Fabrication of Plate Girders And Cover-Plated Beams

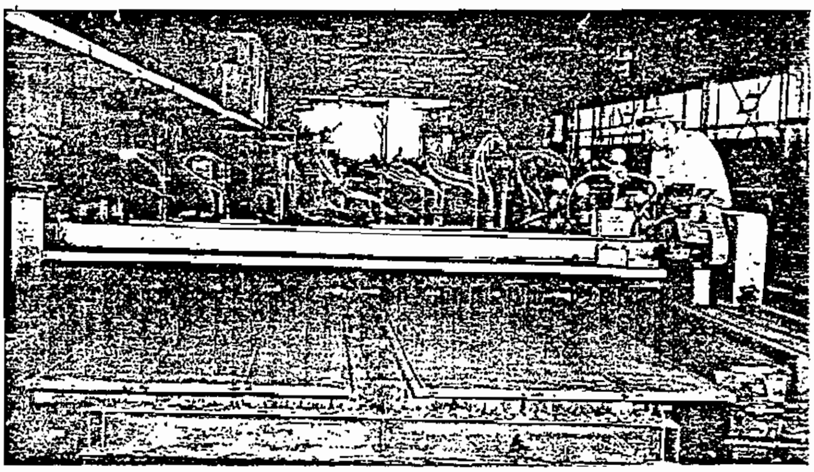
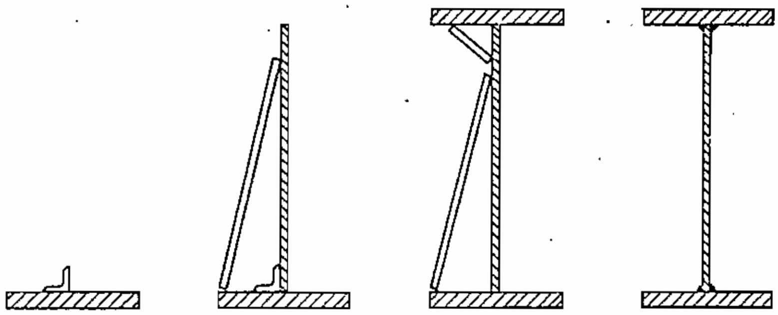


FIG. 1 Multiple burning torches cut heavy steel plate to be used in fabricated bridge girders.

FIGURE 2



1. PLATE PREPARATION

Flange plates may be ordered as bars rolled to the proper width and thickness. No further preparation is required except cutting to proper length and beveling the ends for the butt joint.

Some fabricators will flame cut the flange plates from wide plates; Figure 1. Since there is some shrinkage due to the flame cutting operation, the flange will have a sweep or bend if it is cut along just one side. For this reason the flange is made by cutting along both sides, usually with a cutting unit having multiple torches which are cut at the same time.

For girders with a horizontal curve, the flange plates are flame cut to the proper curve.

2. FIT-UP AND ASSEMBLY

Fabricators having full-automatic, submerged-arc welding heads usually fit the flanges to the web and then complete the fillet welding.

Plate girders may be fitted and assembled by one of the following procedures:

First, one flange is laid flat on the floor. A chalk line is marked along the centerline of the flange and small right-angle clips tack welded at intervals along the length of the flange near this centerline. See Figure 2. Next, the web is placed vertically on the flange and temporarily supported with angles or bars tack welded between the web and the flange. The clips along the flange align the web along the centerline of the flange. The top flange plate may then be placed on top of the web. This method may be used for straight girders if they are not too deep.

The plate girder may be assembled by placing the web down on a fixture in the horizontal position; Figure 3. The flange plates are put in position and some

