Bearing-Pin Connections

1. TYPICAL CONNECTION

Figure 1 illustrates a suggested detail for a pin connection at the end of a built-up compression member of an arch bridge, subject to a reaction of 90 kips.

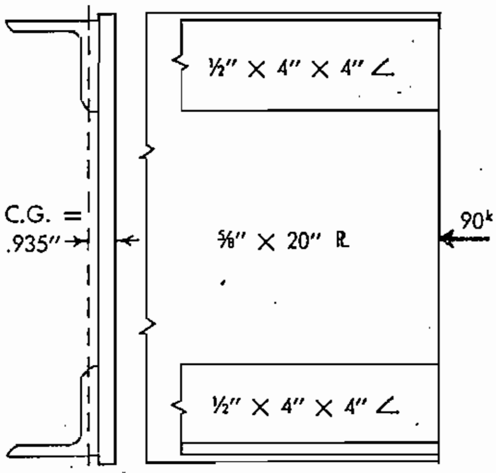


FIGURE 1

There are many approaches to this type of problem and, of course, many solutions. This is simply one analysis and one solution. One of the design requirements in this particular example is to have a smooth-appearing surface on the outside or facia side of the arch compression member.

Notice in the sketch of the cross-section of the built-up compression member, Figure 1, that the center of gravity is .935" in from the outer face.

By selecting an attaching plate of sufficient thickness for its center of gravity to line up with the compression member's center of gravity, the compression load will be transferred in a direct line without any eccentricity.

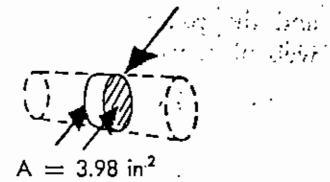
The bearing pin is subjected to a double-shear load: 90,000 lbs on two areas, or 45,000 lbs each. See Figure 2. According to AASHO (Sec 3.4.2), the allowable stress on this pin is 13,500 psi.

$$\therefore A = \frac{45,000}{13,500}$$

$$= 3.33 \text{ in.}^2 \text{ required pin area}$$

or <u>use a 2¼"-dia pin</u> having $A = 3.98$ in.^{2}

FIGURE 2

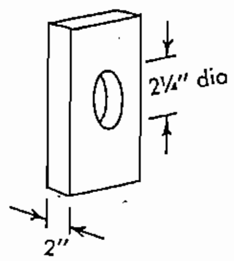


The next step is to compute the thickness of the connecting plate. This is based on the minimum required bearing area of the plate because of the pin reaction against the plate, Figure 3. The 90,000-lb load is divided by the allowable bearing pressure, which in this case is 24,000 psi assuming no rotation, (AASHO 3.4.2) and the minimum bearing area comes out to be 3.75 in.^{2}

$$A = \frac{90,000}{24,000}$$

$$= 3.75 \text{ in.}^2$$

FIGURE 3



Since the pin's diameter has been computed to be 2¼", the required plate thickness to make up this bearing area would be—

$$t = \frac{3.75}{2.25}$$

$$= 1.67''$$

but <u>use 2"-thick plate</u>

since this will also line up with the center of gravity of the compression member (CG = .935").

The next step is a simple determination of the required depth (d) of this connecting plate. See Figure 4. In this analysis, some structural designers consider this connecting plate as a beam supported at the center, or pin, and withstanding the compression loads transmitted from the compression member.

In most cases, the compression load (here 90 kips) is assumed to be equally distributed throughout the various parts of the compression member by the ratio of the individual areas to the total area. Accordingly, the compression load carried by each angle would be—

$$P_{\angle} = (90^k)\,\frac{3.75}{20}$$

$$= 16.9 \text{ kips}$$

and the compression load carried by the ⅝" × 20" web plate would be—

$$P_{PL} = (90^k)\,\frac{12.5}{20}$$

$$= 56 \text{ kips}$$

throughout its entire width. Dividing this load by 20" results in a uniform load of—

$$f = \frac{56^k}{20''}$$

$$= 2.8 \text{ kips/linear in.}$$

Treat this connecting plate as a cantilever beam from the centerline with these two loads:

(1) the concentrated load of 16.9 kips at 8.75" from center, and

(2) the uniform load of 2.8 kips/in. for a distance of 10".

