Beam-to-Girder Continuous Connections

1. INTRODUCTION

Beams may be made continuous through their girder supports by any of the methods illustrated in Figure 1.

In Figure 1 (a), the beam flange and part of the web below are cut back so that this flange can be butt welded directly to the edge of the girder flange, with top surfaces of both members on the same level.

In (b), (c) and (d), the beam web is cut back just below the top flange so that this top flange rests on the top flange of the girder. This allows a very easy method of erection.

Additional plates are used in (c) along the top after the top beam flanges have been welded to the girder. This gives the necessary increased area for the negative moment over the support, and reduces the beam size for the remainder of the span.

Sometimes a small seat is placed below the beam; as in (e) and (f). This facilitates erection and also serves as a backing strip for the groove weld on the lower beam flange.

Top connecting plates are used in (e) and (f). These also serve as cover plates to increase the stiffness (I) or strength (S) properties at ends of the beam.

If beams are offset, Figure 2, the top connecting plate can be adjusted to tie both together with the girder.

At exterior columns, Figure 3, the top connecting plate is cut in the shape of a Tee so as to tie in spandrel beams, girder and column.

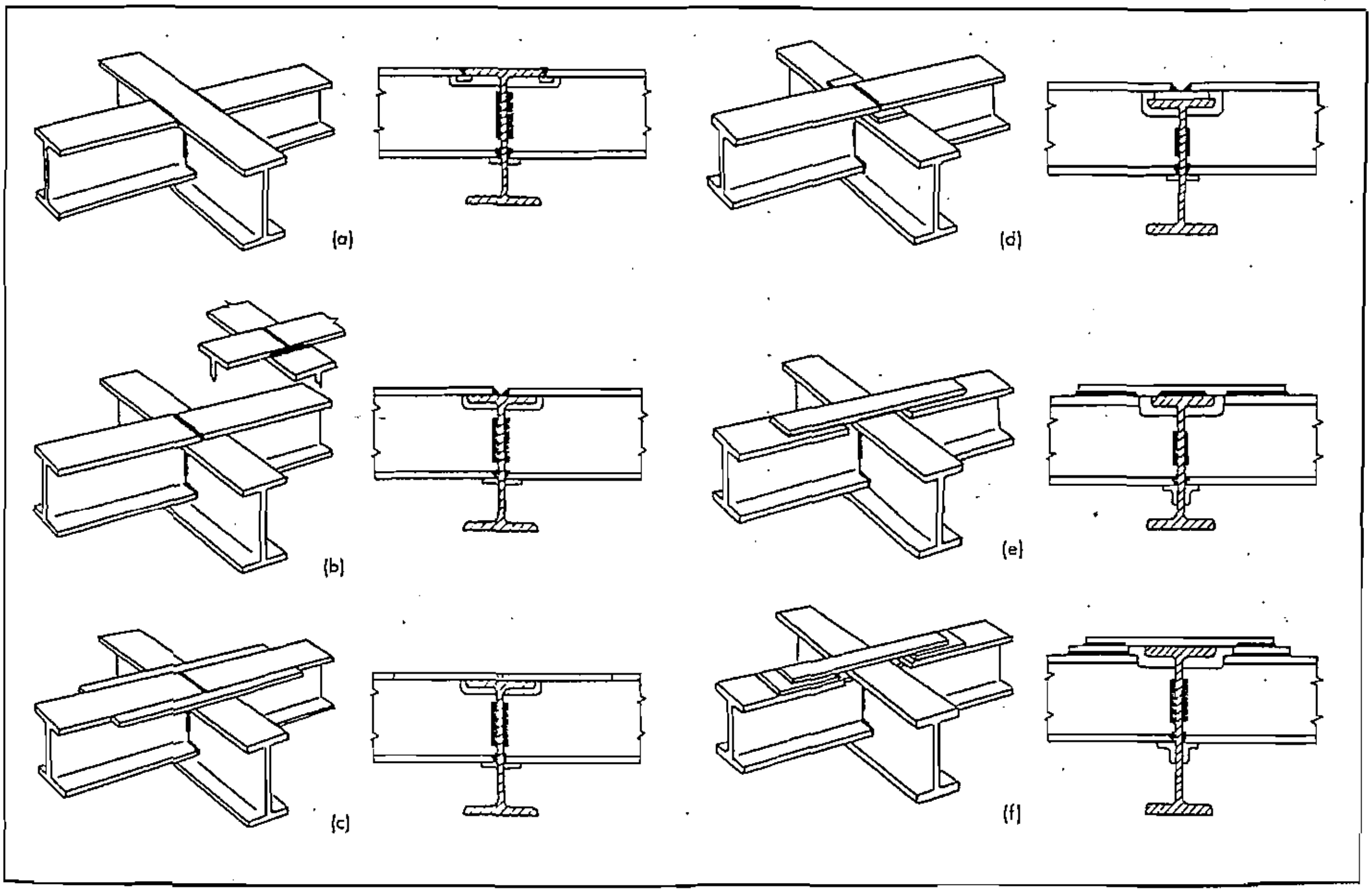


FIGURE 1

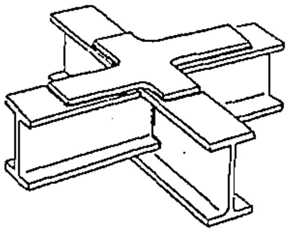


FIGURE 2

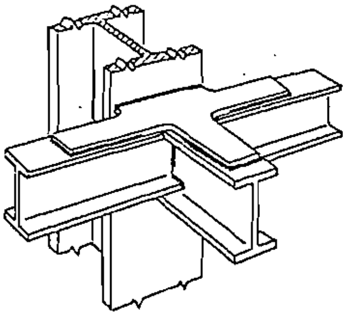


FIGURE 3

2. BUTT WELDING OF INTERSECTING FLANGES VS ISOLATING THEM

Should the intersecting flanges of beams and girders be isolated or may they be welded directly together?

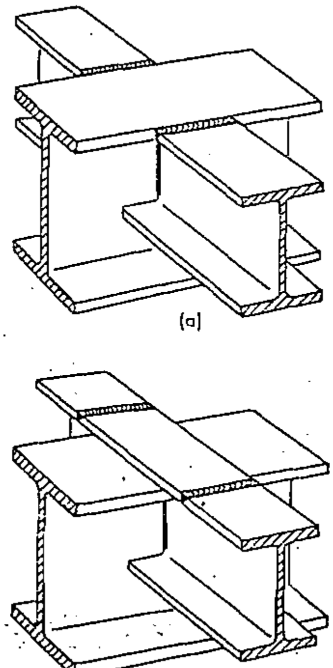


FIGURE 4

Consider the bay, Figure 5, with a dead — live load of 200 lbs/ft². On this basis each beam would have a 20-kip load uniformly distributed; each main girder would have three concentrated forces of 20 kips applied at quarter points.

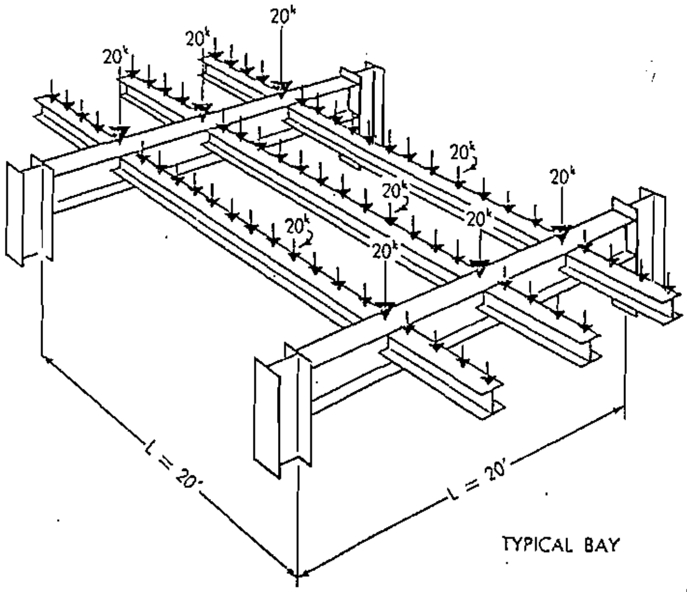


FIGURE 5

(1) For example, assume the girder to be simply supported, and the beams welded for continuity to the girders.

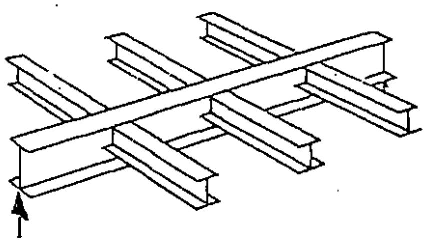
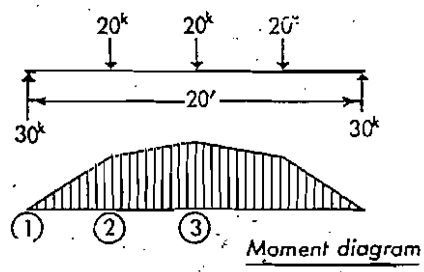