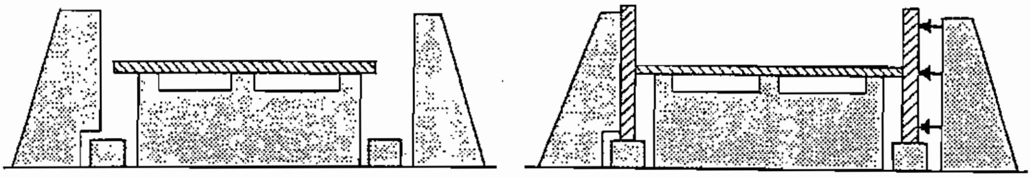


FIGURE 3

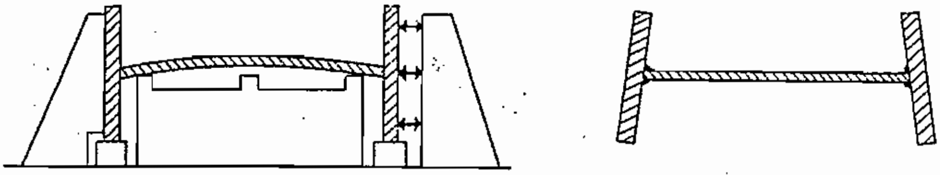


FIGURE 4

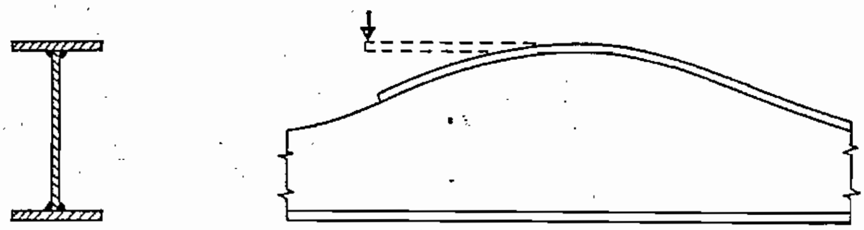


FIGURE 5

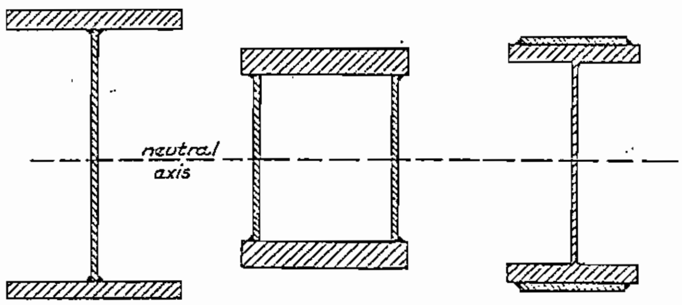


FIGURE 6

clamping method (such as wedges, screws, jacks, or in some cases compressed air) is used to force the flange tight against the edge of the web. These fixtures automatically hold the flange in proper vertical alignment.

If the web is thin and very deep, caution must be used so that excessive pressure is not used against the flanges because this may bow the web upward. See Figure 4. Since the flanges are vertical in the fixture, when the pressure is released and the web straightens out, the flanges may rotate and not be parallel.

Haunched or fishbelly girders are usually assembled with the web horizontal in this manner. However, some fishbelly girders that are not too deep have been assembled upside down with the web vertical. See Figure 5. What would be the straight top flange is placed on the bottom of the fixture, and the web is positioned vertically. What would be the bottom flange is assembled on top, and its own weight is usually sufficient to pull it down against the curved edge of the web with little additional force or heating.

3. CONTINUOUS WELDING

If rolled beams with cover plates, plate girders, and/or box girders are symmetrical, the four fillet welds will be well balanced about the neutral axis of the section. Because of this, there should be very little distortion or bowing of the girder. See Figure 6. The sequence for automatic welding to produce the four fillet welds can be varied without major effect on distortion.

In most cases the welding sequence is based on the type of fixture used and the method of moving the girder from one welding position to another in the shop.

In Figure 7, the fabricator has two fixtures to hold the girder assembly at an inclined angle. These fixtures lie on each side of the automatic welder which runs lengthwise on a track. Since it is more difficult to completely turn the girder over, the sequence must be designed to do this as few times as possible.

