Field Welding of Buildings

1. ERECTION PRACTICES

The main cost in fabrication and erection of any steel structure is labor. It is important to get in quickly on a job and to come out in as short a time as possible.

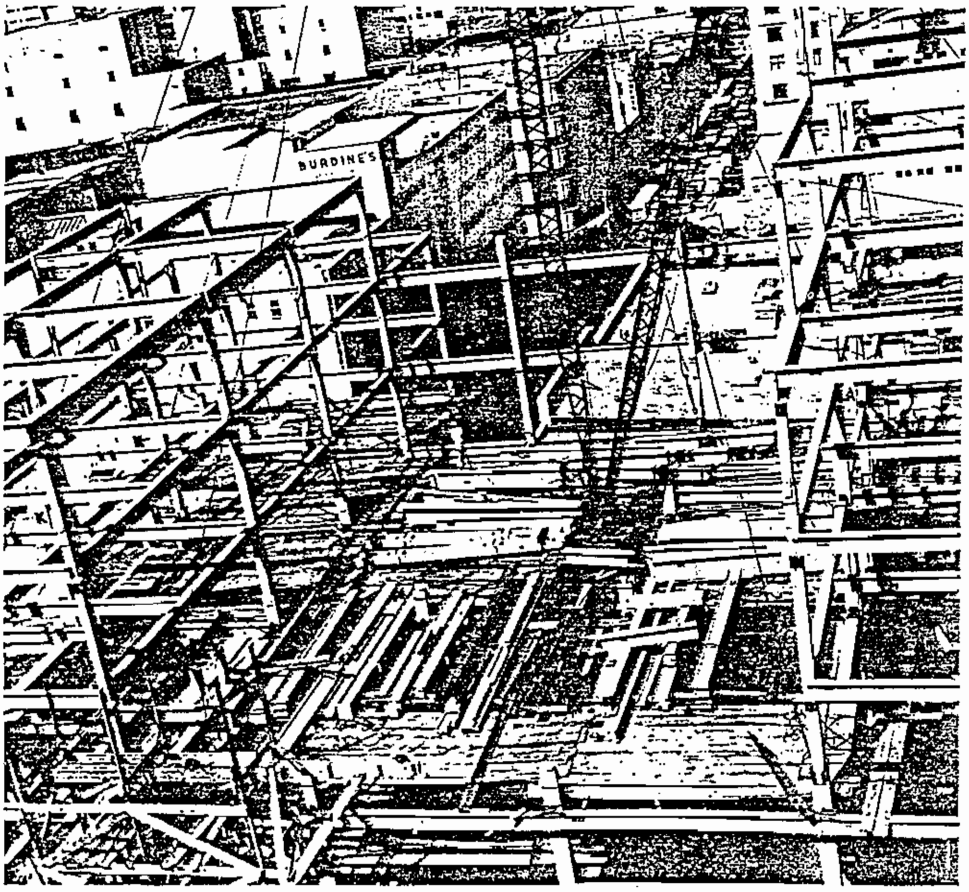
In some cases, steel is brought in by rail and unloaded near the tracks at the job site; otherwise it is brought in by trucks. In the case of a multi-story building, storage space is at a premium, and there must be an even flow of steel to the job as it is needed. The steel is stored in the proper order so that the first steel to be used comes off the top of the pile.

The usual method of erecting a multi-story building is to set up a derrick in the center of the building area. The columns are erected at the periphery of the building and plumbed. The beams are then connected between the columns. This erection progresses toward the center of the building where the derrick is located. Finally, the central section is closed in.

These column sections may come in one or two story heights, although higher sections have been used. When the last beam is closed in at each elevation, it is important that full strength is immediately obtained in these final joints so that the derrick may be jumped to the next elevation without any loss of time. This can be done by placing these beams upon seat brackets which have previously been shop welded to the columns. The flanges of the beam can then be welded to the columns in the flat position for maximum speed.

This erection sequence is repeated for each level until the entire structure is completed. With the exception of the immediate area supporting the derrick, the field welding usually follows the erection by about one floor.

FIGURE 1



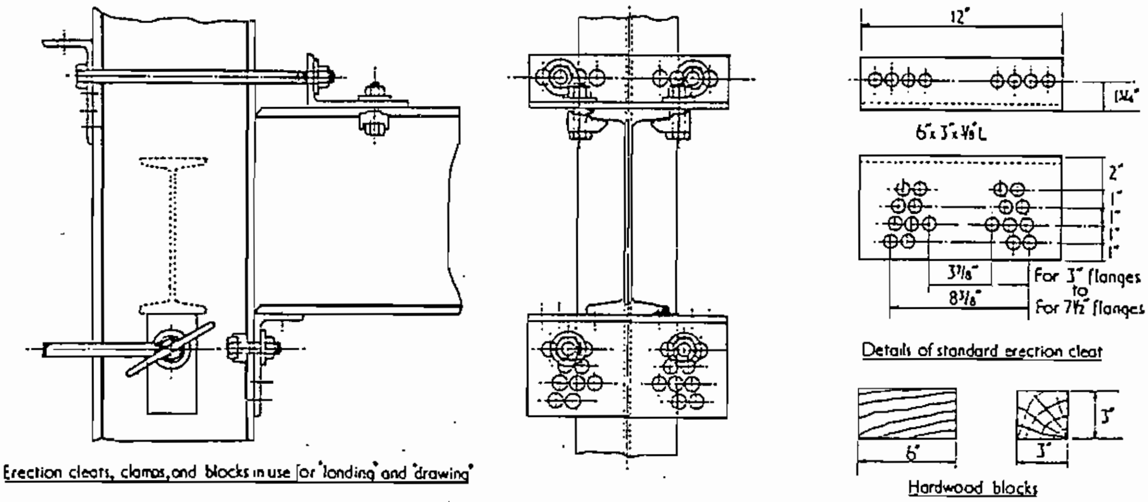


FIGURE 2

2. ERECTION HELPS

Several methods of temporarily fastening these connections have been used. Tack welding alone may be unsatisfactory because it does not make allowance for plumbing the building before final welding.

