7.7 Truss bridges

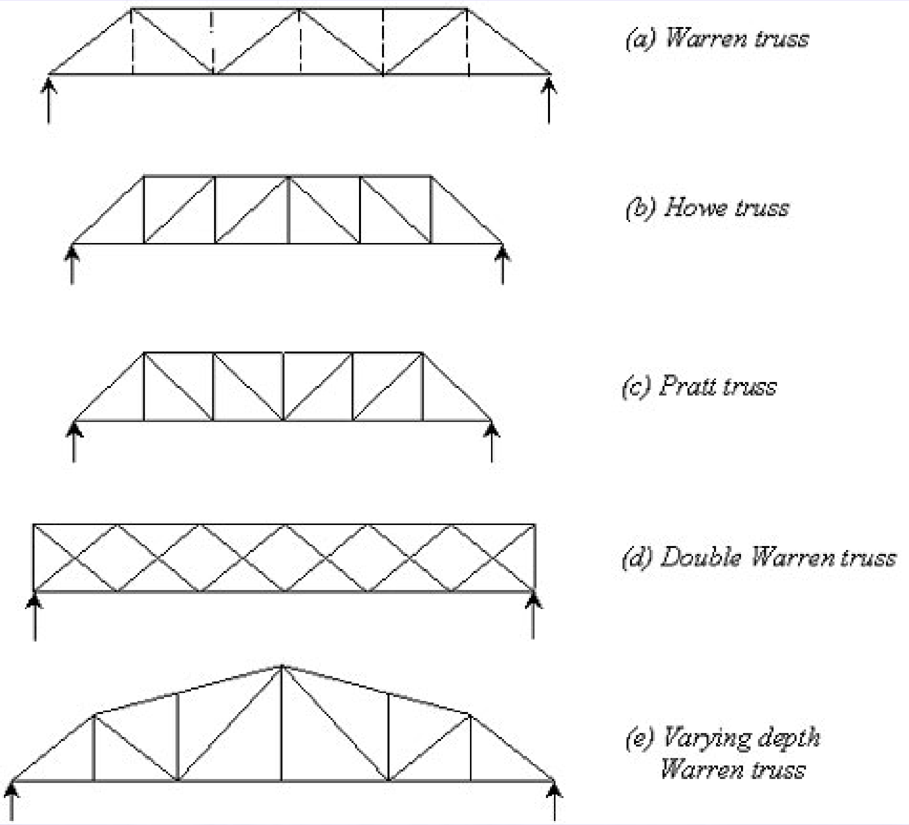


Fig. 7.21 some of the trusses that are used in steel bridges

Truss Girders, lattice girders or open web girders are efficient and economical structural systems, since the members experience essentially axial forces and hence the material is fully utilised. Members of the truss girder bridges can be classified as chord members and web members. Generally, the chord members resist overall bending moment in the form of direct tension and compression and web members carry the shear force in the form of direct tension or compression. Due to their efficiency, truss bridges are built over wide range of spans. Truss bridges compete against plate girders for shorter spans, against box girders for medium spans and cable-stayed bridges for long spans. Some of the most commonly used trusses suitable for both road and rail bridges are illustrated in Fig.7. 21.

For short and medium spans it is economical to use parallel chord trusses such as Warren truss, Pratt truss, Howe truss, etc. to minimise fabrication and erection costs. Especially for shorter spans the warren truss is more economical as it requires less material than either the Pratt or Howe trusses. However, for longer spans, a greater depth is required at the centre and variable depth trusses are adopted for economy. In case of truss bridges that are continuous over many supports, the depth of the truss is usually larger at the supports and smaller at midspan.

As far as configuration of trusses is concerned, an even number of bays should be chosen in Pratt and modified Warren trusses to avoid a central bay with crossed diagonals. The diagonals should be at an angle between 50^o and 60^o to the horizontal. Secondary stresses can be avoided by ensuring that the centroidal axes of all intersecting members meet at a single point, in both vertical and horizontal planes. However, this is not always possible, for example when cross girders are deeper than the bottom chord then bracing members can be attached to only one flange of the chords.

7.7.1 General design principles

7.7.1.1 Optimum depth of truss girder

The optimum value for span to depth ratio depends on the magnitude of the live load that has to be carried. The span to depth ratio of a truss girder bridge producing the greatest economy of material is that which makes the weight of chord members nearly equal to the weight of web members of truss. It will be in the region of 10, being greater for road traffic than for rail traffic. IS:

1915-1961, also prescribes same value for highway and railway bridges. As per bridge rules published by Railway board, the depth should not be greater than three times width between centres of main girders. The spacing between main truss depends upon the railway or road way clearances required.

