



## Lessons Learned in the Field

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# Consider the Transfer of Stress through Members

### Introduction

Here I am, back again. In the second issue of 2001 (Vol. XVIII, No. 2), the editors of *Welding Innovation* were delighted to publish an excellent piece in this space: "Persistence Pays Off" by Rob Lawrence of Butler Manufacturing. Now, where are the submissions from the rest of you out there?

I started this column a couple of years ago with the idea of providing a forum in which our readers could share the important principles gleaned from the everyday challenges of working in the field. It seems to me that often the "evident" solution to a problem turns out to be a dead end. I call these my "ah-ha!" moments. Surely they've happened to many of you. Think about what you actually learned from these experiences, that you were able to apply again in other situations. Then send an email describing your column idea to Assistant Editor Jeff Nadzam at [Jeffrey\\_Nadzam@lincolnelectric.com](mailto:Jeffrey_Nadzam@lincolnelectric.com). Don't worry about preparing a finished, illustrated article. Our writers, editors and artists can help with that. We're just looking for a description of the real-life circumstances, and a statement of what you learned.

All right, then, here are some more lessons I learned, not in school, but working in the field.

### Provide a Path for Transfer of Stress

A common design oversight is the failure to provide a path so that a transverse force can enter that part of the member (section) that lies parallel to the force.

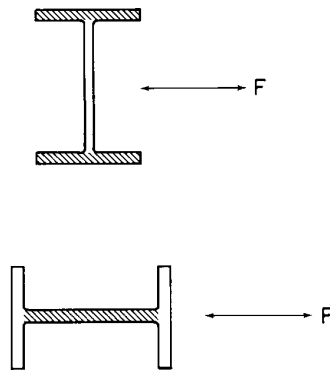


Figure 1.

Given what is needed for the proper transfer of force (as shown in Figure 1), let's consider some examples.

The top of Figure 2 shows a lug that has been welded to a flanged beam in the simplest and most efficient manner—so the force goes into the web, the part parallel to it. In the center sketch of Figure 2, the lug is placed across the bottom flange, necessitating the use of either rectangular or triangular stiffeners to transfer the load to the web. If, for some reason, the cir-

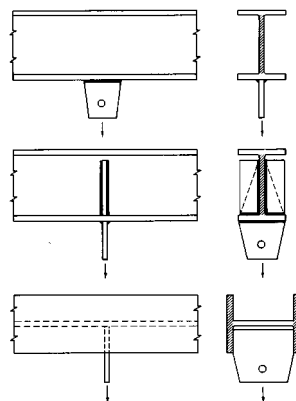


Figure 2.

cumstances require the lug to be placed in this manner, the stiffeners (with the attendant increase in welding and material usage they entail) are mandatory. Merely welding the lug across the more flexible flange could result in an uneven load on the weld. Note that the stiffeners are not welded to the top flange. There would be no reason to weld them there, since the flange will not take the force. At the bottom of Figure 2, the member is in a different position, and the lug is cor-

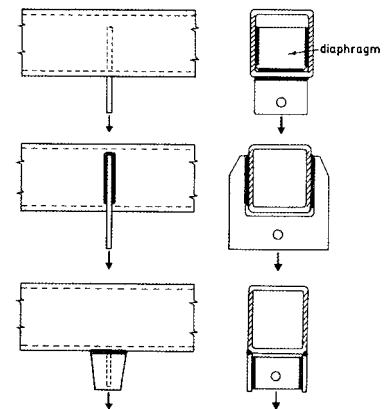


Figure 3.

rectly welded to the flanges that will take the load. It is not welded to the web, since that would serve little purpose in transferring the force.

Figure 3 illustrates how a lug might be welded to a box section so as to transfer force to the parts parallel to it. The sketch at the top, of course, is not applicable to the rolled section shown, since there would be no way of getting the diaphragm inside the box. But if it were a fabricated box section, the diaphragm could be welded in before welding the top plate on. The center

and bottom drawings in Figure 3 show additional ways to attach a lug to a box section. In the center, the lug is shaped as a sling and directly welded to the flange. At the bottom, the lug is designed so it will transfer the force into the two webs. This is a very efficient way to transfer the force on the lug into the webs.