Clamping the beams to the column seat is not always safe, although this has been used for "site erection" of lighter structures; see Figure 2.

The steel is ordered cut to length and delivered to the site of erection. Temporary seat angles are clamped onto the column at the proper position, and a temporary lug clamped onto the top flange of the beam. The beam is hoisted into position and set upon the temporary seat angle of the column. A tie bolt is then screwed on to hold the beam in proper alignment with the column. Next, the beam is welded directly to the column, and any temporary lugs then disconnected and used over again.

Saxe erection clips, which are welded to the beam ends and the column, have been used with success; see Figures 3 and 4. These units consist of a forged steel clip and seat. The clip is shop welded to the end of the beam, and the seat is shop welded at the proper position on the column. During erection, the beam is placed in position so that the clips drop down into the seat. An adjustable clip has been developed to take care of possible poor fit-up between the beam

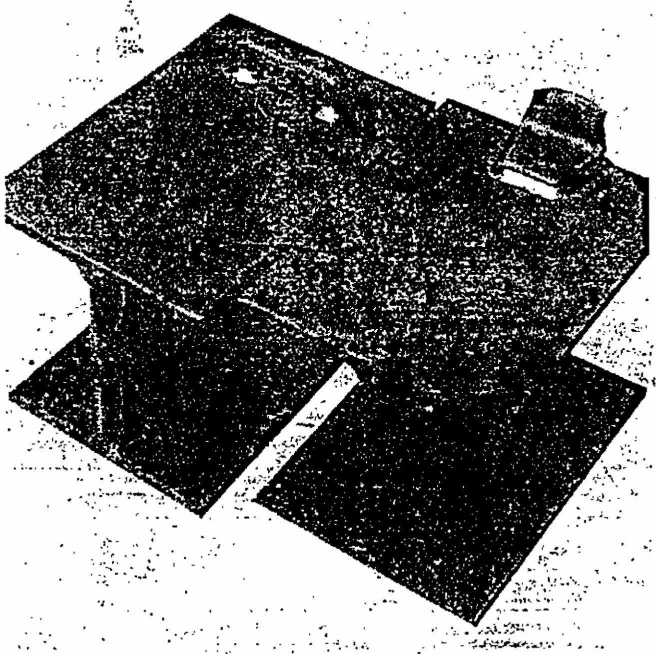


FIGURE 3

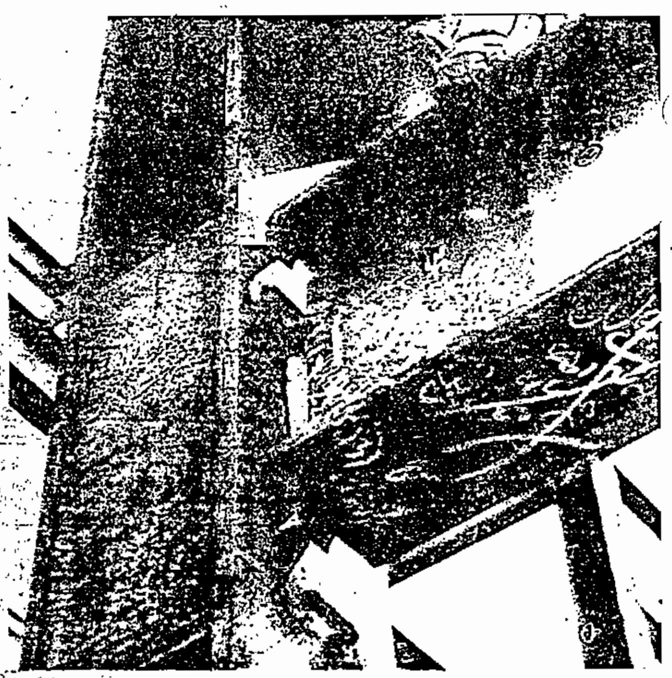


FIGURE 4

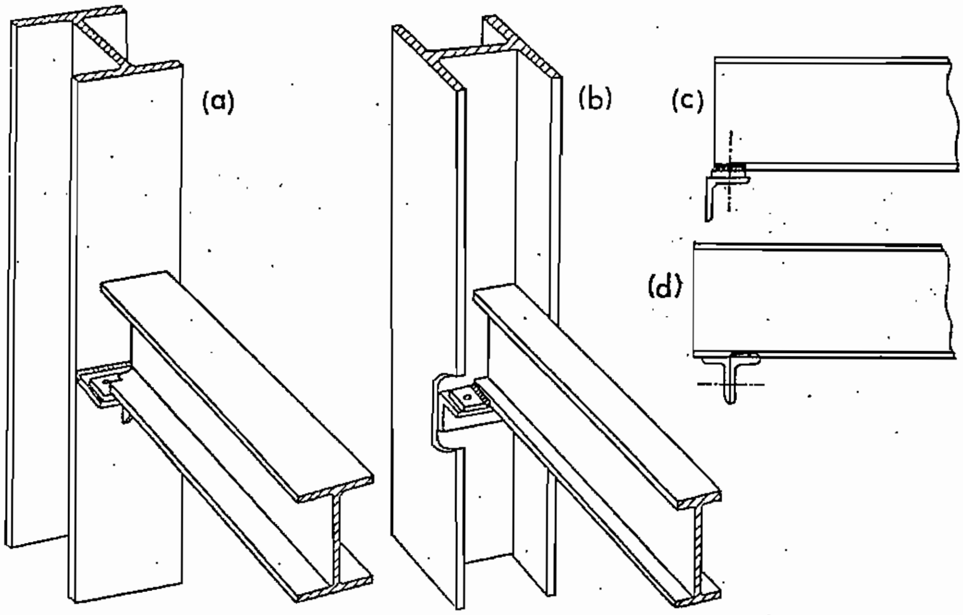


FIGURE 5

and the column.