FIGURE 6

Design the girder as simply supported. Use 14" WF 68# beam having $S = 103.0$ in.³



$$M_3 = \frac{W_1 \, L}{6}$$

$$= \frac{(60^k)(240'')}{6}$$

$$= 2400 \text{ in.-kips}$$

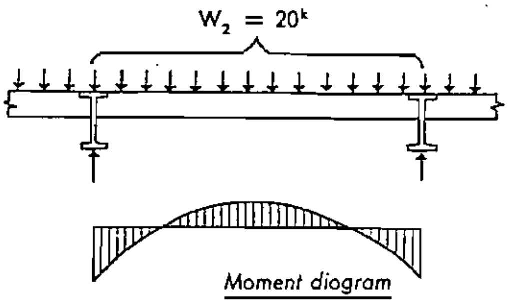
$$\sigma_3 = \frac{M}{S}$$

$$= \frac{(2400 \text{ in.-kips})}{(103.0 \text{ in.}^3)}$$

$$= 23{,}300 \text{ psi compression}$$

Since the girder in itself provides very little end restraint for the intersecting beams which it supports, the beams will be designed as simply supported even though their flanges are welded to the girder. Use a 10″ WF 25# beam having $S = 26.4$ in.³

However, if two beams framing on opposite sides of a girder are loaded, their ends will be restrained and their end moments must be considered.



$$M_e = \frac{W_2 \; L}{12}$$

$$= \frac{(20^k)(240'')}{12}$$

$$= -\;400 \text{ in.-kips}$$

The resulting flange forces and stresses can be diagrammed as in Figure 7.

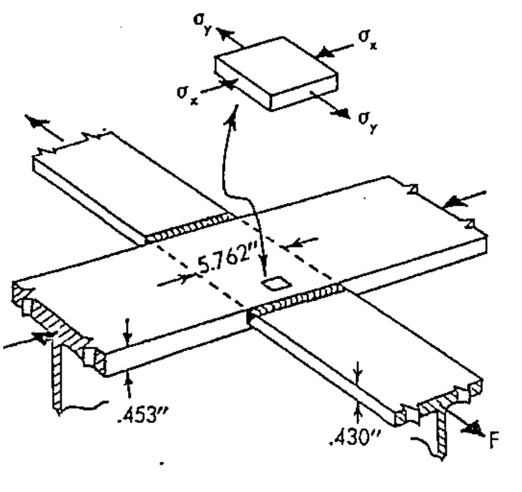


FIGURE 7

Here:

$$F = \frac{M}{d}$$

$$= \frac{(400 \text{ in.-kips})}{(10.08'' - .43'')}$$

$$= 41.5 \text{ kips}$$

$$\sigma_y = \frac{(41.5^k)}{(5.762'')(.453'')}$$

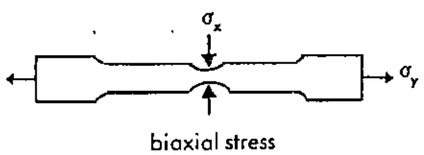
$$= 15{,}900 \text{ psi}$$

These two biaxial stresses, $\sigma_x = -\;23{,}300$ psi and $\sigma_y = +\;15{,}900$ psi, will affect the yield properties of the girder's top flange within the region where the beam flange is attached.

A plate subjected to uniaxial tensile stress, or stress in one direction only, will have a certain critical stress (σ_{cr}) above which the plate will yield plastically.

In this case, this stress point is referred to as the yield strength.

However, if in addition, there is a compressive stress applied at right angles, this will allow the plate to yield easier and at a lower load.



A convenient method to check the effect of the applied stresses upon the yielding of the plate is the Huber-Mises formula. If for a certain combination of normal stress (σ_x) and (σ_y) and shear stress (τ_{xy}), the resulting value of critical stress (σ_{cr}) is equal to the yield strength of the steel when tested in uniaxial tension, this combination of stresses is assumed to just produce yielding in the steel.

$$\sigma_{cr} = \sqrt{\sigma_x^2 - \sigma_x \; \sigma_y + \sigma_y^2 + 3 \; \tau_{xy}}$$

$$= \sqrt{23{,}300^2 - (-23{,}300)(15{,}900) + 15{,}900^2 + 0}$$

$$= 36{,}600 \text{ psi}$$

This would indicate the top flange of the girder is on the verge of yielding, and the tensile flange of the beam should be isolated from the biaxial compressive