The resulting bending moment is then computed:

$$M = M_a + M_b$$

$$= (16.9^k)(8.75'') + \frac{(2.8 \text{ k/in.})(10'')^2}{2}$$

$$= 288 \text{ in.-kips}$$

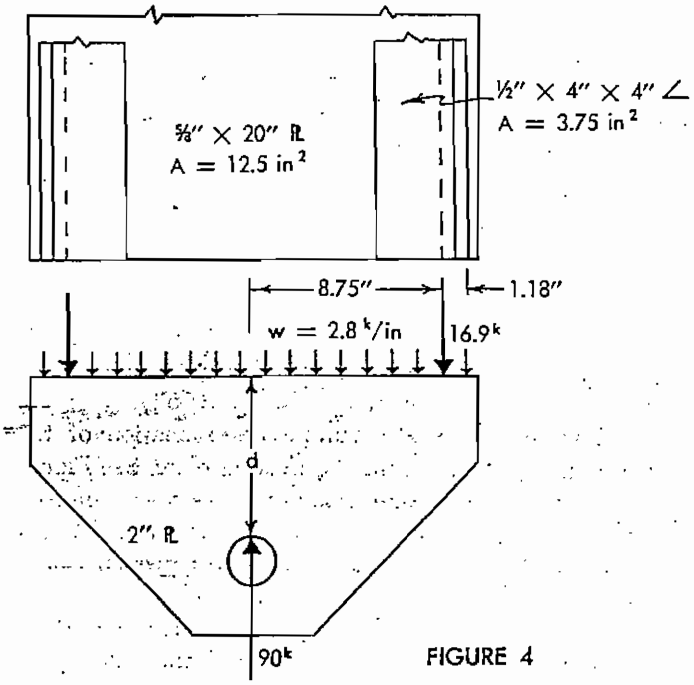


FIGURE 4

Since the required section modulus is in terms of (d):

$$M = \sigma\, S$$

$$\text{and } S = \frac{M}{\sigma}$$

$$= \frac{(288{,}000 \text{ in.-lbs})}{(20{,}000 \text{ psi})}$$

$$= 14.4$$

Since

$$S = \frac{t\, d^2}{6}$$

$$d^2 = \frac{6\, S}{2}$$

$$= 3 \times 14.4$$

$$= 43.2''$$

and the minimum depth of upper plate is found to be—

$$d = 6.58''$$

or 7" deep beyond the pinhole would be sufficient.

2. FINALIZING THE DETAIL

The final detail has been sketched in Figure 5. The outer leg of each angle might be trimmed back slightly so as to fit to the 2" connecting plate. Whether this is cut back or not, there will be a loss of 2⅝" of the angle leg. This area (A = 2 × ½" × 2.625" = 2.625 in.²) is made up by additional attaching stiffening plates. These have been chosen to be two ¾" × 3" plates (A = 4.5 in.²) and two ½" × 1⅜" bars (A = 1.375 in.²). The total added area is thus 5.875 square inches. The entire built-up compression member has an area of 20 square inches. These additional attaching plates simply mean that the cross-sectional area in contact with the 2" connecting plate is in excess of the required 20 square inches.

After the compression member has been welded, its end might be milled to provide a flat, smooth surface for bearing against the 2" plate. If this is done, the entire section would not have to be welded 100% all the way through. Under these conditions, it is suggested that a bevel be made part way through these plates of the compression member and that a groove weld be made on the outside. Reinforcing fillet welds should then be made on the inner side of this compression member where it connects with the 2" plate.

