A BRIEF STUDY OF WELDED JOINTS OF STRUCTURAL STEEL

THESIS FOR THE DEGREE OF B. S.

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A Brief Study of Welded Joints
of Structural Steel

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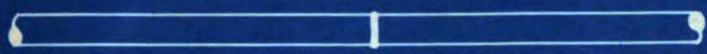
The subject of "Welded Joints of Structural Steel" was selected because of its personal interest to me. The object of this brief study was to secure data for my own information and for the Jarvis Engineering Co., who supplied me with the samples for the various tests. Very little information upon this subject is available, and that which is available has been in use only a short time, and only by those companies who have had special tests made for their own use. This being the reason for Jarvis Engineering Co. desiring information of this kind in connection with their purposed types and methods of welding of structural steel.

This experimental study was the comparison of welded joints with similar riveted joints. All data concerning rivets in tension and shear is known and a comparison of the two types of joints may be made from the following data as found by test of their special welded joints.

Sample No. 1 was a 5/8" diameter round structural steel rod with an acetylene taper weld. This rod was tested in tension and found to neck and break at 13,950#. This was the actual tensile strength of the rod and the acetylene weld showed no defects due to the tension test.

Sample No. 2 was a 3/4" diameter round structural steel rod with an acetylene taper weld. This rod was tested in tension and found to break at 24,320 lbs. This break did not occur in the weld but in the parent metal adjacent to the weld. This is evidence enough to prove that the steel was defective, due to the process of welding alone.

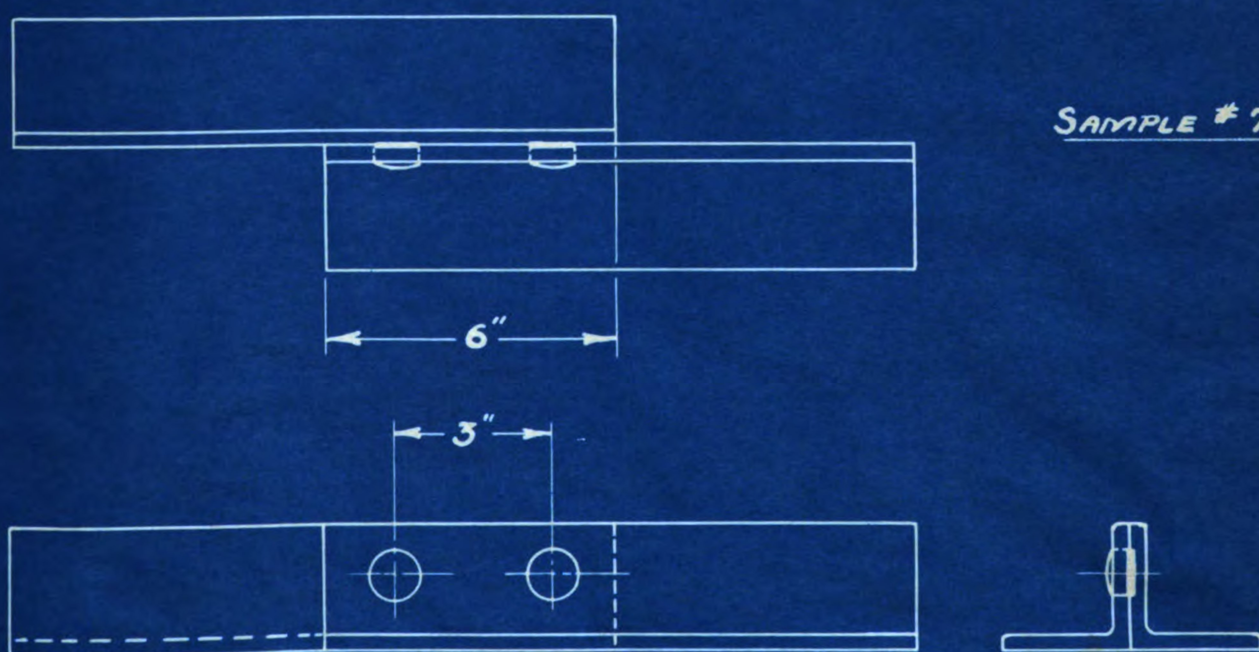
ROUND STRUCTURAL STEEL
RODS TESTED IN TENSION



SAMPLE	WELD	SIZE
#1	ACETYLENE	5/8" Φ
#2	"	3/4" Φ
#3	ELECTRIC	5/8" Φ
#4	"	5/8" Φ
#5	"	3/4" Φ
#6	"	3/4" Φ

2" x 2" x 1/4" Ls - STRUCTURAL STEEL WITH 3/4" RIVET WELD. SAMPLE TESTED FOR SHEAR IN WELD.

