete collapse = \( R + 1 \), where \( R \) is the degree of redundancy of the structure. \( H = R + 1 \)

**Partial collapse:** The number of plastic hinges, \( H \) required to form partial collapse is < \( R + 1 \). (i.e., \( H < R + 1 \))

**Over complete collapse:** The number of plastic hinges, \( H \) required to form over complete collapse is > \( R + 1 \). (i.e., \( H > R + 1 \))

27. Draw a neat sketch of combined shear and bending behavior in beam for I section.
28. What is meant by lateral buckling of beam?

A long beam with laterally unrestrained compression flange when incrementally loaded, first deflects downwards and when load exceeds a particular value; it tilts sideways due to instability of compression flange, and rotates about longitudinal axis. This phenomenon is known as laterally buckling or torsional buckling of beam.

29. How the laterally supported beam fails?

The laterally supported beam can fail by,

- Flexure
- Shear
- Bearing.

30. What is web buckling and web crippling?

A heavy concentrated load produces a region of high compressive stresses in the web either at support or under the load. This causes the web either to buckle or to cripple.

Web buckling occurs when the intensity of compressive stress near the centre of the section exceeds the critical buckling stress of web acting as a strut. This type of failure is more in the case of built up sections having greater ratio of depth to thickness of the web.
31. **What is the purpose of providing stiffener in plate girder?**

In the plate girder the depth of the web is kept large for economy and hence it is made thin to reduce the self weight of the girder. A very thin web may buckle laterally or may cripple under the heavy concentrated load. In such a case the web is strengthened by providing stiffeners.

32. **Under what circumstances load bearing stiffeners are used in plate girder?**

The load carrying stiffeners are attached with the web plate of the plate girder to avoid local bending failure of flanges, crushing of web and buckling of web plate. They are provided under the heavy concentrated loads and the reactions at supports.

33. **Under what circumstances bearing stiffeners are used in plate girder?**

Bearing stiffeners should be provided for webs where forces are applied through the flange by loads or reactions exceeding the local capacity of the web at its connection to the flange.

34. **What is the purpose of providing intermediate stiffeners?**

The intermediate transverse stiffeners are provided to strength the buckling strength of web. They remain effective after the buckling of web and provide anchorage for tension field.

35. **What is the main function of providing horizontal stiffener in plate girder?**

The main function of horizontal stiffener is to increase the buckling resistance of the thin web. They are located in the compression zone. It prevents the web from bending laterally.

36. **What are the reasons behind splicing in plate girder?**

The joint in the plate girder called splicing becomes necessary for plate girders of longer span due to the following reasons:
➢ The rolled steel plates are manufactured up to a limited length. When the maximum manufactured length is insufficient for full length, splicing becomes necessary.

➢ For convenience of handling during transportation and erection it is essential that the plate is too long.

➢ Due to unsymmetrical loading the thickness of plate may change.

37. What are the types of splices?
➢ Flange splice
➢ Web splice.

38. How the flange area of a plate girder is designed?

\[ \text{Flange area, } A_f = \frac{M}{(D f_{yf}/Y_{mo})} \]

- \(M\) = factored moment
- \(D\) = total depth of girder
- \(f_{yf}\) = Yield stress of steel
- \(Y_{mo}\) = Partial safety factor of material.

PART - B

12 MARK QUESTIONS

1. Design a simply supported beam to carry uniformly distributed load of 44 kN/m. the effective Span of beam is 8 m. The effective length of compression flange of the beam is also 8 m. The ends of beam are not to free to rotate at the bearings.

2. The effective length of compression flange of simply supported beam MB 500 @ 0.869 kn/m. Determine the safe uniformly distributed load per metre length which can be placed over the beam having an effective span of 8 m. The ends of beam are restrained against rotation at the bearings.
3. ISMB 550 @1.037 kN/m has been used as simply supported over a span of 4 m. The ends of beam are restrained against torsion but not against lateral bending. Determine the safe UDL per metre, which the beam can carry.

4. Design rolled steel I- sections for a simply supported beam with a clear span of 6 m. It carries a UDL of 50 KN per metre exclusive of self-weight of the girder. The beam is laterally unsupported.

5. Check the beam section WB 500 @1.45 kN/m against web crippling and web buckling if reaction at the end of beam is 179.6 KN. The length of bearing plate at the support is 120 mm. Design bearing plate. The bearing plate is set in masonry.