In Figure 7, the girder assembly is first placed

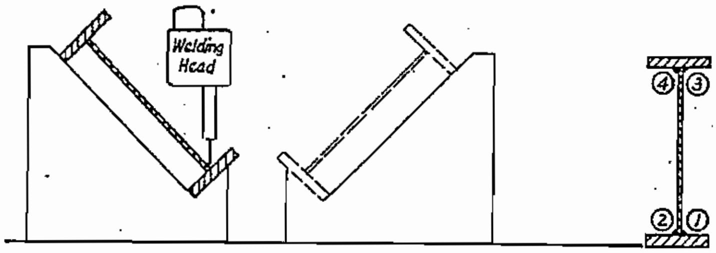


FIGURE 7

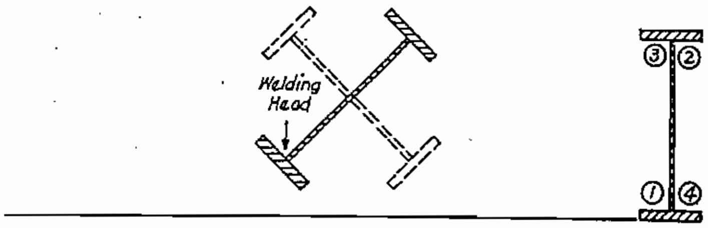


FIGURE 8

in the left fixture and weld (1) is made. The next easiest step is to pick up the girder with the crane hooked to the upper flange and swing it over to the right fixture. Here weld (2) is made on the same flange but opposite side of the web. Now the girder must be picked up, laid down on the floor, turned over, and placed back into one of the fixtures where weld (3) is made in the flat position. Finally the girder is picked up and swung over to the other fixture where weld (4) is made.

In Figure 8, the fabricator uses a set of trunnions on the end of the girder assembly, or places the girder within a series of circular hoops, so that the girder may be revolved. After weld (1) is completed, the girder is turned completely over and weld (2) is made. Now the welding head must be moved over to the back side of the girder and weld (3) is made. Finally the girder is turned completely over and weld (4) is made.

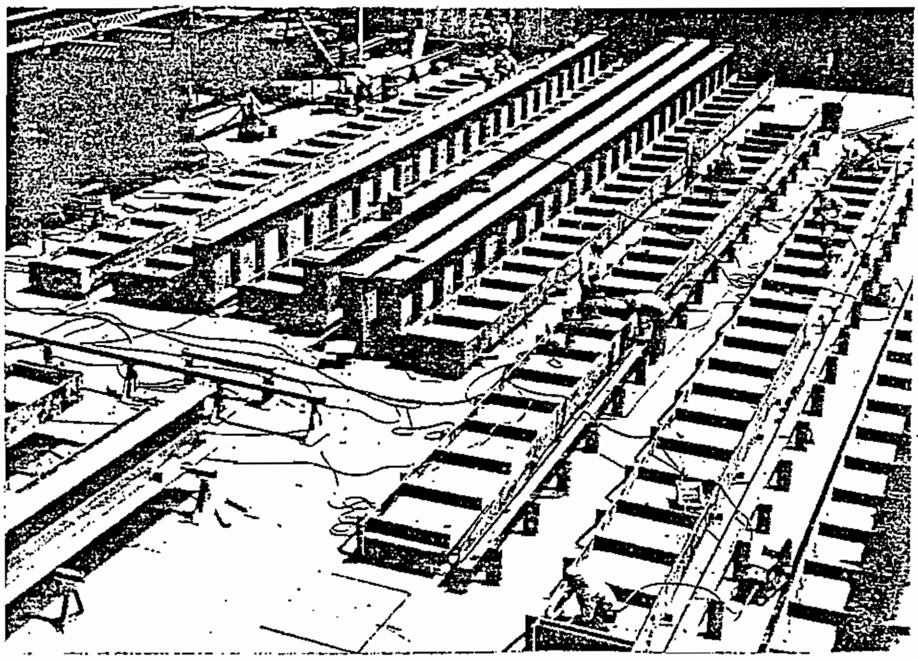
The difference in the above sequence of welding passes depends entirely on the fixturing and methods used rather than any effect on distortion.

4. ANGULAR DISTORTION AND TRANSVERSE STIFFENERS

Usually after the flange-to-web fillet welds have been completed, the transverse stiffeners are fitted and welded into the girder; Figure 9.

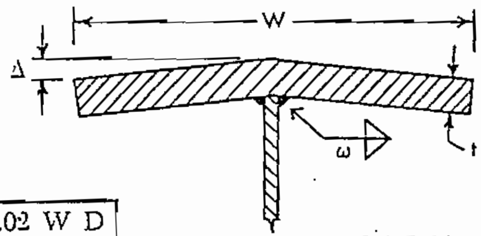
If the flanges are thin and wide, the girders may exhibit some angular distortion of the flange plates. If this has occurred, the flanges may have to be forced

FIGURE 9



apart before the stiffeners can be inserted between them.