SAMPLE # 7a



NOTE: THIS METHOD USED INSTEAD OF GUSSET PLATE AND RIVETS

NOTE: HEAVY LINES SHOW WELDS

Sample No. 3 was a 5/8" diameter round structural steel rod with an electric taper weld. This sample was placed in tension and found to neck and break in the rod at 14,060 lbs. The weld showed no defects due to the test in tension, and may be used as a comparison to the test of sample No. 1 with the acetylene taper weld.

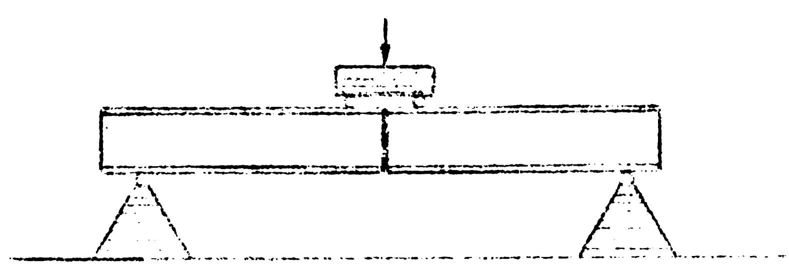
Sample No. 4 was also a 5/8" diameter round structural steel rod with an electric taper weld. This sample was placed in tension and found to neck and break at 14,030 lbs. showing no defects in the weld due to the test. This test checks very closely with that of sample No. 3.

Sample No. 5 was a 3/4" diameter round structural steel rod with an electric taper weld. This sample was tested in tension and found to neck and break at 24,680 lbs. with no defects due to the process of testing the weld.

Sample No. 6 was also a 3/4" diameter round structural steel rod with an electric taper weld. This rod was tested in tension and was found to neck and break at 24,980 lbs. with no defects in the weld. This is also a very good check on the welding of sample No. 5.

Sample No. 7 was composed of two 2"x2"x¼" angles with one leg of each angle welded together by a ¾" rivet weld. This weld was made by punching two-¾" holes in one leg of one angle and carefully filling these holes with weld after the two angles had been clamped together tightly. This sample was tested in tension, or for shear in the rivet welds. The first rivet weld sheared at 28,270 lbs., but the second started to pull the steel of angle 1 with it. The shear test was slowly continued and the weld finally sheared at 29,790 lbs. but left the steel of angle 1 greatly deformed. This type of weld is being used. replacing, in many cases, the method and practice of gusset plates and rivet construction for similar joints.

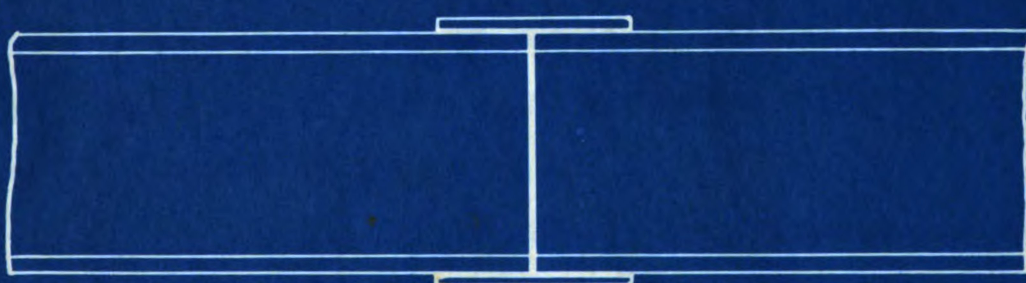
Sample No. 8 was a 5" standard I-beam cut then welded back together, the weld being on all surfaces of the beam. This sample was tested for tension in the weld in the lower part of the I-beam by a method of placing the load in two places as shown in the following diagram. The load was applied until the beam became so deformed that the test could be continued no farther. The load applied was about 22,000 lbs., and the test proved that the weld was far stronger than the beam in bending and there were no defects in the weld arising from the test. The following diagram will show how the beam was supported and the load applied.



