NOTES ON THE TEST OF A BUTT-WELD IN A 24in. x 7½in. x 100lb. ROLLED STEEL JOIST

By Mr. H. E. Grove.

Practically the whole of the author's welding experience has been confined to medium and light steel sections; that is, on steel materials not exceeding ¼ in. in thickness. Most of the results of this work have been communicated to this Institute, but up to now there has been no opportunity for indicating how butt-welds in heavy sections behave when the material is loaded beyond the yield point. At the present moment an electrically welded steel building is in course of erection at the Metropolitan Gas Company's West Melbourne Works, and incorporated in its structure are two lines of steel beams each about 95 feet long, continuous over three spans. One line is a plain 24 in. x 7½ in. x 100 lb. rolled joist, while the other has plated flanges. Each line of beam has three joints designed to make the section continuous throughout its length. The joints are four feet away from the supports in the outer spans, so that the bending moment is about one-third of the safe B.M. of the section. The shear, however, of 22 tons at the joint, approaches the maximum anywhere on the beam.

The mode of making these joints was very carefully discussed, and a good deal of time was spent in trying to perfect a splice-cover joint which would have an efficiency of 100 per cent. All the while the various designs were being laid down, the feeling persisted in our minds that a plain butt-weld would probably do all that was required, and accordingly we decided to make and test a full size specimen of butt-welded beam before finalising design procedure. There being no testing machine available in Melbourne that could test a beam of this size, we had to devise some method that would give us the information. So we placed a 100-ton hydraulic jack between the specimen and two other beams of the same section all laid flat on the floor. At each end of the beams two 1½ in. bolts with heavy channel straps bound the ends of the beams together, giving a span of seventeen feet. The jack was placed at mid span, and the joint was two feet away from the centre line of the jack. Two 3/8 in. web stiffeners were welded into the joist on each side where the jack was placed to prevent the web crumpling at that point.

The ram diameter was 7½ in., and a hydraulic gauge reading up to 4500 lbs. per sq. inch was fitted. The beam withstood this maximum gauge reading without distortion, and the beam was flogged all over the weld with a 14 lb.
hammer, showing no sign of failure. The load at this stage was 186,000 lbs., minus ram friction. The pressure was then dropped and the gauge taken out. The load was now increased and the beam distorted, indicating that the stress in the flange at the load had exceeded the yield point. The joint, again flogged, indicated no sign of failure. The maximum indicated shear was 41.5 tons, nearly twice the shear to be imposed. The maximum indicated stress in the tension flange of the beam at the joint was 15.08 tons per sq. inch, nearly six times the stress which will actually occur at the joint in the building.

The actual stress corresponding to the readings on the index of the ram pressure gauge are from six to ten per cent. less on account of ram friction. But, since the beam actually yielded under the load, it is clear that the above stresses were slightly exceeded, the yield point being somewhat in excess of the elastic limit which is at least half the ultimate tensile strength.

The 24 in. x 7½ in. x 100 lb. R.S.J. has a web thickness of 9/16 in., and the flanges taper from about 3/4 in. at the toe to 1 in. thick at the centre. The joint was prepared by bevelling the abutting ends of the flanges to 60 deg. from the horizontal, leaving a vee of 60 deg. between. The webs were bevelled on each side to a point leaving a vee on each side of 60 deg.

A butt-joint requires more care in its making than does a lap joint, or a joint with cover straps, owing to the contraction stresses that occur, and for that reason a welded butt-joint should never be made between two members rigidly fixed at their outer ends. In the test specimen care was taken to observe this point, and also to make the weld in the same manner as it would be made at erection. The web was welded vertically, and the flanges were welded from above. At erection it is necessary, in a butt-weld of this nature, to obviate overhead welding, and the bottom flange is bevelled so that the trough, formed by the vee, can be welded from above.

