3.5 Analysis of weld group

3.5.1 Eccentric welded connections

In some cases, eccentric loads may be applied to fillet welds causing either shear and torsion or shear and bending in the welds. Examples of such loading are shown in Fig. These two common cases are treated in this section.

Shear and torsion:

Considering the welded bracket shown in Fig. 3.31 (a), an assumption is made to the effect that the parts being joined are completely rigid and hence all the deformations occur in the weld. As seen from the figure, the weld is subjected to a combination of shear and torsion. The force caused by torsion is determined using the formula

$$F = T.s/J = (\text{Moment / Polar moment of inertia}) \qquad \textbf{(3.27)}$$

Where, T is the tension, s is the distance from the centre of gravity of the weld to the point under consideration, and *J* is the polar moment of inertia of the weld. For convenience, the force can be decomposed into its vertical and horizontal components:

$$F_h = Tv/J \quad \text{and } f_v = Th/J \qquad \textbf{(3.28)}$$

Where, v and h denote the vertical and horizontal components of the distance *s*. The stress due to shear force is calculated by the following expression

$$\tau = R/L \qquad \textbf{(3.29)}$$

Where, τ is the shearing stress and *R* is the reaction and *L* is the total length of the weld. While designing a weld subjected to combined shear and torsion, it is a usual practice to assume a unit size weld and compute the stresses on a weld of unit length. From the maximum weld force per unit length the required size of the fillet weld can be calculated.

Shear and bending:

Welds, which are subjected to combined shear and bending, are shown in Fig. 3.31 (*b*). It is a common practice to treat the variation of shear stress as uniform if the welds are short. But, if the bending stress is calculated by the flexure formula, the shear stress variation for vertical welds will be parabolic with a maximum value equal to 1.5 times the average value. These bending and shear stress variations are shown in Fig. 3.32.

It may be observed here that the locations of maximum bending and shearing stresses are not the same. Hence, for design purposes the stresses need not be combined at a point. It is generally satisfactory if the weld is designed to withstand the maximum bending stress and the maximum shear stress separately. If the welds used are as shown in Fig. 3.33 it can be safely assumed that the web welds would carry all the of the shear and the flange welds all of the moment.

