WELDED STEEL CONSTRUCTION

By EDWARD M. SEVCIK, '30

Since its initial introduction into the heavy structural steel field, about three years ago, arc welding of steel structures has progressed very rapidly. It has demonstrated important economies in erection. Welded buildings have meant a saving in steel tonnage over that which would be required for equivalent riveted structures.

What is arc welding? It is a process used for joining or for building up metals. Electric arc welding is sometimes known as autogenous welding since it is that process by which metals to be welded are raised to such a temperature that they will flow together and form a weld without the use of force or pressure.

An arc is formed by current flowing across a gap in an electric circuit, the incandescent vapor providing a path for the arc stream. The metal in the arc stream is in both the liquid and gaseous form, the liquid metal being transferred across the arc by molecular attraction, adhesion, cohesion, surface tension or a combination of these. The transfer of metal can be accomplished against the force of gravity. The metal is melted at the point where the arc strikes the plate or work causing a crater to be formed. Observation of the depth of the arc crater provides a means of gauging the penetration so as to produce good fusion while welding.

WELDED JOINTS

The tensile strength of the fused metal in a flush welded joint, in rolled steel, assuming perfect fusion, will be approximately 80 per cent of the tensile strength of the original work. In cases where bending stresses are encountered the weld is made stiffer than the adjoining parts, so that the bending will take place outside of the weld. The metal added by the welding process is considered a high grade of cast steel, and from this it is readily seen that all of the effects of electrode treatment previous to welding have been eliminated. Also, the degree of fusion will depend upon the operator and the manner in which he handles the arc. The metal added should be free from oxide and slag.

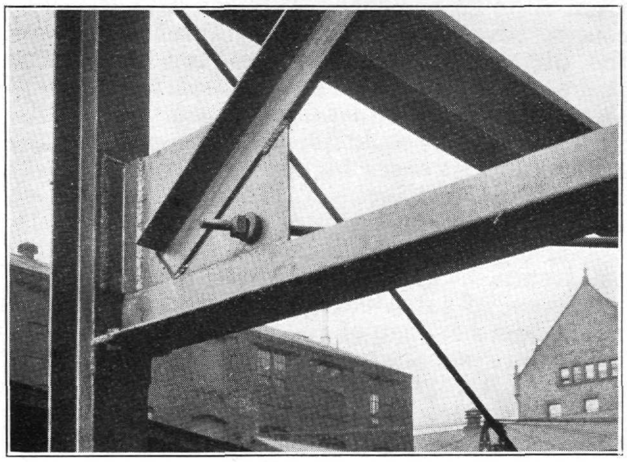

Fig. 1.—View of end gusset plate and joining of the truss to the column.

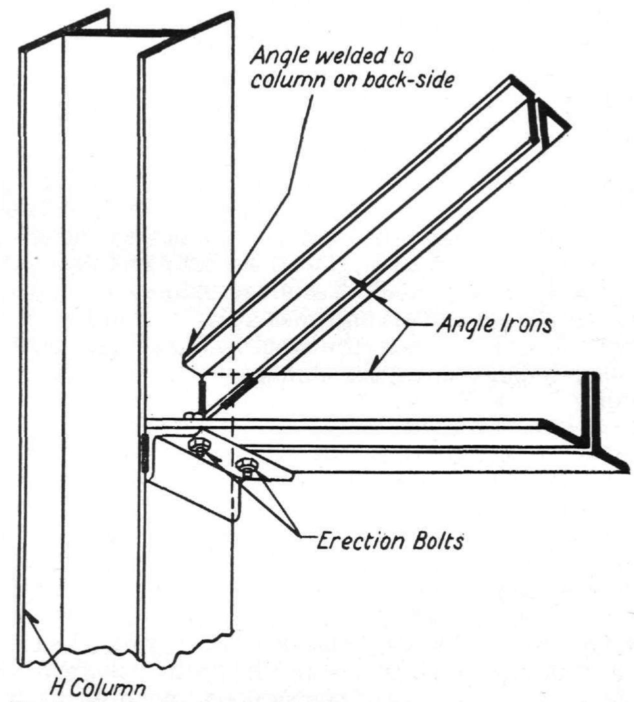

Fig. 2.—Sketch showing the better way to weld the truss members and join them to the column. No gusset plate is used.

The expansion of structural welding has caught the attention of engineers, architects, and builders. As with every new process, however, the progress has been slow at the start. Ultra-conservative policies have been followed; but, as designs are being worked out and shop equipment is made more efficient, the relation between the cost of welded and riveted structures shows further favor toward the welded. Automatic arc welding has been one of the big steps forward.

WELDED STRUCTURES ARE RECENT

The first welded structure of any considerable size was a five-story building erected at Sharon, Pennsylvania, in 1926. This 790-ton skeleton steel job involved four miles of field welding, and about eight and one-half tons of welding wire. The building is 70 feet wide, 220 feet long, and 80 feet high. Since that time numerous other structural steel buildings and even bridges have been erected by arc welding.

The maximum advantages inherent in using arc welding can be joined only by designing the work specifically for welding. If the process is used simply as a substitute for the rivet, results are likely to prove disappointing. When completed the product should be really a job in which every possible advantage of welding has been incorporated into the design.