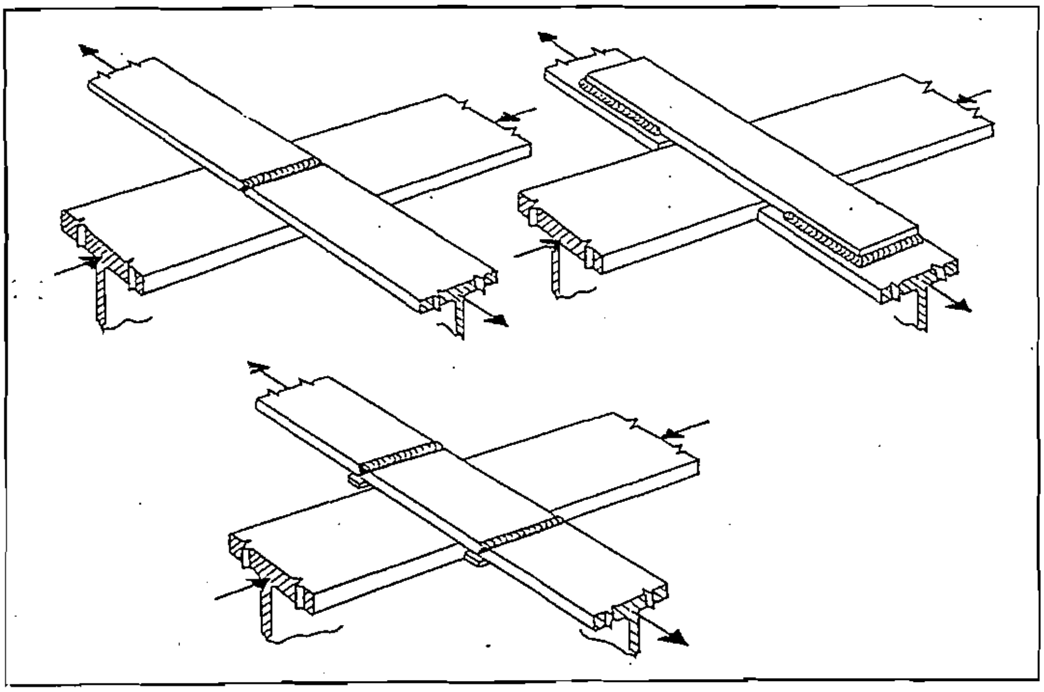


FIGURE 8

stress. This may be done by one of several methods, Figure 8.

(2) Now assume the girder to be fixed at the ends and the beams welded for continuity to the girders.

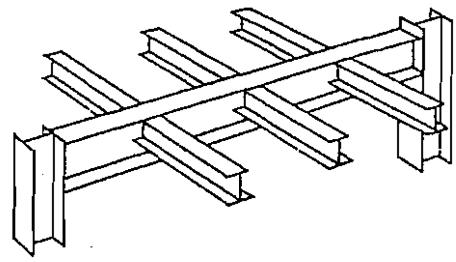
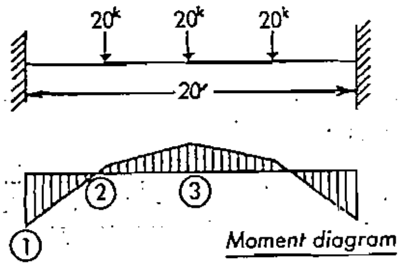


FIGURE 9

Design the girder as having fixed ends. Use 14″ WF 43# beam having S = 62.7 in.³



$$M_1 = -\frac{5\ W_1\ L}{48} = -\frac{5(60^k)(240'')}{48}$$

$$= -1500 \text{ in.-kips}$$

$$\sigma_1 = \frac{.90\ M}{S}$$

$$= \frac{.90\ (1500 \text{ in.-kips})}{(62.7 \text{ in.}^3)}$$

$$= 21{,}500 \text{ psi}$$

(Only need S = 56.2 in.³, but this is the lightest 14″ WF section.)

$$M_2 = +\frac{M_1\ L}{48}$$

$$= +\frac{(60^k)(240'')}{48}$$

$$= +300 \text{ in.-kips}$$

$$\sigma_2 = \frac{M_2}{S}$$

$$= \frac{(300 \text{ in.-kips})}{(62.7 \text{ in.}^3)}$$

$$= 4780 \text{ psi}$$

$$M_3 = +\frac{W\ L}{16}$$

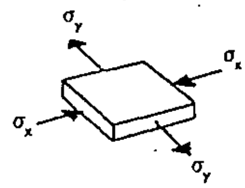
$$= +\frac{(60^k)(240'')}{16}$$

$$= +900 \text{ in.-kips}$$

$$\sigma_3 = \frac{M_3}{S}$$

$$= \frac{(900 \text{ in.-kips})}{(62.7 \text{ in.}^3)}$$

$$= 14{,}350 \text{ psi}$$



$$\sigma_x = -\ 14{,}350 \text{ psi}$$
$$\sigma_y = +\ 15{,}900 \text{ psi}$$
$$\sigma_{cr} = \sqrt{\sigma_x^2 - \sigma_x\,\sigma_y + \sigma_y^2 + 3\ \tau_{xy}}$$
$$= \sqrt{(-14{,}350)^2 - (-14{,}350)(15{,}900) + 15{,}900^2}$$
$$= 21{,}600 \text{ psi}$$

The apparent factor of yielding is—

$$r = \frac{\sigma_y}{\sigma_{cr}} = \frac{36{,}000}{21{,}600} = 1.67$$

This seems reasonable, and under these conditions the beam flange could be butt welded directly to the edge of the girder flange without trying to isolate the two intersecting flanges.