7.7.1.2 Design of compression chord members

Generally, the effective length for the buckling of compression chord member in the plane of truss is not same as that for buckling out-of-plane of the truss i.e. the member is weak in one plane compared to the other. The ideal compression chord will be one that has a section with radii of gyration such that the slenderness value is same in both planes. In other words, the member is just likely to buckle in plane or out of plane. These members should be kept as short as possible and consideration is given to additional bracing, if economical.

The effective length factors for truss members in compression may be determined by stability analysis. In the absence of detailed analysis one can follow the recommendations given in respective codes. The depth of the member needs to be chosen so that the plate dimensions are reasonable. If they are too thick, the radius of gyration will be smaller than it would be if the same area of steel is used to form a larger member using thinner plates. The plates should be as thin as possible without losing too much area when the effective section is derived and without becoming vulnerable to local buckling.

Common cross sections used for chord members are shown in Fig. 7.22. Trusses with spans up to 100 m often have open section compression chords. In such cases it is desirable to arrange for the vertical posts and struts to enter inside the top chord member, thereby providing a natural diaphragm and also achieving direct connection between member thus minimising or avoiding the need for gussets. However, packing may be needed in this case. For trusses with spans greater than about 100 m, the chords will be usually the box shaped such that the ideal disposition of material to be made from both economic and maintenance view points. For shorter spans, rolled sections or rolled hollow sections may be used. For detailed design of compression chord members the reader is referred to the chapter on Design of axially compressed columns.

7.7.1.3 Design of tension chord members

Tension members should be as compact as possible, but depths have to be large enough to provide adequate space for bolts at the gusset positions and easily attach cross beam. The width out-of-plane of the truss should be the same as that of the verticals and diagonals so that simple lapping gussets can be provided without the need for packing. It should be possible to achieve a net section about 85% of the gross section by careful arrangement of the bolts in the splices. This means that fracture at the net section will not govern for common steel grades.

In this case also, box sections are preferable for ease of maintenance but open sections may well prove cheaper. For detailed design reader is referred to the chapter on Design of Tension members.

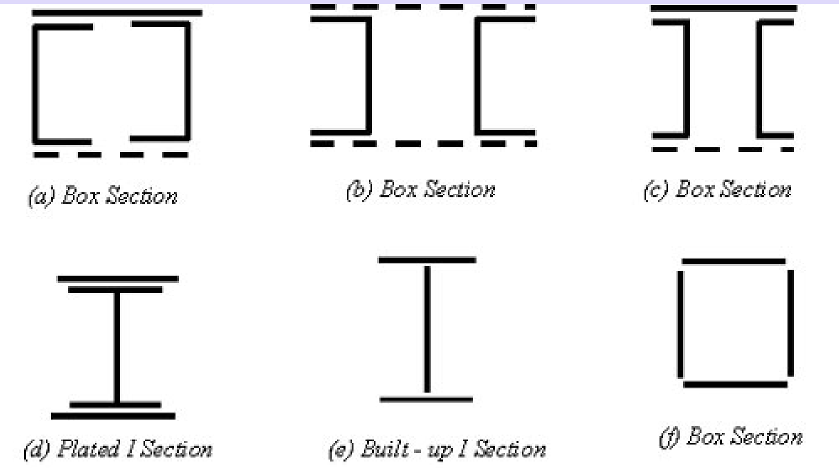


Fig. 7.22 Typical cross-section for truss members

7.7.1.4 Design of vertical and diagonal members

Diagonal and vertical members are often rolled sections, particularly for the lightly loaded members, but packing may be required for making up the rolling margins. This fact can make welded members more economical, particularly on the longer trusses where the packing operation might add significantly to the erection cost.

Aesthetically, it is desirable to keep all diagonals at the same angle, even if the chords are not parallel. This arrangement prevents the truss looking over-complex when viewed from an angle. In practice, however, this is usually overruled by the economies of the deck structure where a constant panel length is to be preferred. Typical cross sections used for members of the truss bridges are shown in Fig. 7.22.

7.7.2 Lateral bracing for truss bridges

Lateral bracing in truss bridges is provided for transmitting the longitudinal live loads and lateral loads to the bearings and also to prevent the compression chords from buckling. This is done by providing stringer bracing, braking girders and chord lateral bracing. In case of highway truss bridges, concrete deck, if provided, also acts as lateral bracing support system.