It is recommended that the working load on any one seat should not exceed 20,000 lbs. If a greater erection load is to be carried, such as a heavy plate girder or truss, it is recommended that two or more seats be used, side by side.

The use of a few erection bolts has been found to be a satisfactory means of temporarily fastening before welding. Bolting may be done directly to main members. It is less costly to punch small attachments for erection bolts than to move heavy main members into the punch shop for punching. Many times, holes are flame cut in the ends of beams for erection bolts.

In Figure 5(a), a small connection plate is shop welded to the bottom beam flange at the end. A seat is also shop welded to the column flange at the proper height. During erection, the beam is placed upon the seat and two erection bolts are used to hold them in place.

In Figure 5(b), the beam is connected to the column web. A seat angle is shop welded to the inside faces of the column flanges and/or to the column web. A flat plate is shop welded at the end of the lower beam flange; see Figure 5(c). During erection, the beam is held in place by two erection bolts. All punching has been done on small attaching plates or angles. No punching has been necessary on the heavy main members. Any of several methods may be used to tie in the top beam flange.

Figure 5(d) indicates that when the beam flange is too wide for easy access to bolts applied as at Figure 5(c), the angle welded between the column flanges may be reversed. In this case, another angle of same size is welded to the underside of the lower beam flange. The erection bolts are run through the vertical legs of the two angles.

Welded studs may be used for erection. In Figure 6, two studs are placed on the beam web and serve the same purpose as erection bolts. The welding of the studs would be done at the same time the beams are laid out. Since the studs are placed on the beam web, it would be difficult to damage them in transit or erection since the overhang of the beam flanges would protect them.