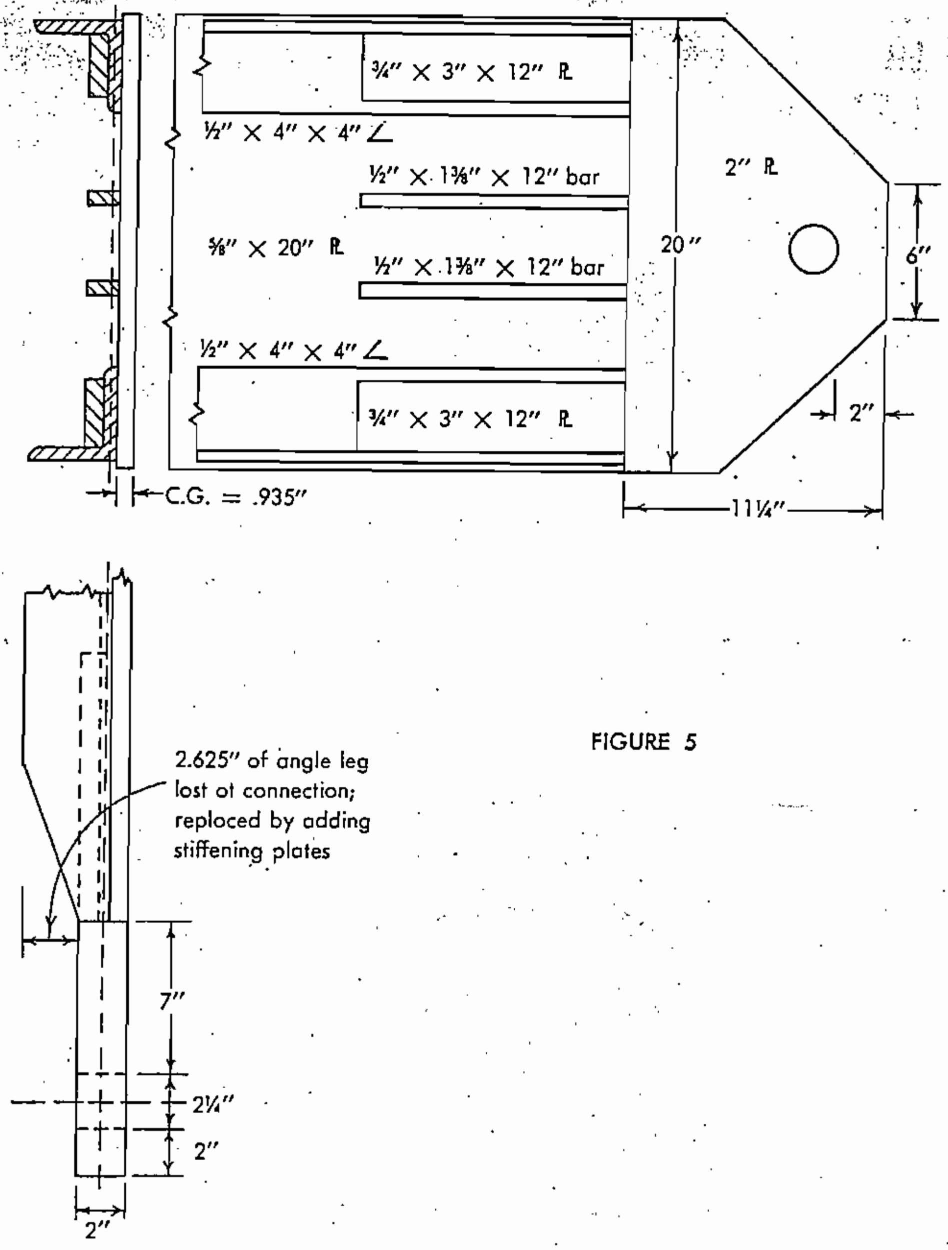
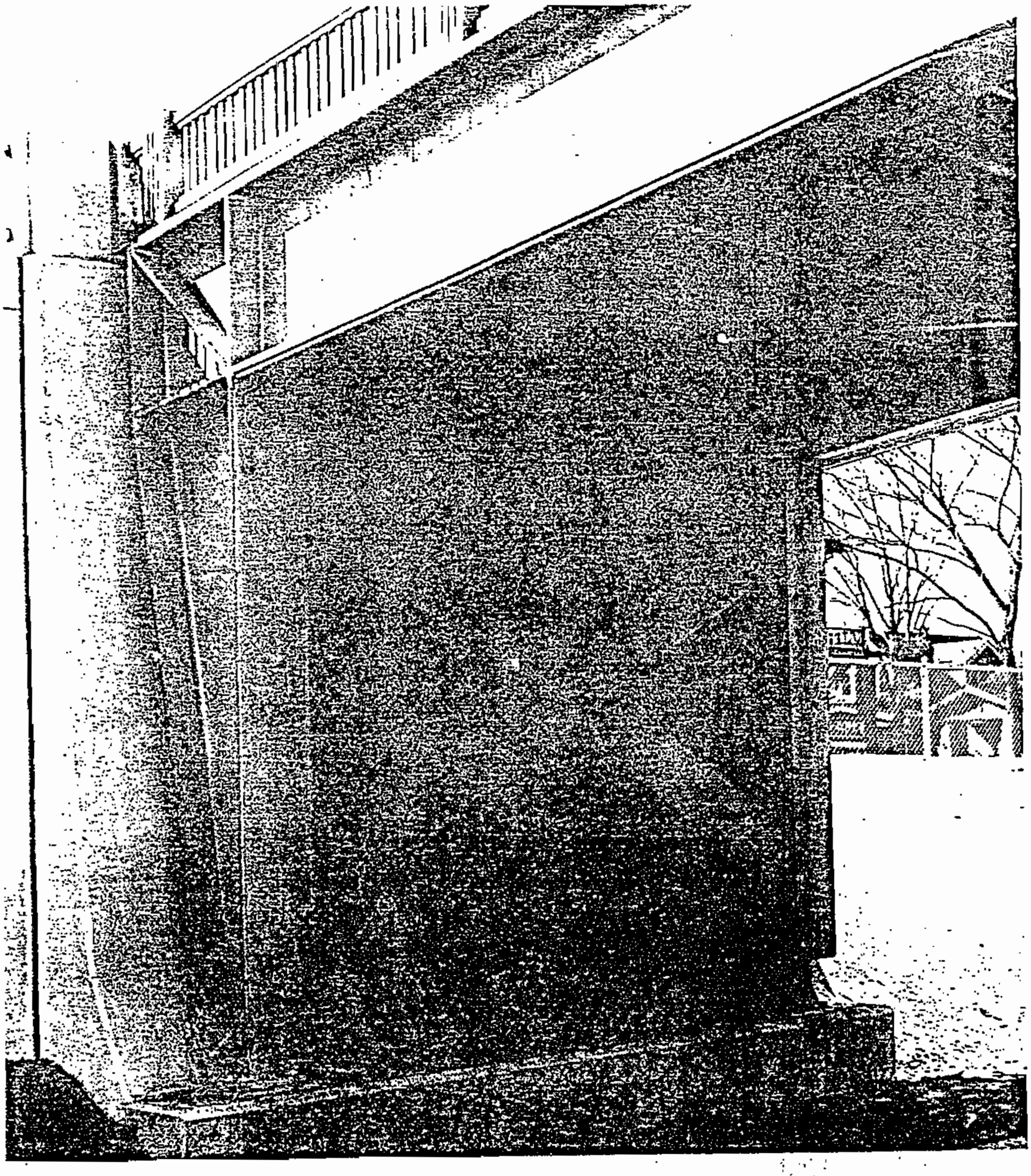

¾" × 3" × 12" ℞
½" × 4" × 4" ∠
½" × 1⅜" × 12" bar
⅝" × 20" ℞
½" × 1⅜" × 12" bar
½" × 4" × 4" ∠
¾" × 3" × 12" ℞
2" ℞
20"
6"
2"
C.G. = .935"
11¼"
2.625" of angle leg lost at connection; replaced by adding stiffening plates
7"
2¼"
2"
2"

FIGURE 5



Bearing-pin connections like those shown on this bridge over Michigan's John C. Lodge Expressway must be designed to transfer the compression load without eccentricity. Note simplicity and beauty of the welded rigid frame employed in this bridge design.