### When the Member Is Circular

Figure 4 illustrates two methods of applying a transverse force to a circular member. The rationale for these methods of attachment is shown in

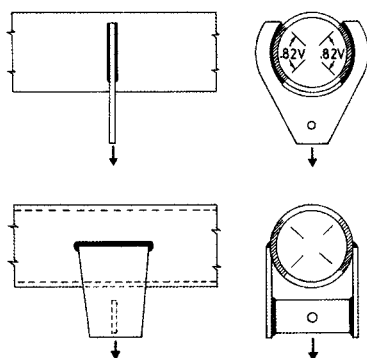


Figure 4.

Figure 5. At the top of Figure 5, the beam is welded to a support. In standard practice, it is assumed that the flanges transfer the bending moments and the web transfers vertical shear. In the case of the circular member at the

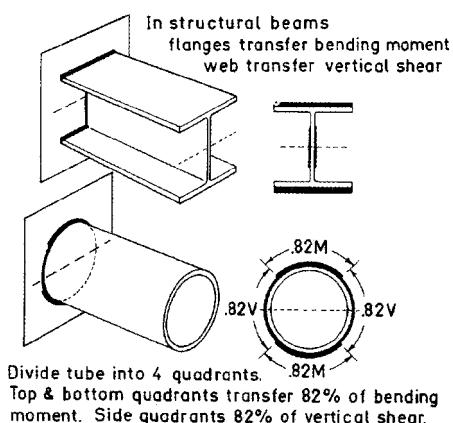


Figure 5.

bottom of Figure 5, however, it is difficult to decide which part of the member is flange, and which part is web. Mathematical analysis has shown that if a tube is divided into four quadrants, the top and bottom quadrants will transfer 82% of the bending moment, and the side quadrants, 82% of the vertical shear. The methods of attaching the lug shown in Figure 4, therefore, are methods that transfer force tending to cause vertical shear into the areas of the circular section most closely parallel to the force.

### More Complicated Examples

Figure 6 provides a more complicated example of force transfer. A tank to haul water on a truck is made up of 1/4 in. (6.4 mm) thick plate, with the sides overlapping the ends so as to provide fillet welds. Considering the forces from the water pressure on the tank ends, the only place for them to

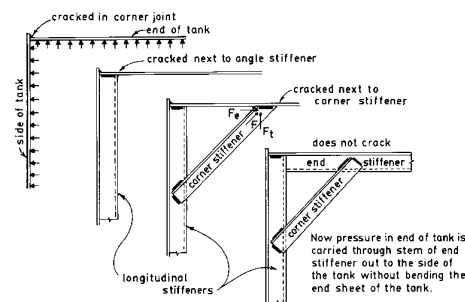


Figure 6.

go is through the welds and into the sides—the parts parallel to their direction. The forces get there by bending the end plate. In service, the welds cracked. Three remedies were tried successively, as shown in Figure 6, using longitudinal and corner stiffeners, and finally both longitudinal and end stiffeners with corner stiffeners.

Figure 7 shows the center sill of a piggyback railroad car to which a bracket is welded to carry a 500 lb. (227 kg) air compressor unit. There are no interior diaphragms. The vertical

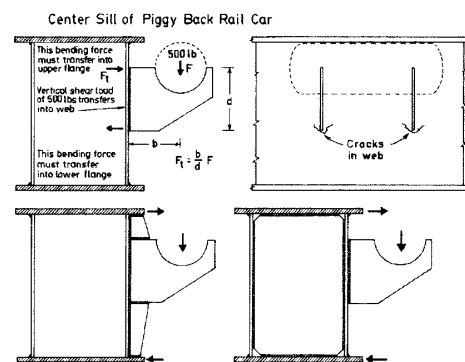


Figure 7.

force from the weight of the unit is transferred as moment into the bracket, creating bending at the web. The two horizontal bending forces must eventually transfer to the parallel flanges, but with an open box section there are no ready pathways. As a result, the web flexes and fatigue cracks appear in the web. The sketches at the bottom of Figure 7 illustrate two possible means for correcting the faulty design. In one, a stiffener is added before the web opposite the bracket side is welded into the assembly. The stiffener is welded to both flanges and to one web. There are now paths for the bending forces to get to the flanges. The second way to correct the design is to shape the bracket so it can be welded directly to the sill flanges in new fabrications, or to add pieces to the bracket on existing cars to accomplish the same purpose.

### Conclusion

The foregoing are just a few examples intended to illustrate the importance of considering the transfer of force through members. Sometimes we engineers act a little like horses with blinders on: we concentrate so single-mindedly on the problem at hand, that we can't see what is going on around us. The ideas discussed in this column should demonstrate how critical it is for us as engineers to take our blinders off, expand our limited views, and test our assumptions.