Sample No. 9 was made of a 5" I-beam in the same manner as sample No. 8 except there were two 4"x3"x½" plates welded on the top and bottom as shown in the figure. This sample was tested in practically the same manner as No. 8 except the load was applied at one point only, directly over the weld. This sample was obviously much stronger than

5" I-Beam Welded On All Sides
(3 Point Loading Used)
Tested In Bending

Sample #8

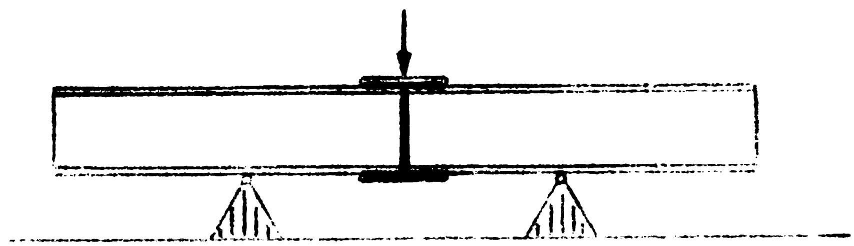


Sample #9

5" I-Beam Welded On All Sides With
4" x 2" x 1/4" Plates Welded On
Top And Bottom
(2 Point Loading Used - Tested In Bending)

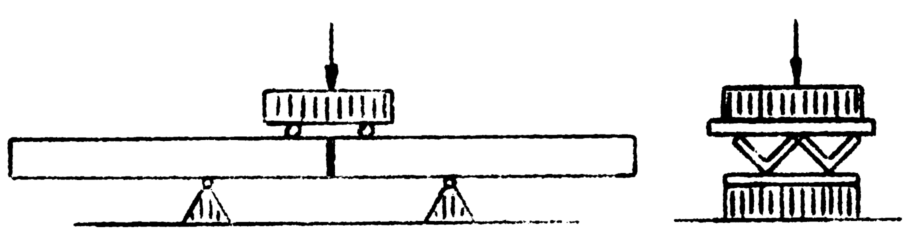
Note: Heavy Lines Show Welds

the other one, so the supports were arranged as shown in the figure, thus increasing the load of the testing machine a great amount and obtaining a more desired result than if the supports had been spaced farther apart. The only information obtained from this test was that the weld was far stronger than the sample of I-beam in bending.



The load was carried to 46,000 lbs., and the only defect was the deformation of the web of the I-beam right at the weld, and the bending of the beam.

Samples No. 10, No. 11 were constructed exactly alike and were tested together. They were composed of 2"x2"x¼" angles cut then welded together, the weld being on all surfaces of the angles but were ground smooth on the outer side of each angle. They were supported and loaded as shown in this diagram.



The load was carried to 7000 lbs. before it was evident that the weld was much stronger in bending resistance than the structural steel itself. These angles were flattened out under

4-2"x2"x1/4" STRUCTURAL STEEL ∠s
TESTED IN BENDING

SAMPLES #10, #11, #12, #13

2 ∠s TESTED BY 3 POINT LOADING
2 ∠s TESTED BY 2 POINT LOADING

NOTE: ALL WELDS GROUND SMOOTH ON OUTSIDE OF ∠s

5" CHANNEL WITH 4"x1/4" PLATE WELDED TO
BACK OF CHANNEL

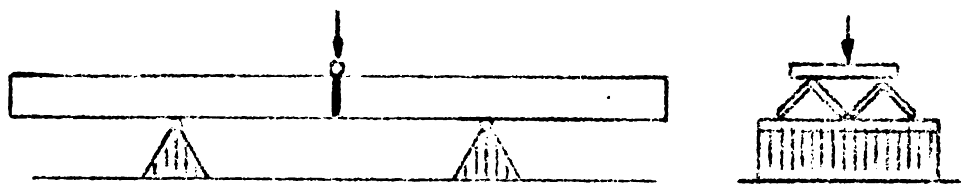
NOTE: WELD TESTED FOR BENDING AND
SHEAR AT SAME TIME