The following formula will help in estimating the amount of angular distortion of the flanges:



$$\boxed{\Delta = \frac{0.02\ W\ D}{t^2}}$$

FIGURE 10

where:

$D = \omega^{1.3}$

See Table A for value of D corresponding to actual leg of weld (ω).

TABLE A

ω	D
3/16	.113
1/4	.164
5/16	.220
3/8	228
7/16	.342
1/2	.406
5/8	.543
3/4	.688
1	1.000

AASHO bridge specifications (2.10.32) state that these stiffeners shall fit sufficiently tight after painting that they will exclude water. In addition, no attachments should be welded to the tension flange if it is stressed above 75% of the allowable.

Some interpret the AASHO specification to mean a force fit; this is costly and not necessary. The following procedure will comply with this:

1. Use a loose stiffener so it may be fitted easily.
2. Push this tight against the tension flange.
3. Weld this to the web of the girder.
4. Weld this to the compression flange.

Some states have not been concerned with this tight fit and have cut the stiffeners short by about 1"; these have been pushed tight against the compression flange and welded to the web. If just a single stiffener is used, it is also welded to the compression flange. The recent plate girder research at Lehigh University found that the stiffeners do not have to be against the tension flange in order to develop the full capacity of the girder. The new AISC specifications follow this in allowing transverse intermediate stiffeners to be cut short at the tension flange by a distance equal to 4 times the web thickness.

Fabricators having semi-automatic welding equipment sometimes insert the transverse stiffeners into the girder before welding the flanges to the web. This is easily done since the unwelded flanges are flat (not distorted). With the girder web in the horizontal position, the semi-automatic welders are used to make the fillet welds between the flange and web as well as the stiffeners in the same set-up.

The corners of the stiffeners are snipped so that the flange-to-web fillet weld may be continued in back of the stiffeners. Quite often all of this welding is completed in a single panel area before moving to the next. The girder is then turned over and the welding completed on the other side.

5. POSITION OF WELDING

The girder may be positioned with the web at an angle between 30° and 45° with the horizon, permitting the welds to be deposited in the flat position. This position is desirable, since it makes welding easier and slightly faster. It also permits better control of bead shape and the production of larger welds in a single pass when necessary.

For example, the largest single-pass fillet weld made in the horizontal position is about 5/16" with a single wire, and 1/2" with tandem arc; whereas in the flat position this single-pass weld may be about 3/4" with either process.

For a 1/4" or 5/16" fillet weld, the position in which the weld is made, whether horizontal or flat, would not make much difference.

If a 3/8" or 1/2" fillet weld is required, the fabricator has several choices.

If the girder may be positioned with the web vertical, this will allow both welds on the same flange to be completed without moving the girder. See Figure 11(a). If the fabricator has two welding heads, these two welds may be made simultaneously, thus reducing the overall welding time. However, this horizontal position does limit the maximum size of the weld which may be made in a single pass.

If the fabricator has a single-wire automatic head, he must make this fillet weld in two passes. If he has a tandem setup, this weld can be made in a single pass with less welding time.

By tilting the girder at an angle, either a single wire or tandem heads can make this weld in a single pass; however, only one of the welds can be made at one time. See Figure 11(b). It would be necessary to rotate the girder for each weld with increased handling time.

A fabricating shop with two automatic welding heads can make two fillet welds on the girder simultaneously. To do this, the shop must decide between two methods of positioning the girder; Figure 12.