3. WELDING OF TAPERED FLANGES

Figure 10 shows the method for butt welding wide-flange rolled beams which have a slightly tapered flange to the edge of a girder flange.

By using a light ⅛″ x 1″ backing bar, it may be hammered as it is tack welded so that it will be tight against the joint.

Figure 11 shows the method for butt welding wide-flange rolled beams with a slightly tapered flange to a flat plate.

By using a light ⅛″ x 1″ backing bar, it may be hammered as it is tack welded so that it will be tight against the joint.

If there is any criticism in doing this, the following should be remembered. This type of butt welded joint on the wide-flange beams with a slightly tapered flange presents a smoother transition in section and transfer of beam flange force, than the widely used type of (beam-to-column) top connecting plate shown in Figure 12 which is accepted.

In this case (Fig. 12) the flange force must work

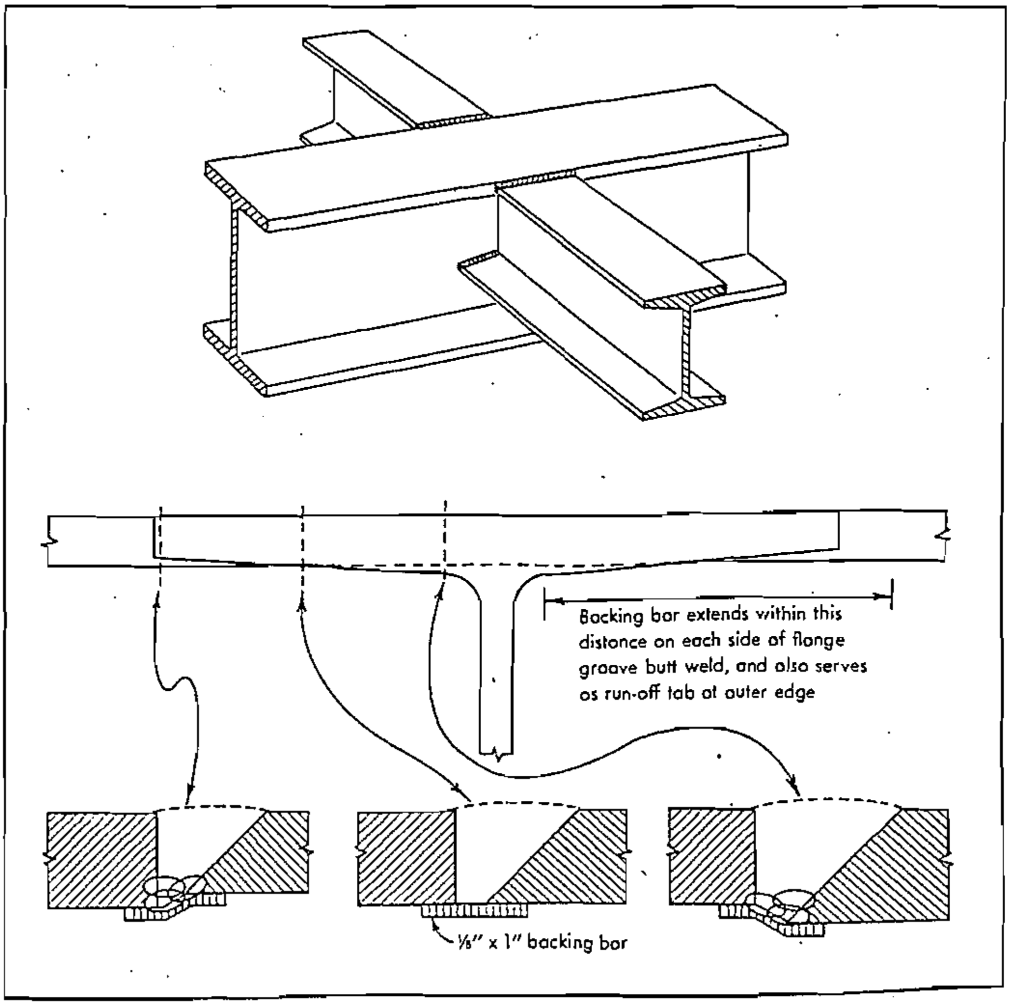


FIGURE 10

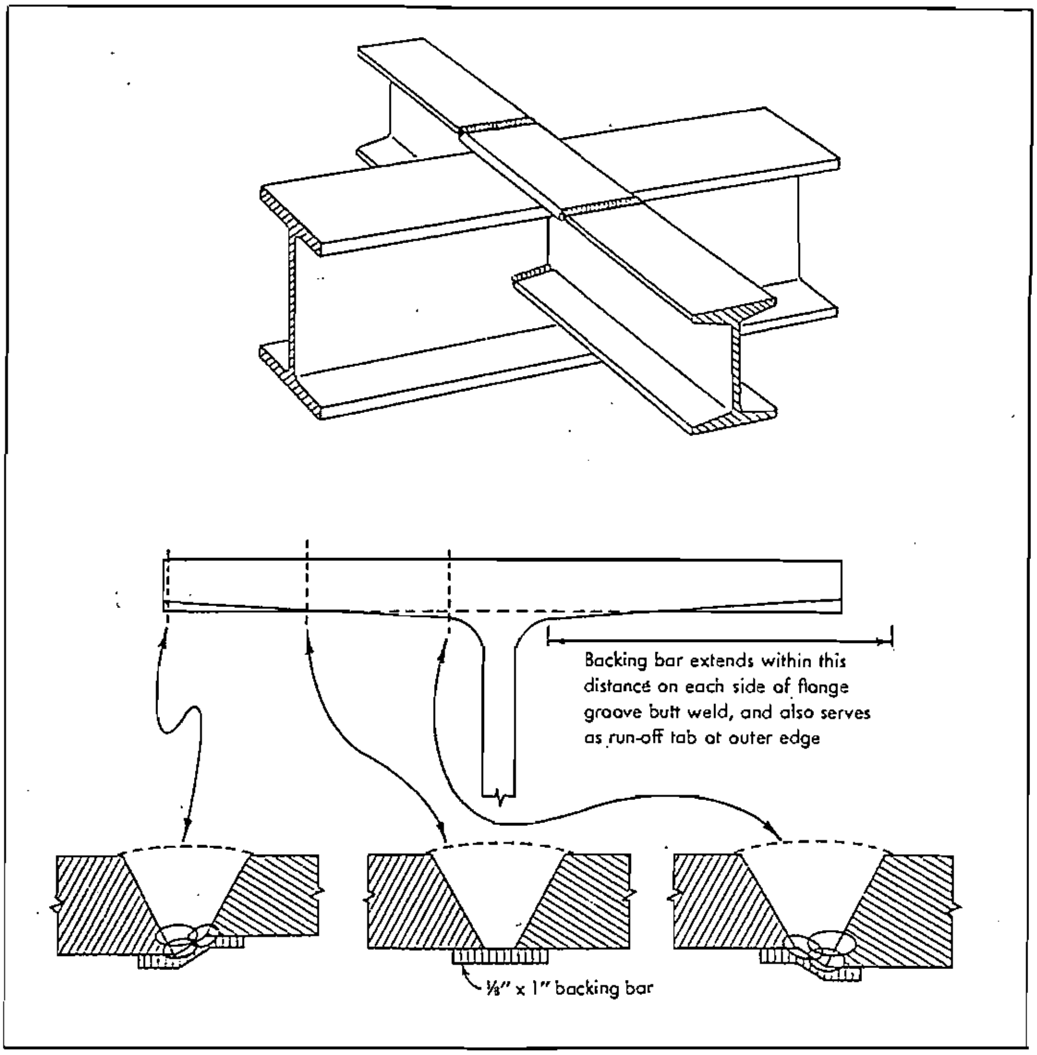


FIGURE 11

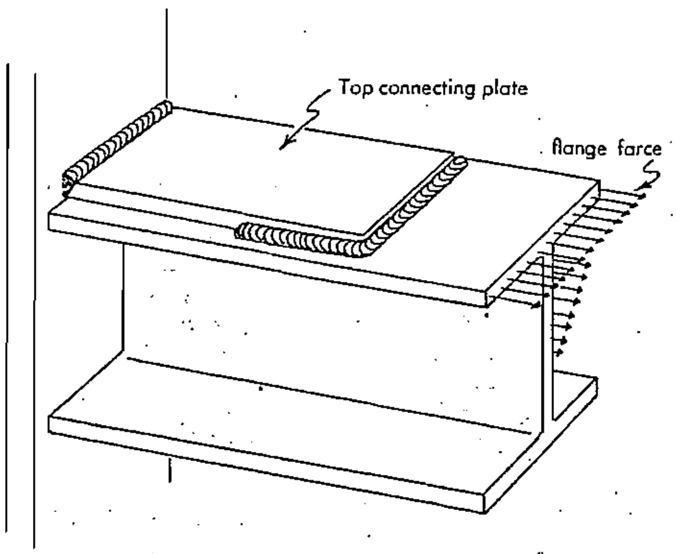


FIGURE 12

itself up through the connecting fillet welds into the top plate, and then out through the groove butt weld into the supporting member. Although there is a transverse fillet weld across the end of the top plate, much of the flange force must spread out along the edge in order to enter the fillet welds along the side of the plate. These connections stood up very well under testing and showed they could develop the full plastic moment of the beam.