SAMPLE #14

NOTE: HEAVY LINES SHOW WELDS

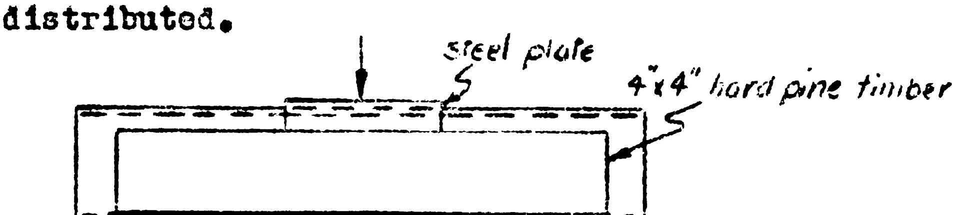
the load but the weld remaine unchanged and seemed as strong as ever.

Samples No. 12, No. 13 were of the same construction as No. 10 and No. 11. The only difference being in the test made. These angles were supported and loaded as shown here.

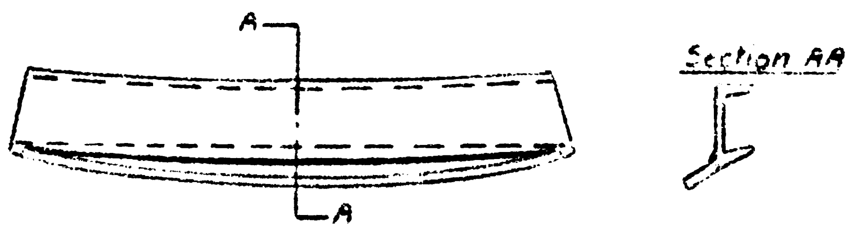


The load was carried to 5,000 lbs. and the only deformation was in bending but there were no defects in the weld due to the test. This method of construction could be used in place of the splice angle construction at a much lesser cost.

Sample No. 14 was a somewhat difficult sample to load but due to the fact that such a structure is often used in steel construction it was important to obtain some very good results if possible. The Sample was composed of two parts, a standard 5" channel with a 4"x½" plate welded to the back of the channel, with the weld on the upper side only, as shown in the figure. This sample is used in practice in supporting brick veneer over doors and windows or any small arches. The exact way in which this would be loaded is not known, so for the test a load was used which would be the maximum in any case. The load was built up as shown in the following figure in such a manner that the load was almost uniformally distributed.



A load was applied as shown and carried to 18,000 lbs. before any deformation was noticeable. This is far more than any loading on an arch from veneering. At this point the plate started to bend downward; the loading was continued and was carried 26,000 lbs. and here the test was halted. The plate was bent down on the outer edge about 3" below its original position. All of this particular deformation was not in the plate alone, but a great part of it occurred in the channel itself. This sketch will illustrate how the deformation occurred.



The weld seemed as strong as previous to the test and showed no signs of pulling from the adjacent steel, nor did it flake in the process of testing. This sample was not welded on the under side of the plate because it is seldom easy for a welder to weld the under side of a structure when it is in place and this type of construction is entirely field work. It also makes a much smoother structure for the fitting of frames such as doors and windows.

It is seen from these tests, also from recent tests conducted by many construction companies, that the advantages and disadvantages of welded joints are somewhat different from those of riveted joints. The following lists are some of the advantages and disadvantages of each type of joint.

Riveted Joints.

Advantages:-

1. Dependable and calculable strength.
2. Rigidity due to the added metal of the lap or butt joint.
3. Resistance to vibration, impact, and to rapid changes in temperature.
4. Parts are drawn tightly together.

Disadvantages:-

1. Difficulty of repair.
2. Increased opportunity for corrosion through holes and river heads.
3. Compromises in design to accomodate riveting machinery.
4. Weakening of plates at holes.

Welded Joints.

Advantages:-

1. Full section of plate is available because no holes are necessary.
2. Low cost.
3. Speed with which repairs may be made.
4. Smooth surfaces for linings and insulations.
5. Decreases weight approximately 15%.