The attaching plate on the column is designed for

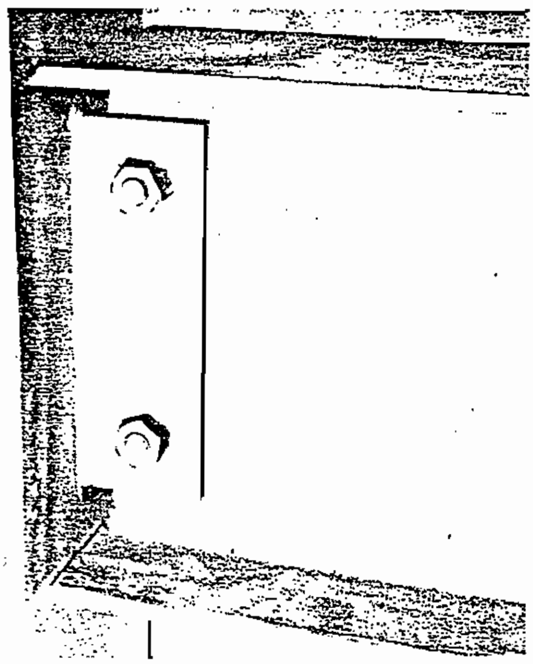


FIGURE 6

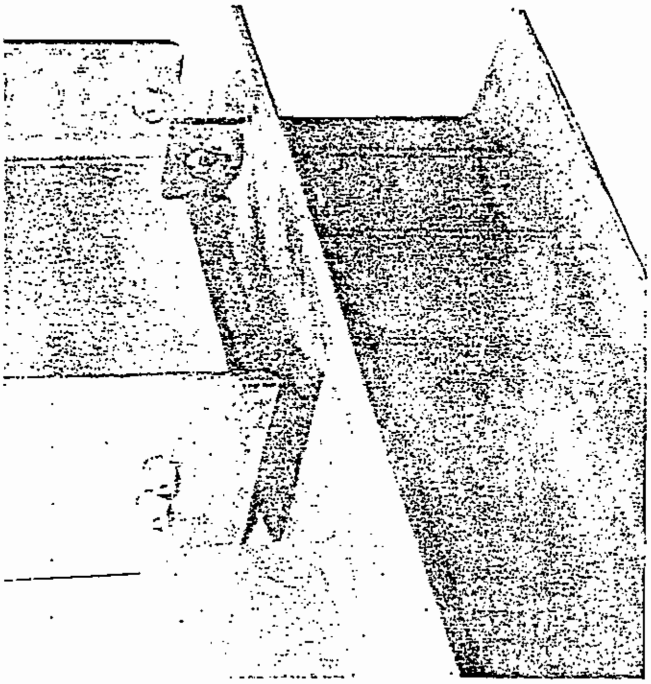


FIGURE 7

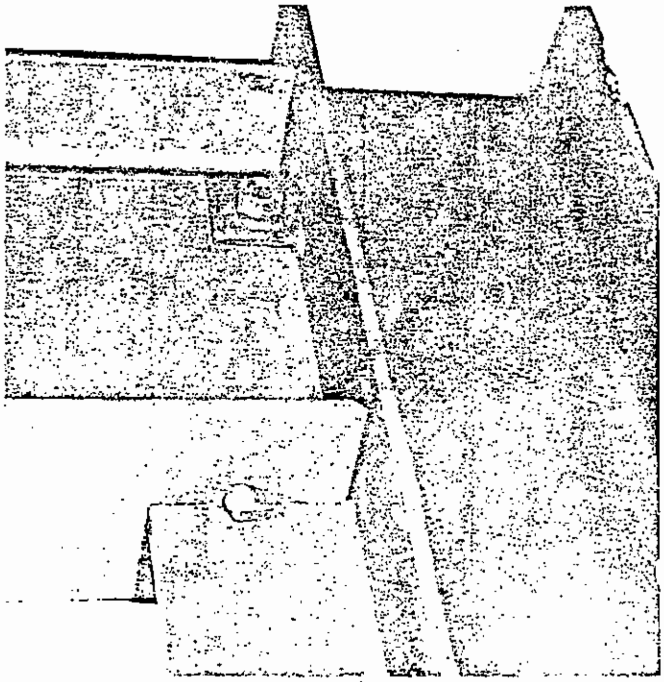


FIGURE 8

the shear reaction and is shop welded in the flat position for minimum cost. No punching or drilling of the main member is necessary. Since the attaching plate would be punched with a template having the same distance between holes as the punch marks for the welded studs, there should be no difficulty in fitting the beam in place during erection.

The small attaching plate may be punched with a slot in the horizontal direction of the beam. This will allow some adjustment, to take care of dimensional tolerance on the column size or beam length and yet give a positive location for the height of the beam.

With this arrangement, the only field welding would be the top and bottom flange butt joints and whatever vertical welding would be required for the shear reaction to the beam web. The flange butt welds would have the proper root opening and use a light backing strap, about ⅛" x 1". This backing strap could extend slightly beyond the joint so as to form a shelf or run-off tab to insure proper build-up at the end of the joint.

By welding a seat plate to the column flange, as in Figure 7, any vertical welding in the field would be eliminated. The plate would have sufficient size and attaching weld to transmit the shear reaction of the beam. Here, two short welding studs are placed one on each side of the bottom flange's centerline at the beam ends. They are spaced to the thickness of the seat plate, and after erection, will keep the beams securely positioned over the seat. A third welding stud is placed on the underside of the top beam flange and engages a small attaching plate shop welded to the column. This plate has a slot punched in it, the slot being lengthwise with the beam.

With this arrangement, the beam can be simply lowered down into position, with the studs dropping into place and locating the beam squarely and tightly for field welding.

A possible improvement of this method would be to have the two welding studs on the bottom flange so they would engage into the holes first. This third stud just under the top flange could be threaded and when tightened with a nut would hold the beam from accidentally being knocked upward and out of the connection.

A slight modification can be made by placing this third stud on the beam web, near the top; see Figure 8. The small attaching plate has a hole larger, perhaps by ⅛", than the stud diameter. In erection, the beam is lowered into position as before, but must be rolled slightly to engage the web stud. A nut is drawn up tightly on this stud for firm holding.

A further variation could use a T-shaped stiffened seat bracket with the horizontal plate punched accurately to receive the two studs on the bottom flange of the beam. The third stud could be placed on the underside of the top beam flange to provide horizontal stability.

It is true that with this method of using welding studs to avoid making holes in the main members, there would be no provision for using the tapered end of a structural offset or spud wrench to bring the beam end into proper alignment with the connection. However, with the accuracy of placing the welding studs and laying out the corresponding slotted holes so as to allow for some horizontal adjustment, there should be little difficulty.

3. FIELD WELDING

Plumbing of a building usually starts around an elevator shaft or service core. This is usually centrally located and has greater bracing. The butt welds of the beam and girder flanges to the supporting column will have some transverse shrinkage. It is necessary that this shrinkage be estimated and the joint opened up by this amount before welding. Otherwise, this shrinkage will accumulate along the length or width of the building and build up to a sizable amount. See Figure 9.

A good estimate of this transverse shrinkage is—

$$\boxed{\Delta = .10 \frac{A_w}{t_{PL}}}$$

$$\boxed{\Delta = .10\ W_{av}}$$

where:

A_w = cross-sectional area of weld

t_{PL} = thickness of plate

W_{av} = average width of weld

The cross-sectional area of the weld may be computed by breaking it down into standard areas; that is, rectangles for root opening, triangles for included angle of bevel, and parabolas for weld reinforcement. This calculation can be greatly shortened by making use of standard table giving the weight of weld metal for various joints; use Table 6 in Section 7.5. It is only necessary to divide these values by 3.4 to arrive at the area of the weld. This value is then placed into one of the above formulas for shrinkage.

Problem 1

To determine the shrinkage effects in making the welds indicated in Figure 9. The girder with a 1½" flange is to be welded to a column. The joint has a ¼" root opening, an included angle of 45°, and uses a backing bar.