The truss end shown in Fig. 1 is an example of how not to weld. The strength is there but the advantages of welding have not been utilized. The welding has simply been used to replace the rivet in a truss designed for riveting. Twice as much welding was done as was really needed. The members were welded to the gusset plates

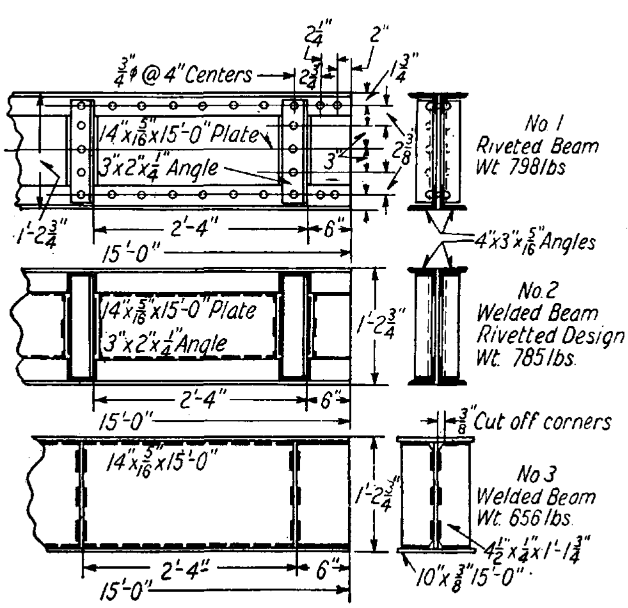

Fig. 3.—Three equivalent beams illustrating the advantage of welded design over the riveted.

and the plates in turn welded to the main truss members. Why not weld the members directly to each other, thus reducing the amount of welding and eliminating the gusset plate material? Fig. 2 shows the better method of welded fabrication for such a truss.

Warpage

Warpage is one of the things that has to be watched for, especially in light truss work. It is caused by unequal expansion and contraction. Expansion and contraction cannot be controlled by force and it is almost useless to try to oppose them. Metals when heated expand or increase in volume and when cooled show a corresponding contraction or decrease in volume. The added or weld section on contracting exerts a pull or force that bends or bows the work.

One of the many important advantages of welding is that of continuity of beams. This is especially important in railroad bridges. The purpose of continuity of beams, or stringers, is twofold: first, to prevent the stringers from sloping at their ends when live load is applied, this repeated motion being a serious source of fatigue in riveted stringer connections; second, to reduce bending moments and thereby permit use of lighter stringers. It is expected that the welded railroad bridges of the future will prove somewhat more permanent than riveted ones because the immovability of the joints removes the chief cause of fatigue. Although weld metal is less ductile than rivet steel, a properly designed and executed welded joint should have greater endurance under stress reversals than a good riveted one, because in the latter case the connection members and rivets are subject to slight motions back and forth, frequently beyond the elastic limit.

Advantage of Welded Design

There is no question as to the advantage of welded design over the riveted in general. This may be brought out by an illustration. In Fig. 3 we have three equivalent beams, each 15 feet long. The first is a riveted beam, the second is a riveted design in which welding replaced the rivet, and the third is a welded beam designed for such fabrication.

Beam No. 1 is the usual riveted type and weighs 798 lbs. It was center loaded and failure took place by buckling of the top flange, the yield point being 55,000 lbs. and the ultimate load 68,900 lbs. Section modulus was 61.1

Beam No. 2 is identical with No. 1 except that its parts were welded together. It weighed 785 lbs. Failure occurred by crimping of the top flange. Elastic limit was 65,000 lbs.; ultimate being 77,200 lbs. Section modulus was 60.2.

Beam No. 3 was designed to take advantage of the possibilities in joining steel members with the electric arc. No angle iron was used—just plate material. The web stiffeners were welded solid to the flanges. The beam weighed 656 lbs. or approximately 18 per cent lighter than beam No. 1. Buckling of the top flange caused failure. Elastic limit was 65,000; ultimate was 78,000 lbs. Section modulus was 62.2.

This shows the advantage of designing the piece for welding by placing the metal in locations where the greatest strength can be developed with the amount of material used.

Author's Note: Much of this material has been taken from various pamphlets issued by the Westinghouse Electric and Manufacturing Co. The photographs were also furnished through the courtesy of this organization.

LARGE TURBINE SPINDLE SHIPPED FROM PHILADELPHIA

The largest turbine spindle, so far as maximum diameter is concerned, ever built by the Westinghouse Electric & Manufacturing Company, was shipped recently from the South Philadelphia Works. It was built for the Milwaukee Electric Railway & Light Company, Milwaukee, Wisconsin.

At the time it was designed it appeared the only way it could be shipped completely bladed, was to dismantle it and ship it in two sections on account of the extreme dimensions. The coupling end measured 12 feet 2 inches in diameter across the blades from tip to tip while the thrust end measured only 5 feet 8 inches, with a width of 23 feet 11 inches for the shaft from end to end. Therefore, by loading it in a diagonal position the actual width of the load would be reduced to 11 feet 9 inches.

It was doubtful if the railroad company would accept the responsibility of moving such a load, especially through such congested and busy cities and rail lines from Philadelphia to Milwaukee. A contract was made with the Pennsylvania Railroad Company that they would transport the load provided it did not exceed 11 feet 9 inches in width.

When the spindle was ready for shipment a special depressed type of car was secured from the Pennsylvania Railroad Company having a capacity of 210,000 pounds and the floor 2 feet 5 inches high from top of rail. A specially constructed skid was built and fastened to the car by means of steel rods and bolts. The net weight of the spindle loaded on the skid was 110,980 pounds.

The loading was planned so that all the additional weight used to balance the car consisted of other parts of the turbine unit, and it was not necessary to use any dead weight.