

Fabrication Tips

Q. Is fabrication dangerous?

A. Only if you are uninformed, careless or negligent. Every process and tool for steel fabrication has its own technique and safety guidelines. Get instruction from a qualified person before you start fabricating, proceed thoughtfully and cautiously, and follow all safety guidelines.

Q. We designed our bridge to be exactly as high as the rules permitted and then we cut, drilled and welded according to our calculated dimensions but the bridge turned out to be 1/8 inch too high so the contest judges imposed a penalty. What happened?

A. Fabrication processes are subject to statistical variation so there's a 50% probability that an as-built dimension will be larger than its intended value. There are also statistical variations in site conditions and the possibility of making an outright mistake in fabrication (e.g., misreading a measurement). The dimensional requirements in the contest rules are enforced without tolerances because they are limits (i.e., maximums and minimums). You can reduce the probability of violating a dimensional limit by designing slightly on the safe side. For example, if your design height had been 1/4 inch less, there would not have been a violation even though the bridge turned out 1/8 inch higher than it was designed to be.

Q. After we fabricated and assembled a truss, its shape did not match our drawings or the truss for the other side of the bridge. How can we build more accurately?

A. Try drawing the truss full size on panels (e.g., plywood, OSB, gypsum board). Then cut members to fit the drawing, lay them on the panel, connect the bolted connections and tack weld all other connections (careful not to burn the panel – have some water handy). Then undo the bolted connections, remove the parts from the panel and finish welding.

Q. We designed a four-sided frame with a diagonal and then cut all five members to their design lengths but when we assembled the frame the diagonal didn't fit. How can we prevent this problem?

A. Cut and assemble the four sides first, then cut the diagonal to fit.

Q. How can we make sure that every corner of a rectangle is 90 degrees?

A. Measure both diagonals – they should be equal.

Q. We designed a connection so that two members would form a 40 degree angle. We used a protractor to align the two members before welding the connection but the connection did not line up when we assembled the bridge. How can we lay out an angle more precisely?

A. Throw away the protractor and rely on trigonometry. For example, you could have marked one member at 36 inches from the center of the connection, marked the other member $36 \cos 40 = 27\text{-}9/16$ inches from the center of the connection, and then aligned the two members so that the marks were spaced $36 \sin 40 = 23\text{-}1/8$ inches. Even with rounding those dimensions to the 1/16 of an inch, the angle would be accurate to a few hundredth of a degree, much closer than you can read a protractor.

Q. How can we precisely mark steel for cutting or drilling?

A. First apply black marker in the general area, then scratch fine lines in the black using a straight edge and scribe or sharpened steel rod. The scratch will be very visible in contrast to the surrounding black.

Q. We carefully measure and mark the centers of holes before drilling but sometimes the holes are slightly off their intended locations. How can we make sure that a drilled hole is in the right place?

A. You will need a drill press, center punch and center drill bit (a center drill bit is short, with a large shank diameter and small cutting tip – this makes it stiffer than a regular drill bit). First locate and mark the center, then use the center punch to make a small dent at that point. Chuck a center drill bit into the drill press and clamp the part to the table so that the bit fits into the dent. Make a guide hole with the center drill bit – it does not need to completely penetrate the part. Finally, finish the hole with a regular drill bit.

Q. We wanted to make holes in two pieces that should line up. We measured carefully to locate the center of each hole but after drilling they did not line up. How can we make holes that line up?

A. The best way is to hold the two pieces together with clamps or tack welds, then drill through both. If this is not possible, drill the outside piece and use the proper size transfer punch to mark the center on the inside piece. A transfer punch has the same diameter as the hole and has a centered punch point – it works best if the first hole is through thick material.

Q. We tried to make several identical welded parts but they didn't turn out to be perfectly identical. What's the trick?

A. First make a jig – just a steel plate with shims and stops welded to it so that the pieces to be welded fit snugly between the stops. Use the jig to hold the pieces while you tack weld, then remove the part from the jig and complete the welds.

Q. We cut two members and welded connection fittings to them, then put them together and tried to drill a hole for the bolt that would connect them. It was very difficult to hold the two members in position for drilling. Is there a better way?

A. Always think carefully about the sequence of fabrication. In this case, it might have been better to match drill the connection fittings first, bolt them together and then weld the members to them.

Q. We want to buy a welder. Which process is best for the student steel bridge contest?

A. “Gas metal arc welding” (GMAW, frequently called MIG welding) is easy to learn with a little instruction and practice, and works well for the material thicknesses most commonly used in contest bridges. However, novices sometimes fail to achieve adequate fusion due to improper technique or machine settings. These “bubble gum” welds usually are weak and appear lumpy and bulky, with edges that do not merge smoothly into the base metal. “Gas tungsten arc welding” (GTAW, frequently called TIG welding) is less prone to this problem and is better for very thin steel but requires considerably more skill.

Q. What's a tack weld?

A. It's a small weld that holds pieces together temporarily. Tack welds are meant to be removed (usually by grinding) or incorporated in the permanent weld.

Q. Parts bend and warp when we weld them. How can we prevent this?

A. Clamp the pieces together and tack weld them symmetrically (i.e., same size tacks on opposite sides). Then recheck the alignment of the pieces and correct if necessary (small tack welds will accommodate a little bit of realignment). Minimize the size and length of the final welds to be just strong enough (with an adequate factor of safety), and make them as symmetric as possible. Build them up by symmetrically placing relatively small segments, allowing the part to cool a few minutes after each pair of segments.