From Table 6 in Section 7.5, the weight of weld metal is 5.93 lbs/ft. and has an area of—

$$A_w = \frac{5.93}{3.4} = 1.74 \text{ in.}^2$$

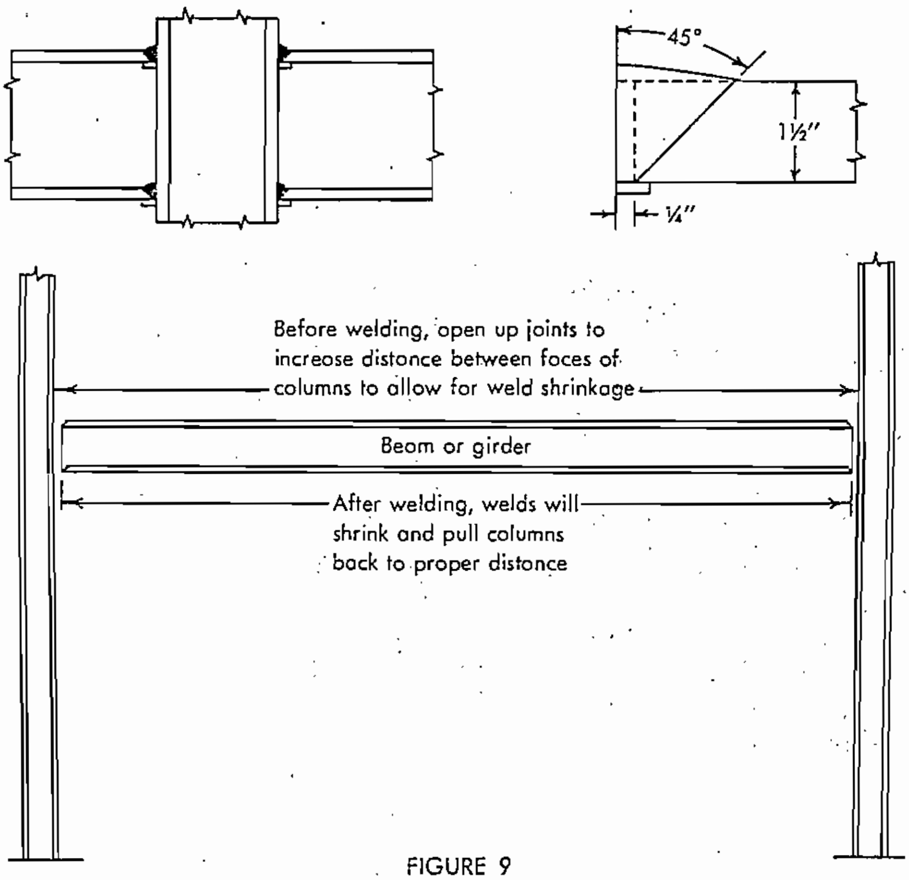


FIGURE 9

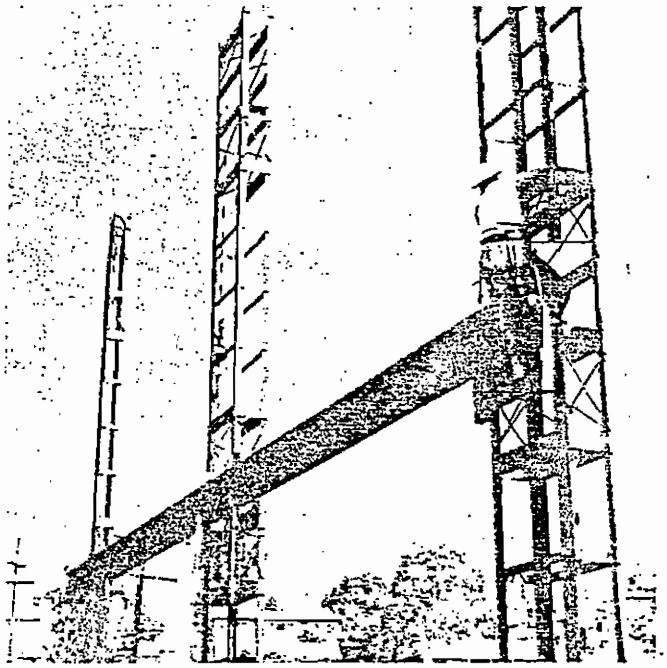


FIGURE 10

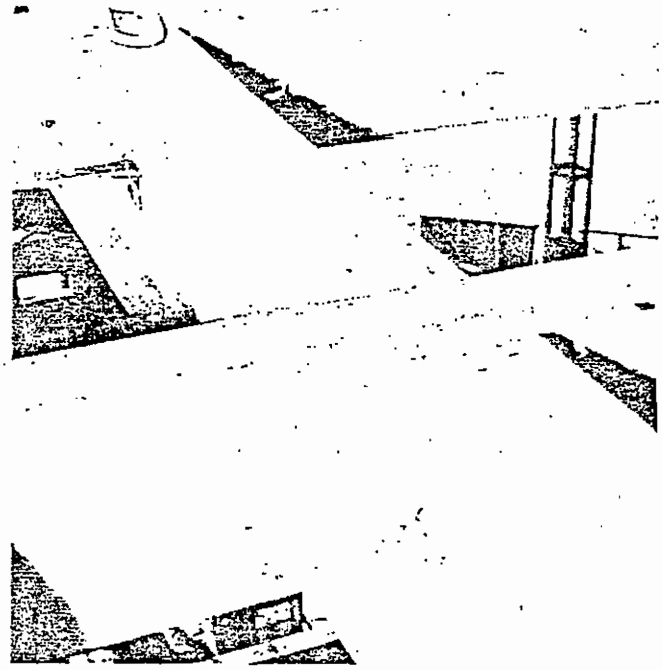


FIGURE 11

The transverse shrinkage is—

$$\Delta = .10 \left(\frac{1.74}{1\frac{1}{2}}\right)$$

$$= .116'' \text{ or about } \tfrac{1}{8}''$$

Using ¼" fillet welds on the web will result in very little transverse shrinkage. The average width of a ¼" fillet weld is ⅛", and 10% of this is .012" or about 10% of the shrinkage of the flange butt welds.

In this example, the joint of the girder flanges would be opened up an extra ⅛" on each end of the girder so that the distance between the faces of the two columns is ¼" greater than the detail calls for. After welding, the two joints should shrink sufficient to bring the two columns back to the desired spacing. This shrinkage could be checked after welding and this value adjusted.