Disadvantages:-

1. Tendency toward brittleness of welds cast in place.
2. Uncertainty of strength.
3. Lack of uniformity in composition between the weld and the parent metal, resulting in variable corrosion resistance.
4. Unworkmanlike appearance of much welded work.

Many architects and builders have had a longing desire to erect a one-hundred story building. This desire may now be realized only since the development of the new type of electrically welded flooring which materially reduces the weight of the structure.

Recently a new floor construction, known as the "battle-ship" type, was announced and given its first public demonstration at Biloxi, Miss. This floor is one in which steel plates and steel beams are used and are stitched together to form the flooring. Machines for welding this type of flooring have been designed by the General Electric Co., so that hand labor is required only to guide the machine and the skilled electric arc welder is no more needed. The speed of this machine is automatically controlled and may be adjusted to various grades of welding thus eliminating any chance of overheating the parent metal of the weld.

This steel plate flooring or steel deck will act as a girder to prevent any torsional distortion of the building when subject to wind or earthquake action, and in general a building having this type of floor construction is much more rigid in every respect.

Comparative costs have been figured for this type of floor using a heavy grade of linoleum and perhaps a rug to reduce noise, and the old type of concrete slab construction with a wood flooring and a rug which was required for quietness. It was found that the "battle-ship" flooring with the linoleum covering was much better because of the lower costs and because there is no chance whatsoever of shrinkage and cracking. Also it is considered in a design that if a part of the foundation should fail the floors of this type would easily take care of the failure without allowing cracks to appear.

This type of flooring is equally applicable to residences, multiple story buildings, and even to bridges. For building construction it will save from 20 to 60 pounds per sq. ft. of floor in dead weight. In a 75-story building, it is estimated that with floor panels $21\frac{1}{2}$ ft. by $22\frac{1}{2}$ ft., the saving in dead load on the foundations for each column is nearly two million pounds, which indicates that its use will permit an increase of 25 percent or more in the height of buildings or in the number of floors without increasing the loads on the foundations.

Practical tests have been made in connection with loaded roof trusses. One arc-welded roof truss with a

54 ft. span was erected and found to withstand the maximum loading for the beams and angles and was much more rigid when loaded with snow or in heavy winds than a same rivet roof truss. The saving in weight of this welded truss was found to be 15.5 percent for the entire roof. In some cases it has been impossible to weld all joints in a structure in the field but new equipment and methods of construction are being introduced which will enable the welder to weld all types of joints. At present some companies weld all joints constructed within the fabricating shop and rivet all field joints; others reverse the order but soon all joints in steel work will be constructed by the welding process only.

Many objections have been made by city commissioners to the noise of the riveting hammer and in some cases orders have been issued to eliminate the noise of the riveting hammer by encasing it or by use of the electric weld. Electric welding does not eliminate all of the noise of erecting a steel frame but it does materially lessen it.

Electric welding has been applied to about seventy buildings, varying in height from one to eleven stories, to a great many railroad bridges, to many steel barges, to some ships, and to many miles of steel pipe for transporting oil or water. It is because of these applications in practise and tests that the design of welded steel structures is no longer guess work. The factor of safety used is 4,5, or 6 which gives the safe or permissible stresses used in welded joint design.

To secure the greatest value possible from welding, the design of the main steel members, as well as of the joints, should be made with welding in view. Shelf angles are now being welded to columns and girders within the fabricating shop thus eliminating a great amount of shop handling of beams, girders, and columns to the different punch presses.

The building code of many cities does not permit a contractor to use welded construction within the city. This means that he must use the riveting hammer and create the undesirable noise again. With this in view most of the cities having this type of building code are revising them and permitting the construction and erection of welded buildings.

Among the first to make the correction was Pittsfield, Mass. It was the first city to incorporate welding into its building code in any form and the first eastern city to adopt the American Welding Society code. Among the largest of our cities the ones who did not make any change are:- Philadelphia, New York City, Chicago, Dallas, Schenectady, and Pittsburgh. But it is my opinion that these cities will adopt the code permitting welding as one means of securing quiet in the vicinity of hospitals, hotels, apartment houses, schools, and office buildings.

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