It might be argued that method (a) should be used

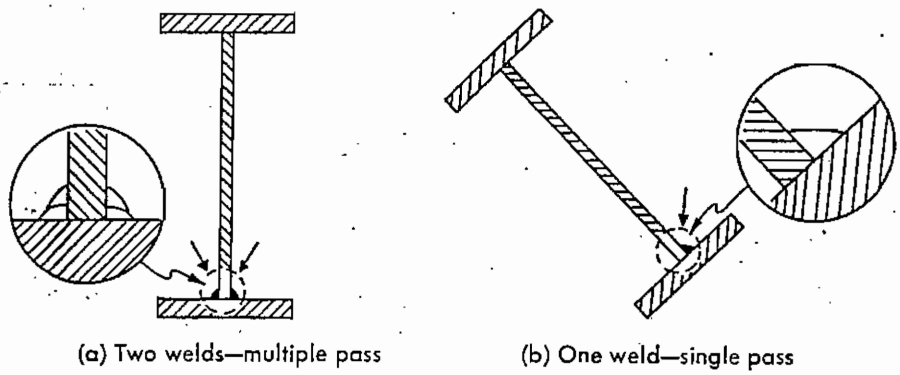


FIGURE 11

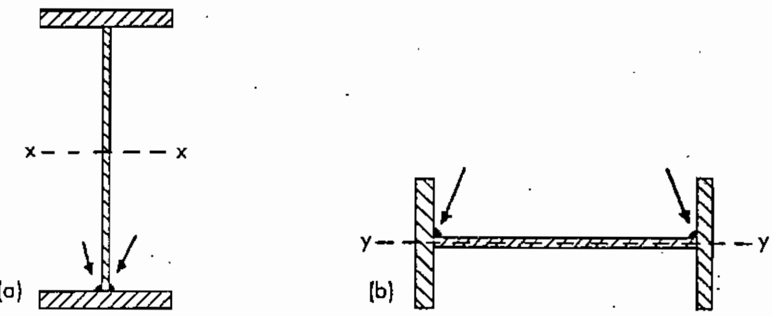


FIGURE 12

because the girder is much more rigid about this axis (x-x) and therefore would deflect less as a result of the first two welds on the bottom flange.

However in method (b) the weld is next to the neutral axis (y-y) of the girder. Its distance to this axis is much less than that in (a), and therefore it would have very little bending effect on the girder.

Since this is a thick flange, there may be concern about getting a large enough fillet weld to provide enough welding heat for the mass of flange plate. Therefore, it might also be argued that method (a) would provide double the amount of heat input on the flange.

Actually there should be little difference between these methods in the effect of weld shrinkage after all of the welds have been made.

6. COVER PLATES FOR BEAMS

Many times, rolled beams must have cover plates added to their flanges for increased strength. Usually two cover plates are added, keeping the section symmetrical about the horizontal axis. For composite beams having shear attachments on the top flange so that the concreto floor acts compositely with the beam, a cover plate may be added to the bottom flange for increased strength. All of these beams must have a certain amount of camber.

The welds connecting the cover plates to the beam flange tend to shrink upon cooling. With a cover plate on each flange, this shrinkage on top and bottom flanges of the beam will balance and the beam will not distort. However, if there is a cover plate on just the bottom flange, the unbalanced shrinkage will cause the center of the beam to bow upward; in other words, it will increase the camber of the beam.

The cambering that results from this unbalanced welding can be estimated by the following formula:

$$\boxed{\Delta = \frac{0.005\ A\ d\ L^2}{I}}$$

where:

A = total cross-sectional area of welds, sq. in.

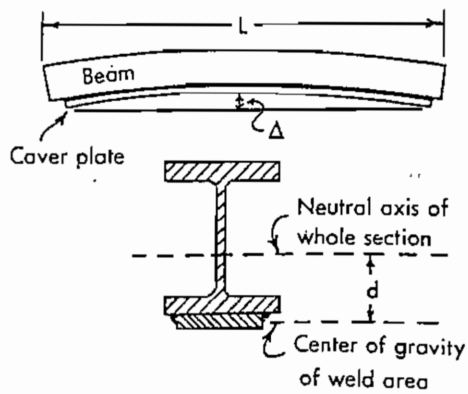
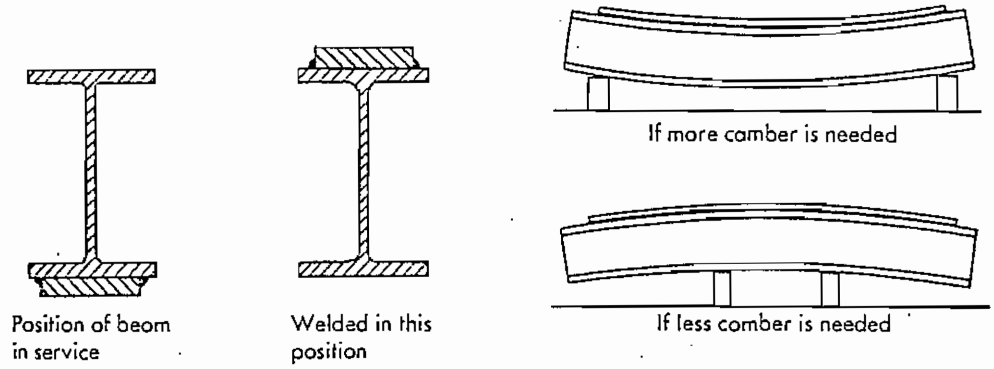