6. A beam simply supported over an effective span of 7 m, carries an uniformly distributed load of 50 kN/m inclusive of its own weight. The depth of the beam is restricted to 450 mm. Design the beam, assuming that the compression flange of the beam is laterally supported by a floor construction. Take \( f_y = 250 \text{N/mm}^2 \) and \( E = 2 \times 10^5 \text{N/mm}^2 \). Assuming width of the support is 230 mm. (May/June 2007)

7. Design a bearing stiffener for a welded plate girder with the following specifications.
   Web = 1000 mm X 6 mm thick.
   Flanges = 2 Nos. of 350X20 mm plate on each side.
   Support reaction = 350 kN.
   Width of the support = 300 mm. (May/June 2007)

8. A simply supported steel joist with a 4.0 m effective span carries a udl of 40 kN/m over its span inclusive of self weight. The beam is laterally unsupported. Design a suitable section. Take \( f_y = 250 \text{N/mm}^2 \). (Nov/Dec 2007)

9. Design the step by step procedure for design of vertical and horizontal stiffeners in a plate girder. (Nov/Dec 2007)
UNIT – V

ROOF TRUSSES AND INDUSTRIAL STRUCTURES

Roof trusses – Roof and side coverings – Design loads, design of purlin and elements of truss; end bearing – Design of gantry girder

PART - A

TWO MARK QUESTIONS AND ANSWERS

1. Draw neat sketches of various types of roof trusses.
2. Draw a neat sketch of roof truss with its component parts.

3. What are the types of load that may act on roof trusses?
   - Dead load
     - Load from coverings, purlins, self weight of trusses and bracing.
   - Live load
   - Wind load

4. How economical spacing of roof trusses obtained?
   The economical spacing of trusses is between $1/3$ to $1/5$ of span.

5. List the various forces acting on a gantry girder.
   - Weight of the trolley or crab
   - Weight of the crane girder
6. What are the loads to be considered while designing the purlins?

- Impact loads – it is due to sudden application of brakes.
- Lateral load (surge load) – transverse to the rail
- Longitudinal load (drag load)

7. List the various types of roof sheetings commonly used.

- Asbestos cement sheets
- Tiles
- Galvanized corrugated iron sheets
- Aluminium sheets
- Slate roofing.

8. Which section is best suited for a purlin?

- Angle section
- Channel section
- I-section

9. How is the selection of section made for roof truss element?

- The members of the truss are made of either rolled steel sections or built-up sections depending upon the span length and intensity of loading.
- Rolled steel single or double angles, T-section, hollow circular, square or rectangular sections are used in the roof trusses of industrial buildings.
- In long span roof trusses and short span bridges, heavier rolled steel sections, such as channels and I – sections are used.
Built-up I-sections, channels, angles and plates are used in the case of long span bridge trusses.

10. How to fix the spacing of trusses?

The economical spacing of trusses is between 1/3 to 1/5 of span.

- For lighter load, carrying no snow or superimposed load except wind, the larger spacing may be more economical.
- Spacing of 3-4.5 m for spans up to 15m and 4.5 – 6 m for spans of 15 – 30 m may be economical.
- The spacing of long span trusses may be 12 – 15 m.

11. What are economical considerations for industrial truss?

- Method of fabrication and erection to be followed, facility for shop fabrication available, transportation restrictions, field assembly facilities.
- Preferred practices and past experience.
- Availability of materials and sections to be used in fabrication.
- Erection technique to be followed and erection stresses.
- Method of connection preferred by the contractor and client (bolting, welding or riveting).
- Choice of as rolled or fabricated sections.
- Simple design with maximum repetition and minimum inventory of material.

12. Write about basics of plastic analysis?

In plastic analysis and design of a structure, the ultimate load of the structure as a whole is regarded as the design criterion. The term plastic has occurred due to the fact that the ultimate load is found from the strength of steel in the plastic range.

This method is rapid and provides a rational approach for the analysis of the structure. It also provides striking economy as regards the weight of steel since the sections required by this method are smaller in size than those required by the method of elastic analysis.

13. What is meant by first yield moment?
As $W$ is increased gradually, the bending moment at every section increases and the stresses also increase. At a section close to the support where the bending moment is maximum, the stresses in the extreme fibers reach the yield stress. The moment corresponding to this state is called the first yield moment $M_y$, of the cross section.