As the characteristics of the weld metal are a little inferior to the mild steel sections, it is necessary to compensate for this by adding an excess of metal. Our practice is to add at least 25 per cent. more metal in the joint, and to bring the weld well over the edges of the parent metal. We value the last run of metal chiefly for its annealing effect.

After lining up the members, leaving 1/16 in. space between them, the joint is first tack-welded together, and then a light run of metal is deposited on the two sections to mark
the limits of the weld. This serves to apply heat gently to
the metal, and is a guide to the welder when finishing the
weld, for fusing into this run on completion prevents under-
cutting on the parent metal. The next step is to deposit a
light run into the bottom of the vee, and when this is com-
plete the slag covering is thoroughly removed with hammer
and chisel. We do not fill the vee in from side to side, as
would seem the obvious thing to do, but one face is built up
by carrying a single run to the outer edge. After the slag
has been thoroughly cleaned off with hammer and chisel, the
weld metal is hammered with the ball peen of the hammer;
this stretches the metal which has begun to contract on
itself. A light run of metal is next deposited in the new
top to the vee, and, after cleaning from slag, the other
face is built up, cleaned and hammered. As the vee gets
smaller, so the two opposing faces are fused and "knitted"
into each other. This building up continued until the metal
was ½ in. higher than the face of the "parent" metal, and
the welding was continued over and tapering down to the
first light limiting runs laid down. This gave a width of
1½ in. all round. The last run was not hammered. Alto-
tgether 256 feet of No. 10 and 20 feet of No. 8 electrodes
were used in the test joint which took 13½ hours to weld.

The gratifying feature about this work is the certainty
with which joints of 100 per cent. efficiency can be made; in
fact, it is necessary to take care that too lavish a use of the
electrode is not made.

The President said Mr. Grove had submitted a fund of
information. No one in the State had a better knowledge
of electric welding than Mr. Grove, who had carried out some
of the biggest works here. He had shown that even the
biggest structural material could be safely welded electrically.
The thanks of the Institute were due to Mr. Grove for giving
so freely of his brains and experience.

Mr. A. Lewis said Mr. Grove had shown very interesting
examples of welding. He asked if, for the purpose of boiler
welding, the weld would be water-tight.

Mr. Grove said it would be both oil tight and water-
tight.

Mr. Lewis said he had had experience of the weld metal
being porous, and had been compelled to have recourse to
caulking.

Mr. Grove said they had undertaken an oil tank, which
was very difficult to make perfectly tight. But they had no
fear of the result. It was a question of the absolute cleaning of the metal at each layer, and the proper heating. At first they had such difficulties, but there came a time when they did not happen. It was necessary to watch the shrinkage in welding. Welding, and designing for welding, would be the simplest thing in the world if there were no expansion and contraction. That was a matter that no text book could teach. They did small portions at a time and tried to equalise it.

Mr. WM. CHAS. ROWE said he appreciated the cleaning of the surface of the metal, but he did not understand the pulling of the metal.

Mr. GROVE said the trouble in a welded joint was its inevitable contraction. In a big V joint there was contraction stress in the weld metal; and they had to try and compensate for that by stretching the metal by hammering. A steel joist with one flange plate on it would curve. They tried to anticipate as far as possible the amount of the curve, and before welding they would bend the joist in the opposite direction. Before the plate was put on they bent the beam, and when released it would come back straight. The contraction stresses thus were much reduced.

Mr. R. J. BENNIE moved a hearty vote of thanks to Messrs. A. B. Robison, A. Lewis and H. E. Grove for their valuable papers. They had supplied some very valuable information. The information in connection with the Queensland Sugar Mills was very interesting. He was familiar with the work outlined by Mr. Grove. It presented many interesting problems. It was part of a work of construction upon which they hoped in a few months to present a joint paper.

Mr. WM. CHAS. ROWE, in seconding the vote of thanks, said the evening had been one of the best for a long time. It was particularly noticeable that the paper by Mr. Robison had resulted in much additional information being received from another source.

The vote of thanks was carried with acclamation.
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