* * *

The box columns in the building shown in Figure

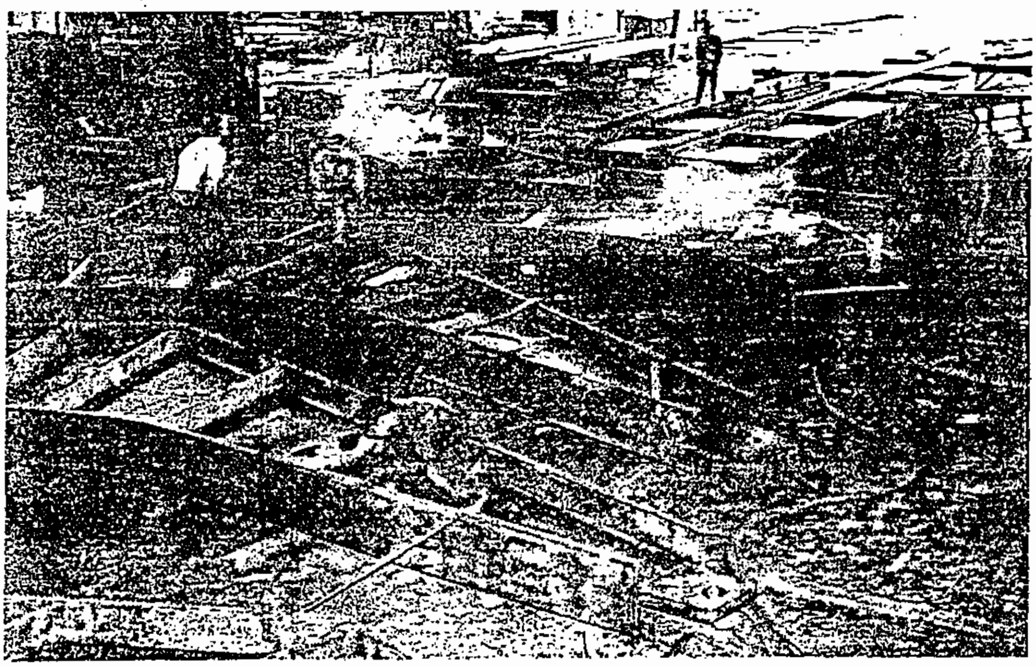


FIGURE 12

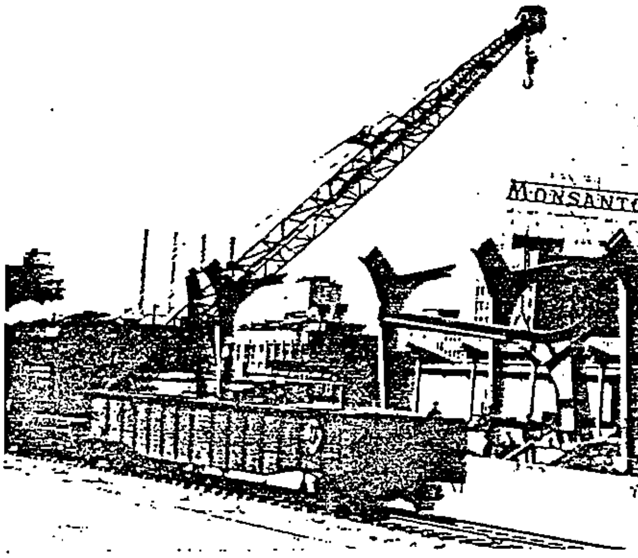


FIGURE 13

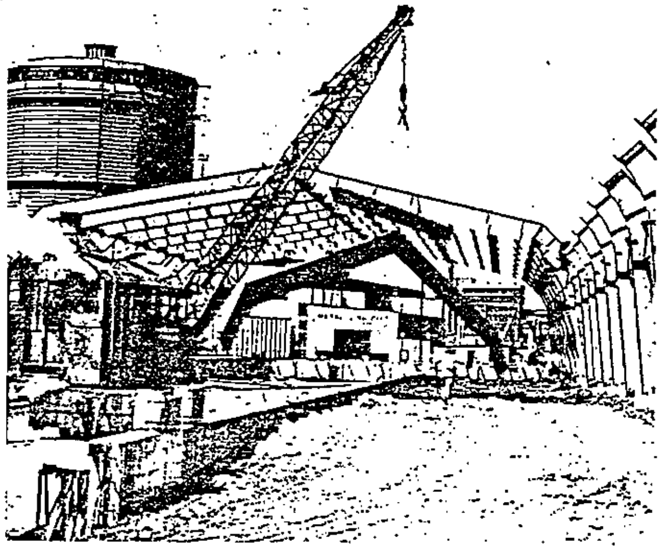


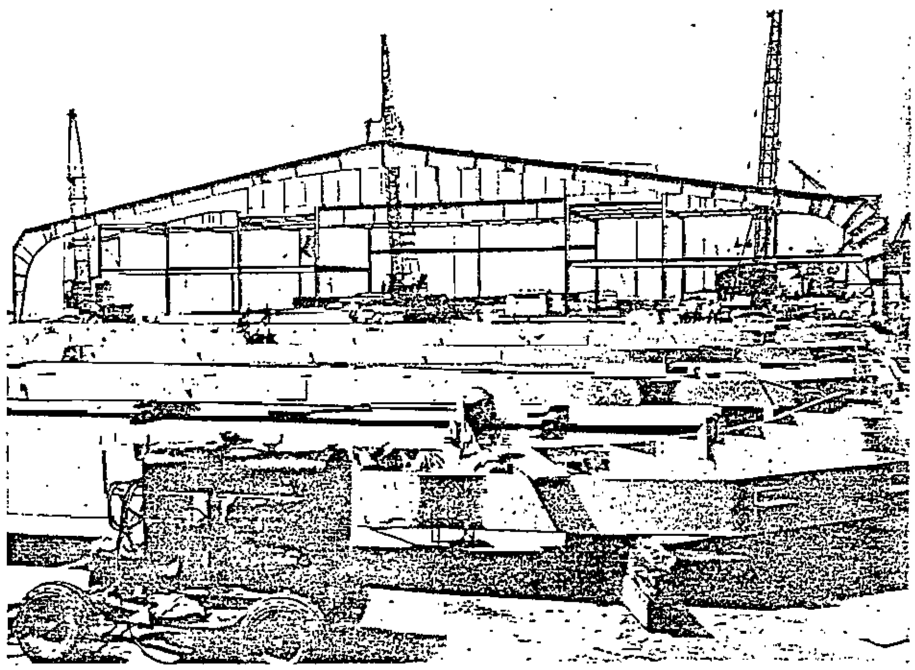
FIGURE 14

10, were fabricated by welding together four angles. After they were erected, a short angle section was removed and a long section of the girder was slipped into position within the column. Later the angle section was put back.

The ends of the beams were coped back so they could be slipped into place with their top flange resting on the top flange of the girders; Figure 11. A short seat angle shop welded to the girder web supported the lower beam flange. This resulted in a very fast erection procedure without the use of erection bolts. Later the bottom beam flange was field welded to the girder web, using the seat angle as a backing strap.

A plate was placed between the top beam flanges and the girder. The top flanges of the beams were butt groove welded together, using the plate as a backing strap. The plate was then fillet welded to the beam flanges. A long cover plate was then welded to the beam flanges to take care of the increased negative moment of the beam at this support point. Notice that this type of welded connection makes the beam continuous, thereby reducing its required size. At the same time, it does not tie the top flanges of the beam to the girder, which might produce some biaxial stresses. All of the field welding shown here was done in the flat position, greatly speeding up the erection welding.

FIGURE 15



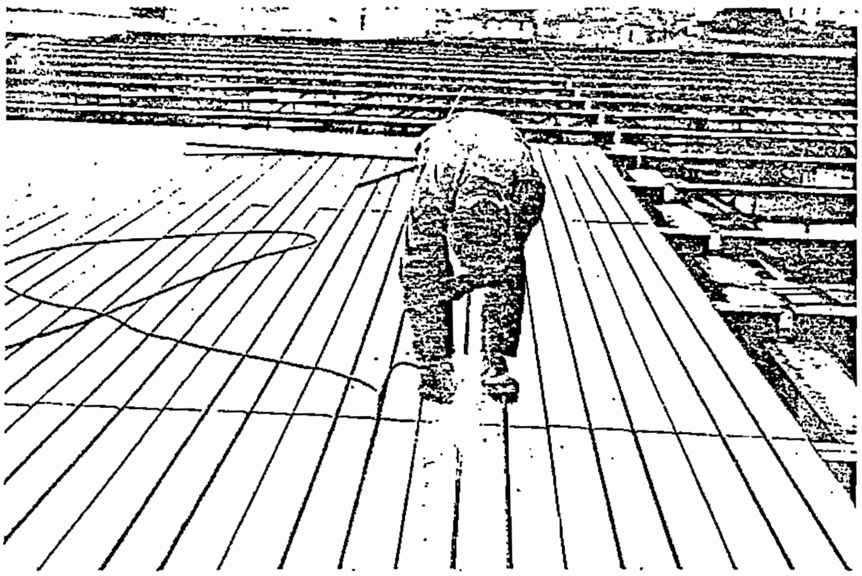


FIGURE 16

Welding is used quite extensively on rigid frames. Figure 12 shows the shop fabrication and welding of sections of a large rigid frame. For small structures, the entire frame is fabricated and erected in one piece.