14. Write about Principles of plastic analysis.
   (i) Mechanism condition: The ultimate or collapse load is reached when a mechanism is formed. The number of plastic hinges developed should be just sufficient to form a mechanism.
   (ii) Equilibrium condition: $\Sigma F_x = 0$, $\Sigma F_y = 0$, $\Sigma M_{xy} = 0$
   (iii) Plastic moment condition: The bending moment at any section of the structure should not be more than the fully plastic moment of the section.

15. Explain about Crane gantry girders.
   The function of the crane girders is to support the rails on which the traveling cranes move. These are subjected to vertical loads from crane, horizontal lateral loads due to surge of the crane, that is, the effect of acceleration and braking of the loaded crab and swinging of the suspended load in the transverse direction, and longitudinal force due to acceleration and braking of the crane as a whole.

16. What are assumptions are made for arrangement of live load in the analysis of frames?
   a) Consideration is limited to combination of:
      i) Design dead load on all spans with full design live load on two adjacent spans and
      ii) Design dead load on all spans with full design live load on alternate spans.
   b) When design live load does not exceed three-fourths of the design dead load, the load arrangement of design dead load and design live load on all the spans can be used.

17. Explain about Drift Analysis
Drift in building frames is a result of flexural and shear mode contributions, due to the column axial deformations and to the diagonal and girder deformations, respectively. In low-rise braced structures, the shear mode displacements are the most significant and, will largely determine the lateral stiffness of the structure.

In medium to high-rise structures, the higher axial forces and deformations in the columns, and the accumulation of their effects over a greater height, cause the flexural component of displacement to become dominant.

18. Draw a neat sketch of overhead crane with all its components.
19. **Calculate the permissible deflection for a truss of 10 m span.**

(IS800:2007-Pg: 31 – table 6)

Deflection limit = span / 150

= 10 x 1000 / 150

= 66.67 mm

**PART - B**

**12 -MARK QUESTIONS**

1. A roof truss- shed is to be built Jodhpur city area for an industrial use. Determine the basic wind pressure. The use of shed 18 m* 30 m

2. An industrial roof shed of size 20 m* 30 m is proposed to be constructed at Mangalore near a hillock of 160 m and slope is 1 in 2.8. The roof shed is to be built at a height of 120 m from the base of the hill. Determine the design wind pressure on the slope. The height of roof shed shall be 12m

3. A communications tower of 80 m height is proposed to be built hill top height 520 m with a gradient of 1in 5. The horizontal approach distance is 2.8 m km from the level ground. The tower is proposed at Abu mount. Determine the design wind pressure.

4. Design a purlin for a roof truss having the following data:

Span of the truss = 6.0m

Spacing of truss = 3m c/c.
Inclination of roof = 30°
Spacing of Purlin = 2m c/c
Wind pressure = 1.5 kN/m²
Roof coverage = A.C Sheeting weighing 200 N/m²
Provide a channel section Purlin. (Dec 2007).

5. Design a gantry girder to be used in an industrial building carrying an EOT crane for the following data:

- Crane capacity = 200 kN.
- Total self weight of all components = 240 kN.
- Minimum approach at the crane hook of gantry girder = 1.2m
- Wheel base = 3.5m
- C/C distance between gantry rails = 16m
- C/C distance between columns = 8m
- Self weight of rail section = 300 N/m
- Yield stress = 250 N/mm²

Design the main gantry section. Connection design not required. (Dec 2007).

6. Design the angle purlin for the following specifications:

- Span of truss = 9m c/c.
- Pitch = 1/5 of span
- Spacing of purlin = 1.4 c/c.
- Load from roofing material = 200 N/m².
- Wind load = 1200 N/m².

7. Determine the dead load, live load and wind load on a FINK type truss for the following data and mark the loads on the nodes of the truss.

- Span = 12m
- Pitch = ¼ of span
- Height at eves level = 10m from the ground
- Spacing of truss = 5m c/c.
8. A shed is proposed to be constructed at Chennai. The slope of the roof truss is corresponding to a pitch of \( \frac{1}{4} \). The average height of the roof above the ground is 12 m. The life of the structure is expected to be about 50 years. The terrain has less obstruction. The cladding length is in between 30m to 40 m. The permeability of the truss is assumed to be medium. Calculate the various load on the truss. The roof covering is GI sheeting.