1. INTRODUCTION

1.1 Scope

Although concentrically loaded connections are simpler to design and generally more efficient, there are many cases where eccentrically loaded connections are not easily avoided. This Module presents design aids for determining the resistance of eccentrically loaded fillet weld groups in welded joints. The capacity of connected parts and other modes of behaviour are beyond the scope of this publication.

While Design Module No. 2 (DM2) includes connection configurations encountered in common applications, the CISC does not discourage the use of other connection types and configurations that are proven adequate for their intended purposes.

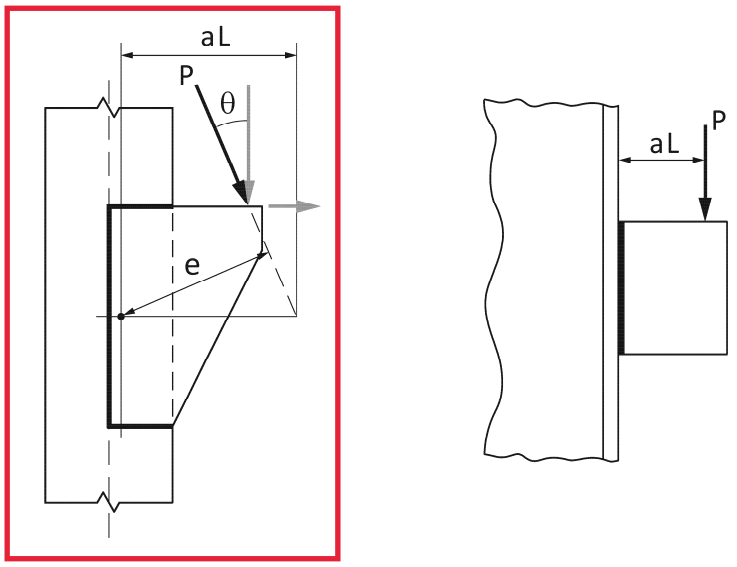
1.2 Types of Eccentrically Loaded Weld Groups

Point loads may be applied eccentrically in the plane of the weld group or out-of-plane. For weld groups loaded in-plane, the load eccentricity is represented by the distance, *e*, with respect to the group centroid, as shown on the left-hand side of the figure below. The relation between the eccentricity, *e*, the horizontal distance, *a L*, where *L* is the length of the vertical fillet weld(s), and the load angle, θ, is described in Section 2.

If the load is applied out-of-plane, as shown on the right-hand side, the load eccentricity is the perpendicular distance between the plane of the weld group and the line of action of applied force. For this type of connection, only vertical loads are considered, as described in Section 4.

1.3 Weld Electrodes and Plate Material

The design aids are based on a matching electrode, X_u = 490 MPa. For connections loaded out-of-plane, the mechanical properties of the plate are F_y = 300 MPa and F_u = 440 MPa. Hence, the design aids may be conservatively applied to several other steel grades, such as CSA G40.21-350W and ASTM A992/A992M, A572/A572M [345].



In-Plane Loading Out-of-Plane Loading

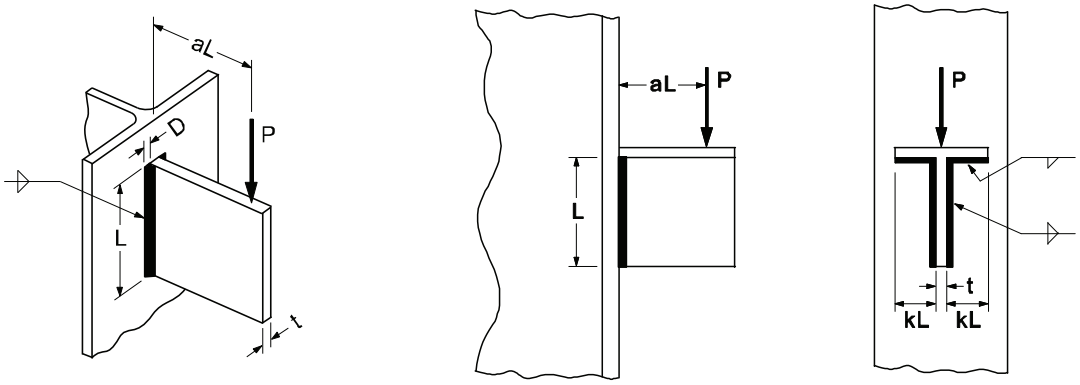
Eccentrically Loaded Weld Groups

4. WELD GROUPS LOADED OUT-OF-PLANE

4.1 Description

Two configurations involving a vertical load applied out-of-plane with respect to the fillet weld group are shown in the figure below. The left-hand side of the figure shows a plate welded to the flange of a column with a pair of vertical fillet welds. The eccentricity of the load, *P*, with respect to the weld group is denoted by *aL*, where *L* is the weld length. As shown on the right-hand side, a stiffened seat is welded to the column using a tee-shaped weld configuration. The length of the horizontal welds is denoted by *kL*.

In both types of connections, the lower portions of the welded parts are assumed to bear against each other at the ultimate load. The closed-form solution given below for the welded connection consisting of two vertical welds was developed by Kwan *et al.* (2010).



Pair of vertical welds Tee-shaped configuration

Welded Connections Loaded Out-of-Plane

4.2 Pair of Vertical Welds

(a) For $a/Q > 0.53$, the factored load resistance (based on weld failure) is given by:

$$P_r = \frac{0.711\phi F_y t L}{a(Q + 1.421)} \qquad \text{Eq. 7}$$

where a = eccentricity ratio and,

$$Q = \frac{F_y t}{X_u D} \qquad \text{Eq. 8}$$

(b) For $a/Q \le 0.53$, the factored load resistance (based on weld failure) is given by:

$$P_r = P_{ro}[1 - 1.89(a/Q)] + 1.89(a/Q)P_{r53} \qquad \text{Eq. 9}$$

where

$$P_{ro} = 2(0.67)\phi 0.7071 X_u D L \qquad \text{Eq. 10}$$

and P_{r53} is obtained using equation Eq. 7 for an eccentricity, a, that yields a value of a/Q of 0.53 for the applicable value of Q.