ROOF TRUSS


- Clause 8.35 and 8.36 (p.59) and 8.9 (p.69) of IS:800-2007
- All purlins shall be designed in accordance with the requirements for uncased beams and the limitations of bending stress based on lateral instability of the compression flanges and limiting deflection under Section 5.6.1
- The calculated deflections should not exceed those permitted for the type of roof cladding used.
- In calculating the bending moment, advantage may be taken of the continuity of the purlin over supports. The bending moment about two axes should be determined separately and checked according to the biaxial bending requirements.
- All working loads should be multiplied by appropriate partial load factors
- Permissible stresses for wind and earthquake load to be increased by 33% becomes invalid
- Purlin should be designed for biaxial bending
- Bending moment should be calculated by plastic analysis
- Width to thickness ratio of section should be less than limiting value specified in codal provisions
- For calculating flexural strength, shear strength also to be checked
- Permissible values of deflection are modified and depend upon type of cladding
  Limiting deflection- 1/150 for elastic cladding- GI Sheets
  - 1/180 for brittle cladding- AC sheets;

Design of a Roof Truss

The members of the trusses are made up of either rolled steel sections or built-up sections depending upon the span length and intensity of loading. Rolled steel single/double angles, T-sections, hollow circular, square, or rectangular sections are used in roof trusses of the 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. Access to the surface of the members for inspection, cleaning and repainting during service are important considerations while using built-up sections. Hence, in highly corrosive environments, fully closed welded box-sections or hollow sections are used with their ends fully sealed to reduce the maintenance cost and improve the durability of the trusses.

The various steps involved in the design of truss members are as follows:

1. Depending upon the span, required lighting, and available roofing material, the type of truss is selected and a line diagram of the truss is sketched

2. Various loads acting over the truss are calculated using the provisions of IS875 (Parts 1-5)
3. The purlins are designed and the loads acting on the truss at the purlin points are computed. The design of the purlin is a trial and error procedure. The various steps involved in the design of the purlin are summarized as follows:

- The span of the purlin is taken as c/c distance between the trusses
- Calculate the gravity load due to sheeting and live load. Calculate the wind load.
- Obtain components of these loads parallel and perpendicular to the sheeting. For an unsymmetrical section (such as angle, channel) it is not possible to load the purlin through the shear centre. In such a case, the purlin is subjected to lateral-torsional buckling in addition to biaxial bending.
- Try various combinations of loads after multiplying appropriate partial safety factors
- Determine the maximum bending moment and shear force.
  The perpendicular component produces bending about the major axis of bending and the parallel component bends the purlin about the minor axis. Thus, the purlin is subjected to biaxial bending. In the case of angle and channel section, the load does not pass through the shear centre due to which the section is subjected to lateral torsional buckling.
- Check for shear
  Compute the design capacity $M_{dz}$ and $M_{dy}$
- Check the capacity of the purlin to satisfy the interaction equation given by as,
  $$[(M_z/M_{dz}) + (M_y/M_{dy})] \leq 1$$
- Check the deflection
- Check the lateral torsional buckling, if required

4. The roof truss is analysed for the various load combinations using the graphical, the method of sections, the method of joints or by a computer programme and the forces acting on the members for various combinations are tabulated.

5. Each member may experience a maximum compressive or tensile force (called design force) under a particular combination of loads.

- A member who is under tension in one loading combination may be subjected to reversal of stress under some other loading combination. Hence, the members have to be designed for both maximum compression and maximum tension and the critical force has to be adopted
- The principal rafter is designed as a continuous strut and the other compression members are designed as discontinuous struts

6. When the purlins are placed at intermediate points, i.e., between the nodes of the top chord, the top chord will be subjected to bending moment in addition to axial compression. Since the rafter is a continuous member, the bending moments may be calculated by any suitable method i.e. moment distribution, computer programme etc. Then the member is designed for combined bending and axial compression.

7. The members meeting at a joint are so proportioned that their centroidal axes intersect at the same point, in order to avoid eccentricity. Then the joints are of the trusses are designed either as bolted or as welded joints. If the joint is constructed with eccentricity, the members and fasteners must be designed to resist the moment that arises. The moment at the joint is divided between the members in proportion of their stiffness.
8. The maximum deflection of the truss may be computed by using either strain energy method or matrix stiffness analysis programme. The computed deflection should be less than that specified in Table 6 of the code.

9. The detailed drawings and fabrication drawings are prepared and the material-take-off is worked out.

10. The lateral bracings are then designed. When a cross braced wind girder is used, it is necessary to use a computer analysis programme, as the truss will be redundant. However, it is usual to neglect the compression diagonal and assume that the panel’s shear is taken by the tension diagonals. Such idealization is useful to make the wind girder determinate and obtain the forces in various members by using method of section or method of joints.

11. Rafter is the primary compression member; a double angle (equal or unequal) is often preferred. Similarly, the main ties may be subjected to compression during handling or due to wind suction. Moreover, these ties often have a long unsupported length and hence double angle sections are more suitable for these main ties also. All other web members can be designed as single angle members. The width of the members should be kept as minimum as possible, since wide members have greater secondary stresses.

From practice, the following minimum sections are recommended for use in the compound fink trusses:
- Rafters- 2ISA 75 x 50 x 6
- Main ties- 2ISA 75 x 50 x 6
- Centre tie- 2ISA 65 x 45 x 6
- Main sling- 2ISA 65 x 45 x 6
- Main strut- ISA 65 x 45 x 6
- All other members- ISA 50 x 50 x 6

12. The trusses are stiff in their plane, they are weak out-of-plane.
- Hence, in order to make the buckling load in both the horizontal and vertical plane equal, provide the members which are stiffer in the horizontal plane such as rectangular sections, double angles, or H-sections. When such lateral bracings in the form of purlins are not provided, the entire top chord of the truss may buckle laterally.
- This discussion is valid for the bottom chords of the truss also, when it is subjected to compression due to reversal of stresses due to wind suction. Hence, lateral (longitudinal) ties are often provided at regular intervals in the bottom chords also.
- Depending upon the L/r ratio of the top and bottom chord members in the horizontal and vertical planes, it may be advantageous to adopt unequal angles
- The longitudinal ties are under tension in most load situations but may be subjected to compression under wind loading condition depending upon the bracing orientation. There must be at least two longitudinal ties to form a truss action under wind loading condition. The longitudinal ties may also be used to support false ceiling. It is desirable to restrict the slenderness ratio of such ties to 250, to avoid sagging.
- It is desirable to restrict the slenderness ratio of such ties to 250, to avoid sagging.
Legend:
- A-G Location of trusses
- BB-Truss bottom chord in braced bay
- C-Column
- CC-Corner column
- CB, CG-Column in braced bay and in gable end
- DL, DT-Diagonal in bottom chord level in Longitudinal and Transverse direction
- DG-Diagonal bracing in gable end
- ES-Eave strut
- TB-Truss top chord in braced bay
- T-Tie in the bottom chord level
- Bracing
- Cross section at the end bay
- Structural framing for an industrial building
Different types of trusses

Roof Truss Details