For larger structures, the frame may be divided into two or more sections and assembled at the job site and erected. Figures 13 and 14 show the construction of a rigid-frame freight terminal area, and the upright portions of the frame being unloaded from the railcar and hoisted into position by the rail crane. Later the central portions of the arch were put into position. Welding machines, also on flat cars, were brought in and the field joints welded.

Frames for the Long Beach Harbor Shed were assembled on the ground, Figure 15. The sections were laid out on wood blocks and jacked up to proper position and checked with a transit. The field joints were then welded. Three crawler cranes picked the entire frame up and placed it in position. Some of the field welding which was inaccessible when on the ground, such as the back side of the web butt joint, was completed in the air.

FIGURE 17

4. WELDING OF JOISTS AND FLOORING

Welding is used universally in the attachment of open-web joist to beams. This becomes a simple matter of laying the joist on the beam at the proper place and later welding in the flat position. A considerable amount of light-gauge steel roof decking is used on top of joists or beams. This is easily and quickly attached by means of welding in the flat position. The use of both open-web joist and steel decking is shown in Figure 16.

Floor decking of heavier gauge has been used as a support for any of several floor materials. Welding is used in the flat position to fasten this steel deck to beams of the steel structure. Many times this deck is designed to take the horizontal forces on the structure caused by wind or earthquake.

5. WELDOR PLATFORMS

It does not take much in the scaffolding to support a weldor and his equipment. Many of the joints can be reached without any platform; the weldor simply works off of the beam or works from a ladder.

