4.3 Design of tension members

In the design of a tension member, the design tensile force is given and the type of member and the size of the member have to be arrived at. The type of member is usually dictated by the location where the member is used. In the case of roof trusses, for example, angles or pipes are commonly used. Depending upon the span of the truss, the location of the member in the truss and the force in the member either single angle or double angles may be used in roof trusses. Single angle is common in the web members and the double angles are common in rafter and tie members of a roof truss.

Plate tension members are used to suspend pipes and building floors. Rods are also used as suspenders and as sag rods of roof purlins. Steel wires are used as suspender cables in bridges and buildings. Pipes are used in roof trusses on aesthetic considerations, in spite of fabrication difficulty and the higher cost of such tubular trusses. Built-up members made of angles, channels and plates are used as heavy tension members, encountered in bridge trusses.

4.3.1 Trial and error design process

The design process is iterative, involving choice of a trial section and analysis of its capacity. This process is discussed in this section. Initially, the net effective area required is calculated from the design tension and the ultimate strength of the material as given below.

$$A_n = F_t / \left(f_u / \gamma_{m1}\right) \qquad \textbf{\textit{(4.12)}}$$

Using the net area required, the gross area required is calculated, allowing for some assumed number and size of bolt holes in plates, or assumed efficiency index in the case of angles and threader rods. The gross area required is also checked against that required from the yield strength of the gross sections as given below.

$$A_g = T_d / \left(f_y / \gamma_{m0} \right) \qquad \textbf{\textit{(4.13)}}$$

A suitable trial section is chosen from the steel section handbook to meet the gross area required. The bolt holes are laid out appropriately in the member and the member is analyses to obtain the actual design strength of the trial section. The design strength of the trial section is evaluated using Eqs.4.1 to 4.5 in the case of plates and threaded bars and using Eqs.4.6 in the case of angle ties. If the actual design strength is smaller than or too large compared to the design force, a new trial section is chosen and the analysis is repeated until a satisfactory design is obtained.

4.3.2 Stiffness requirement

The tension members, in addition to meeting the design strength requirement, frequently have to be checked for adequate stiffness. This is done to ensure that the member does not sag too much during service due to self-weight or the eccentricity of end plate connections. The IS: 800 imposes the following limitations on the slenderness ratio of members subjected to tension:

(a) In the case of members that are normally under tension but may experience compression due to stress reversal caused by wind / earthquake loading $l/r \le 250$.

(b) In the case of members that are designed for tension but may experience stress reversal for which it is not designed (as in X bracings). $l/r \le 350$

(c) In the case of members subjected to tension only. $l/r \le 400$

In the case of rods used as a tension member in X bracings, the slenderness ratio limitation need not be checked for if they are pre-tensioned by using a turnbuckle or other such arrangement.