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METALLIC ARC WELDING AS APPLIED TO BRIDGES AND ALLIED STRUCTURES WITH SPECIAL REFERENCE TO THE NORTH WESTERN RAILWAY

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Joining steel or iron members of a structure together by Metallic Arc, also known as Electric arc Welding, instead of using rivets or bolts is becoming an important branch of Structural Engineering. In Western Countries the method of Metallic Arc Welding has already become very common.

The process means the fusion together of two surfaces of metal so that the junction shall have all the qualities of the parent metal. For this, an electrode applied along the line of the weld is fused into the parent metal by the heat of the electric arc. The quality of a welded joint depends on three things: the electrode, the temperature of the weld during fusion which is in direct relation to the current used, and the skill of the operator.

There are 3 types of electrodes, i.e. bare wire, paste coated and asbestos covered alectrodes. Welds made with bare wire electrodes are unprotected from the atmosphere during fusion and they require higher current and longer arc. The resulting deposit is porous and brittle. Paste coated electrodes are cheaper than the asbestos covered ones but the slag produced has a high melting point and does not become sufficiently fluid to afford complete protection from the oxidizing influence of the atmosphere. Also the paste, chiefly chalk, has tendency to flake off as the electrode gets hot leaving the wire

bare. Welding with asbestos covered electrodes is like modern steel making where a flux, having a lower melting point and a lighter density than the steel, added to the charge, protects it from the atmosphere. For welding in Bridge Work where the ductile properties of the parent metal have to be retained, the last mentioned electrode is used.

Tensile strength tests were carried out on the welds made by these types of electrodes and the result showed that the best were with certain types of asbestos covered electrodes. These results were also confirmed by Izod Impact Test. Tests were carried out on 12 specimen of each type and result averaged. Some variations in the results are attributable to human factor. Test was also carried out in which specimens were tested in an alternating stress testing machine. The number of reversals before fracture were noted and the results compared. For weld deposit number of reversals varied from 840 to 1950 and ultimate stress varied from 17.9 to 28.9 tons p.s.i, whereas for Mild Steel Plate, number of reversals were 24000 and ultimate stress was 28-33 tons p.s.i. The apparent lack of consistency between the results is interesting and it shows the necessity for investigating the ductile qualities of weld metal subject to suddenly applied stresses.

Direct or Alternating current may be used with asbestos covered electrodes which although generally attached to the positive pole, can be attached to either pole. To weld with covered electrodes about 30 Volts on Direct and 70 Volts on Alternating current circuit are required but owing to the resistance of slag or other causes a pressure of 100 Volts may be needed. The ampeeage to be used depends upon the cross sectional area and covering of the electrodes, and thickness of the parent metal. The penetration of the weld metal with the parent metal is dependent on the temperature developed, which is proportional to the current used. Too high temperature in the metal adjacent to the weld will enlarge the crystal structure and render the joint brittle. Too low temperature may result in lack of penetration and consequently a weak joint. Inexperienced welders are apt to use an excessive ampeeage as it is easier to maintain the arc and the work is done more quickly. The strength of the welded work should be checked periodically.

Overhead welding is more difficult than vertical or horizontal flat welding. The operator is provided with a screen helmet, gloves and fireproof overalls. There is no danger to the staff working on a welding

job so long as they do not look at the arc without using proper screen of specially coloured glasses.

Distortion of the structure during welding is allowed for otherwise internal stresses will be set up. To avoid expensive straightening after welding, the amount of deposit on either side of the neutral axis is kept as nearly equal as possible. In this way the distortion on one side will balance that on the other. Another method of eliminating the distortion is that of "peening" the joint i.e. after each run of weld has been allowed to cool, it is lightly hammered with a round faced hammer.

In a girder structure, the types of joints usually used are butt joint, longitudinal fillet joint, cross fillet joint, angle fillet joint and angle weld joint. But welds are used to transmit direct stress or longitudinal shearing stress or both with or without bending or torsional moment having no component about the longitudinal axis of the weld. Fillet welds are used to transmit longitudinal or transverse shear or both.

The use of welded junctions enables the designer to place joints axially to the members which is simpler than when designing with riveted joints; but every welded joint requires careful consideration in design to avoid serious concentration of stress. Butt welds are useful in direct compression or tension, and fillet welds in end or side shear. Where a member carrying direct stress is joined to another member the centre of gravity of the welded seams should be on the centre of gravity of the members. It is usual to provide joints that are capable of carrying the variety of stresses induced within them by taking values proved to be reasonably conservative by experiments.

The structures which have been designed at the outset for arc welding compare favourably with those designed for riveted joints economically but this is not the case if structure has been initially designed for riveted connections. An economy of 25 percent in weight has been shown in comparison with a riveted structure when electric arc welding was used. In the North Western Railway Electric Arc welding has been used successfully in case of Indus Bridge at Kotri (roadway brackets),

strengthening of Plate Girder spans in Quetta Division, two 50 ft span all welded truss purloins, and bottom of High Service water tank at Lalamusa.

Note :

Paper No. 174 appeared in the Proceedings of Punjab engineering Congress, 1934. Vol. XXII at pages 79 to 93. It has 13 Plates showing details of welded joints. Discussions are at pages 93a to 93m.