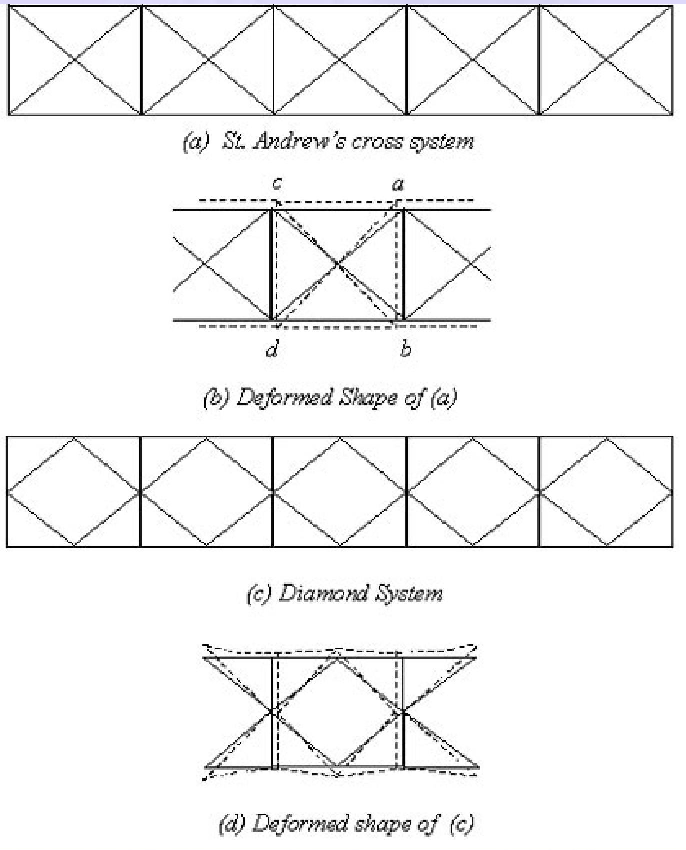


Fig.7.23 Lateral bracing systems

The nodes of the lateral system coincide with the nodes of the main trusses. Due to interaction between them the lateral system may cause as much as 6% of the total axial load in the chords. This should be taken into account.

Fig. 7.23 shows the two lateral systems in its original form and its distorted form after axial compressive loads are applied in the chords due to gravity loads. The rectangular panels deform as indicated by the dotted lines, causing compressive stresses in the diagonals and tensile stresses in the transverse members. The transverse bracing members are indispensable for the good performance of St. Andrew's cross bracing system.

In diamond type of lateral bracing system the nodes of the lateral system occur midway between the nodes of the main trusses [Fig.7. 23(c)]. They also significantly reduce the interaction with main trusses. With this arrangement, "scissors-action" occurs when the chords are stressed, and the chords deflect slightly laterally at the nodes of the lateral system. Hence, diamond system is more efficient than the St. Andrew's cross bracing system.

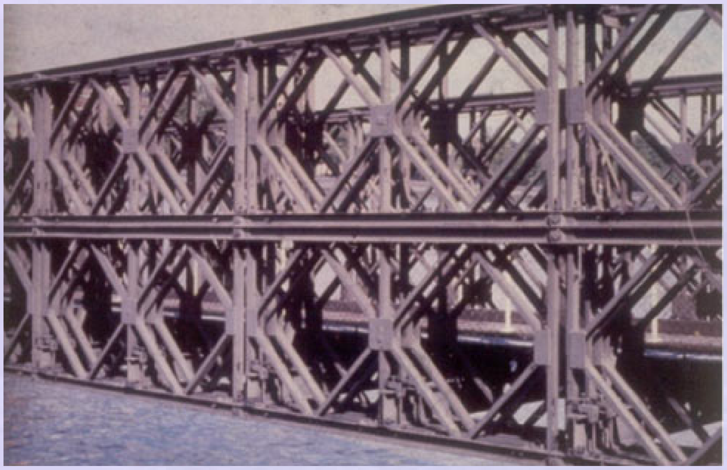
It is assumed that wind loading on diagonals and verticals of the trusses is equally shared between top and bottom lateral bracing systems. The end portals (either diagonals or verticals) will carry the load applied to the top chord down to the bottom chord. In cases, where only one lateral system exists (as in Semi-through trusses), then the single bracing system must carry the entire wind load.

Truss bridges

Suspended central span

Continuous span

Sloping chord



Bailey Bridge