4. EXAMPLES OF CONTINUOUS CONNECTIONS

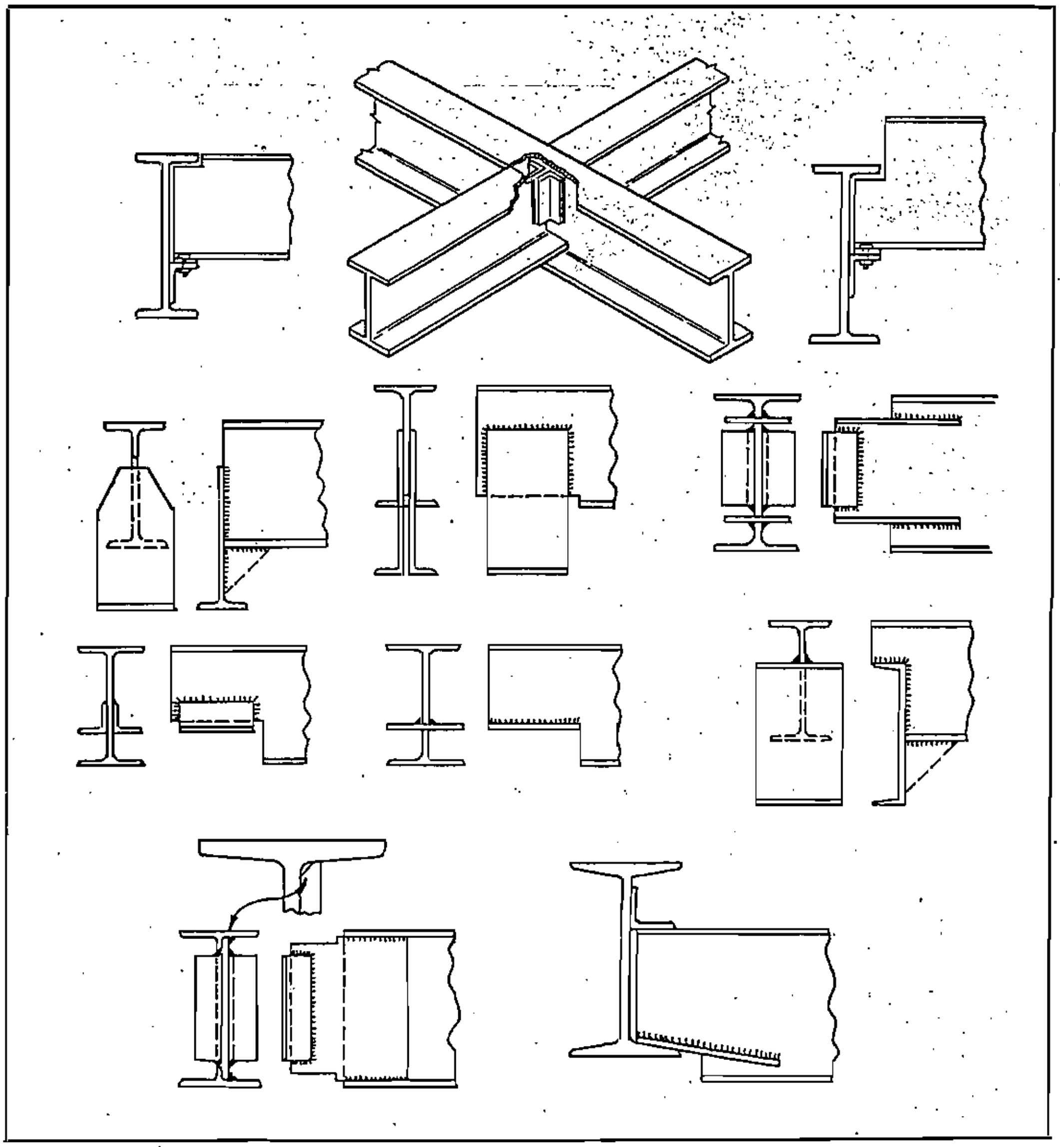
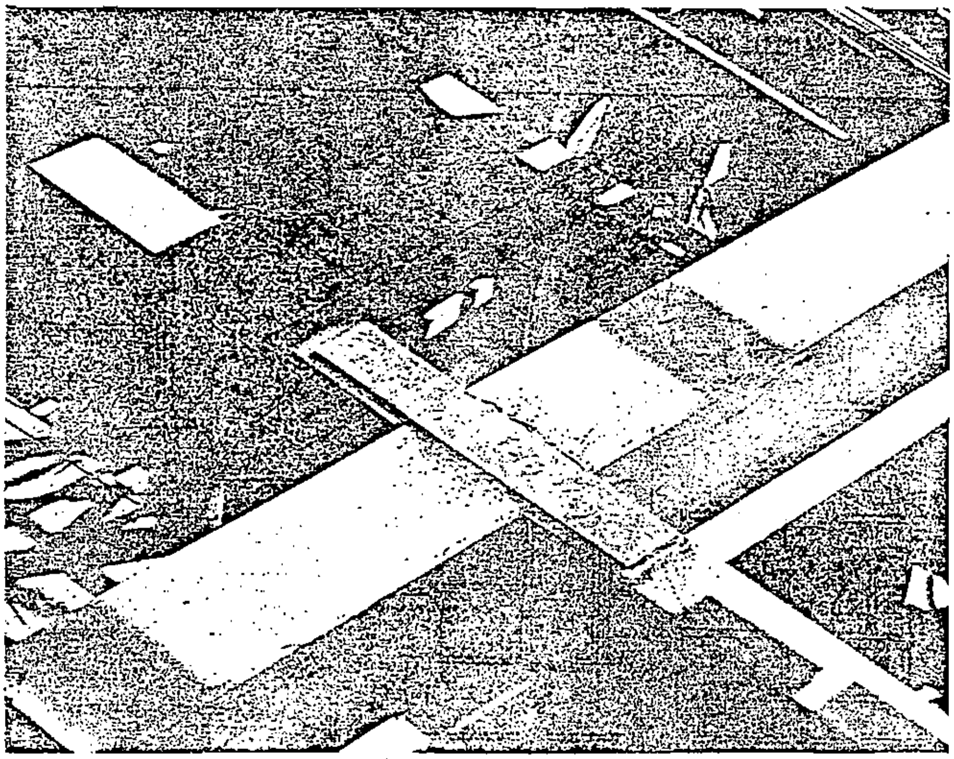
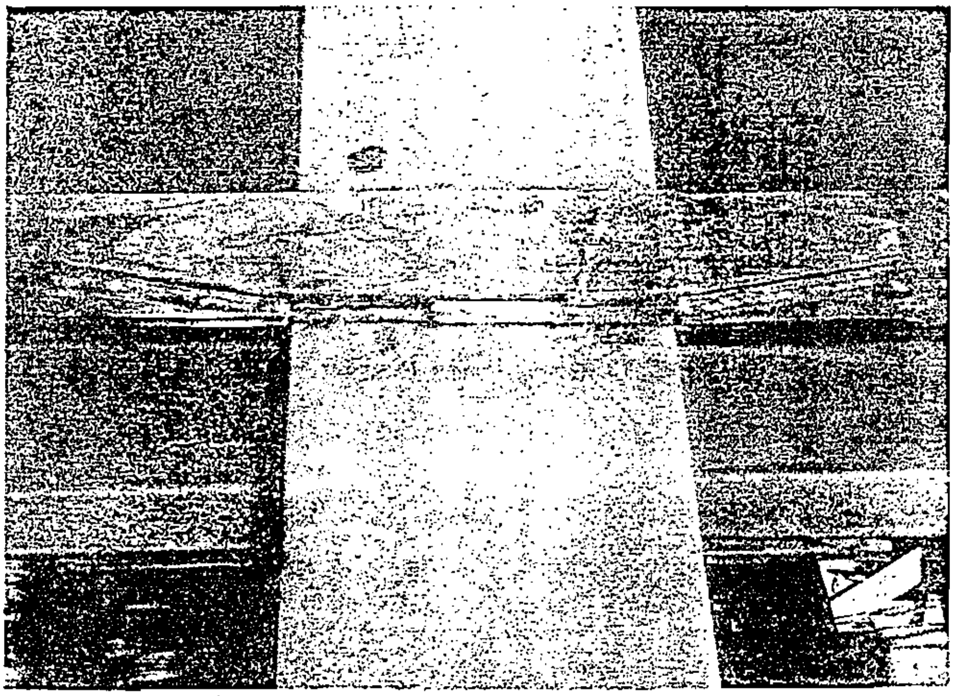


FIG. 13 Beams framing to girder web.



Welded connections are used throughout the Ainsley Building in Miami. Here, the beams are given continuity by connecting top flanges, using strap plates reaching across the girder. Lower flanges are butt welded to the web on both sides.



Continuous welded connections were used extensively in building the 7-story Harvey's Department Store in Nashville, Tenn. Here cross beams are given continuity through the main floor girders by means of a 1" thick cover plate and a bottom support plate, wider than the beam flange. This type of connection eliminates any need for beveling plates and laying groove welds.