FIGURE 13



(a) When cover plate is less than flange width

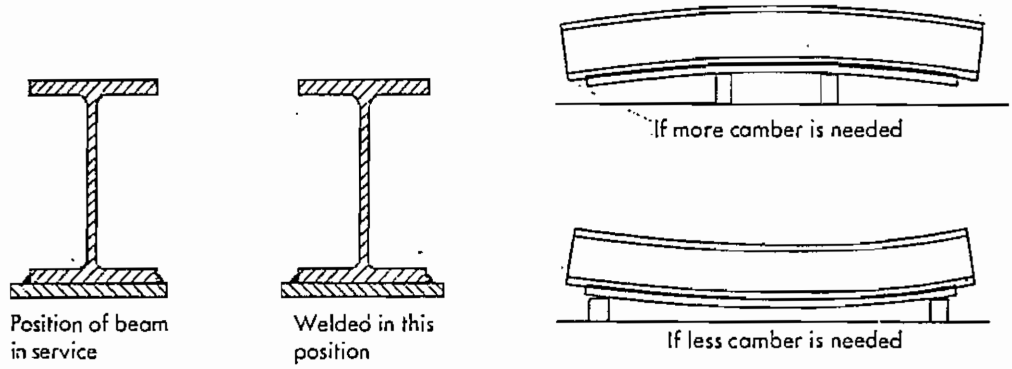


FIGURE 14

(b) When cover plate is greater than flange width

d = distance from the center of gravity of welds to the neutral axis of the section, inches

L = length of the beam, inches

I = moment of inertia of the section, in.^{4}

This may be more or less than the final desired camber, Figure 14. If this camber due to welding is excessive, the beam must be supported in such a manner that it tends to sag in the opposite direction before welding. If the camber due to welding is not enough, then the beam must sag in the same direction before welding.

A good experienced shop man will support the beam either near its ends or near its midpoint so as to control the direction and extent to which the beam bends before it is welded.

If the cover plate does not extend to the full width of bottom flange, it must be welded with the beam upside down, Figure 14(a). Supporting this beam near its ends will increase the final camber, and supporting the beam near its midpoint will decrease the final camber. If the cover plate extends beyond the bottom flange, it must be welded in this position and just the opposite technique must be used in supporting it; Figure 14(b).

The fillet welds holding this cover plate to the beam should be interrupted at the corner, if it is wider than the beam flange, as shown in Figure 15.

7. SHOP WELDING VS FIELD WELDING

It is practical to do as much welding in the shop as possible and to make only those welds in the field that can't be made in the shop. The following two sections on the Field Welding of Buildings (Sect. 4.13) and of Bridges (Sect. 4.14) include some recommendations on shop welding specific connection joints.

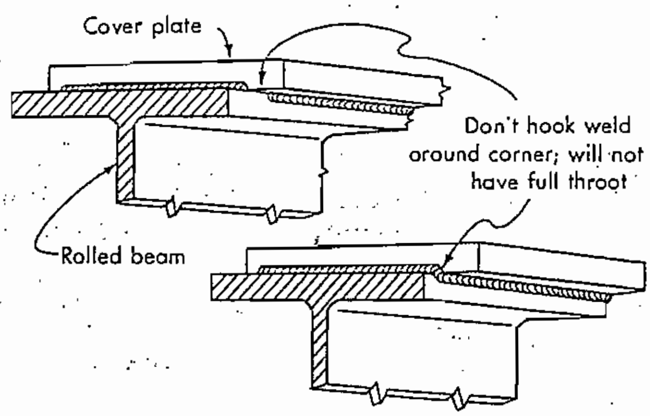


FIGURE 15