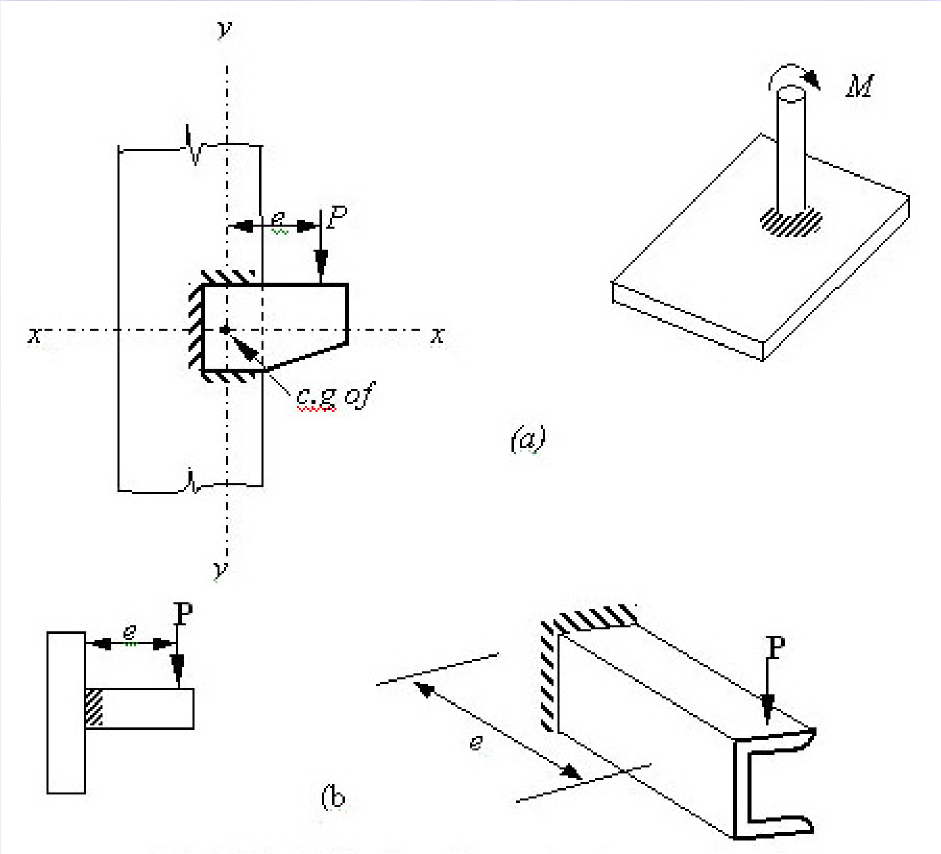

Fig. 3.31 (a) Welds subjected to shear and torsion,
(b) Welds subjected to shear and bending

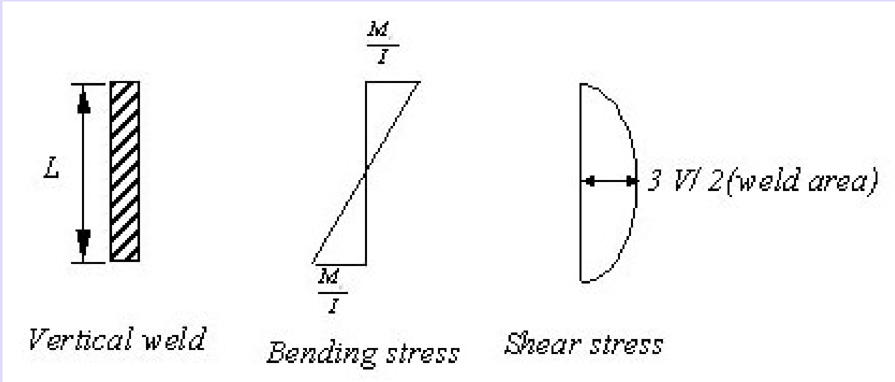

Fig. 3.32 Variation of bending and shear stress

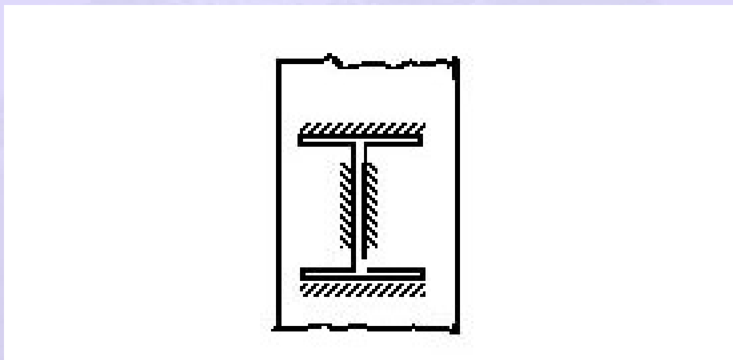

Fig.3.33 Weld provision for carrying shear and moment

When fillet welds are subjected to a combination of normal and shear stress, the equivalent stress f_e shall satisfy the following

$$f_e = \sqrt{f_a^2 + 3q^2} \leq \frac{f_u}{\sqrt{3}\gamma_{mw}} \qquad \textbf{(3.30)}$$

Where, f_a is the normal stresses, compression or tension, due to axial force or bending moment and q is the shear stress due to shear force or tension.

However, check for the combination of stresses need not be done:

i) for side fillet welds joining cover plates and flange plates, and

ii) for fillet welds where sum of normal and shear stresses does not exceed *fwd.*

Similarly, the check for the combination of stresses in butt welds need not be done if:

i) butt welds are axially loaded, and

ii) in single and double bevel welds the sum of normal and shear stresses does not exceed the design normal stress, and the shear stress does not exceed 50 percent of the design shear stress.

Combined bearing, bending and shear:

Where bearing stress, f_{br} is combined with bending (tensile or compressive) and shear stresses under the most unfavorable conditions of loading, the equivalent stress, f_e, shall be obtained from the following formula

$$f_e = \sqrt{f_b^2 + f_{br}^2 + f_b \, f_{br} + 3q^2} \qquad \textbf{(3.31)}$$

Where, f_e is the equivalent stress; f_b = calculated stress due to bending in N/mm^2; f_{br} is the calculated stress due to bearing in N/mm^2 and q = shear stress in N/mm^2. However, the equivalent stress so calculated shall not exceed the values allowed for the parent metal.