For welds below the beam, it may be necessary to put up a platform. Figure 17 shows a rectangular wooden platform with four ropes attached to it. The platform is fastened to the steel structure at the proper level by the ropes. Although this type of platform is self-contained, it is rather heavy, especially for one man.

Figure 18 shows a simpler scaffold for a similar position in the steel structure. It is lighter and easier for one man to set up. Two wood planks have ropes fastened at their ends; the ropes are tied to steel grab hooks. The hooks, supporting the wood planks, are dropped over the top flange of the beam, and the other two planks are put into place. This platform can be used on all beams having approximately the same depth without any further adjustment in the rope length. It can be used in almost any condition. Usually a weldor's helper or one from the erecting crew will set up the necessary scaffolding ahead of time, so there will be no delay in welding.

On large structures which have connections requiring quite a bit of welding at the connections, it may help to use a weldor's cage which hooks over the top flange of the beams and is put in place by the derrick. This is shown in Figure 19. These cages can be covered on three sides to form a windbreak when used on the outside of the steel structure. The weldor is not aware he is working at a great height when he is inside this shielded cage.

FIGURE 19

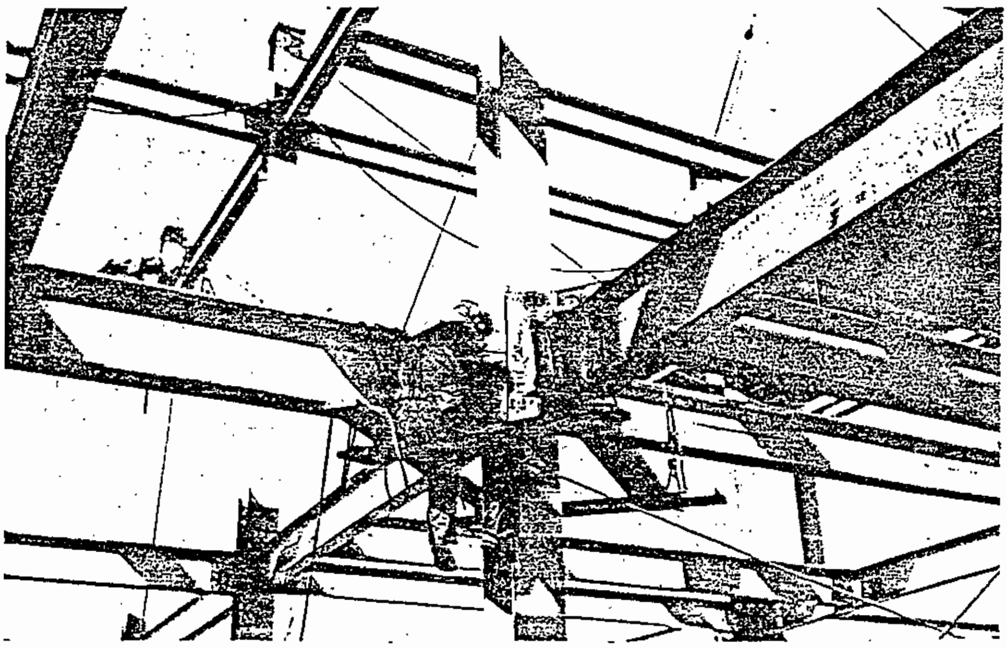
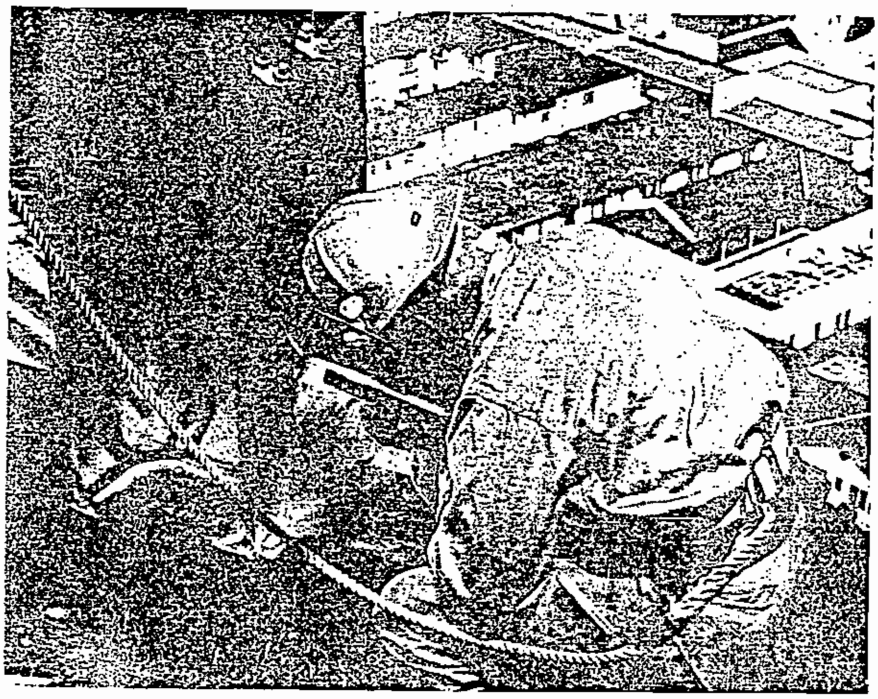


FIGURE 18



Semi-automatic welding, using self-shielding cored electrode, being employed in making beam-to-column connections on Wilshire-Ardmore Building in Los Angeles.

Semi-automatic welding speeding erection of 32-story Commerce Towers in Kansas City, Missouri. Making welded girder connections in the open was facilitated by use of lightweight compact gun and continuously-fed, self-shielding cored electrode.