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Theme III.

Practical Questions in Connection with Welded Steel Structures.

1) Since the time of the Paris Congress electric welding has made great progress in many countries and a large number of welded railway and road bridges have been constructed. In several countries official regulations on welding are now in force.

2) Experience has shown that low carbon structural steel is a perfectly suitable material for welding; neither is there any doubt as to the suitability of high tensile steels provided the composition of the alloy is known to be such that welding will not make it brittle and liable to crack, and provided that the electrodes are suitably adapted to the composition of the steel to be welded.

3) The types of structure designed with welded connections are pleasing in their proportions, and lend themselves well to the aesthetic development of design.

4) As a rule welded structures are lighter than riveted. Complete structural members such as heavily loaded columns, frames, etc. can be very simply carried out in welded design. The use of welding also offers great advantages in the strengthening of existing steel structures.

5) It may be stated in general that welding entails great care in workshop operations followed by continuous supervision on the site. The quality of welded work depends greatly on the skill of the welder, and calls, for continuous training and supervision of the workmen engaged. A great deal of experience is necessary in order to minimise shrinkage stresses, and this is particularly true in regard to site joints.

6) Laboratory fatigue experiments have shown that butt welds are superior to fillet welds in resisting dynamic stresses of large amplitude at right angles to the seam. Both laboratory experiments and experience in practice have further shown the fatigue strength of welded butt seams, properly carried out, to be at least as great as that of the usual riveted connections. I-beams may be built up in different ways by the butt welding of the web and flange plates, and their fatigue strength is practically equal to that of rolled joists.

7) The fatigue strength of butt welded seams is considerably increased if the root of the seam is re-welded after removing the slag, etc., and if a gradual transition in the seam from the parent metal to the weld is ensured.

The fatigue strength of end fillet seams, and at the ends of side fillet seams, is considerably less than that of continuous fillets. This implies that at the places affected the permissible stress in the parent metal should be reduced. In structures exposed to dynamic stresses intermittent seams and slot welds should be avoided. In the case of fillet seams it is very important that good penetration at

the root should be ensured, and for this reason it is recommended that in forming such seams a preliminary run should be made with a welding rod of 3 to 4 mm diameter = abt. $\frac{1''}{8}$ to $\frac{5''}{32}$. The fatigue strength of end fillet seams and at the beginning of side fillets can be considerably increased by a gradual transition from the parent metal to the weld.

8) The heat produced in welding gives rise to shrinkage stresses which may become considerable if the work is unable to follow the movement due to shrinkage. In view of the plastic behaviour of the material these thermal stresses are usually of no significance for the safety of the structure. Extensive experiments on the fatigue bending strength of welded girders have shown that the high shrinkage stresses are not dangerous even in the longitudinal seams of the structures. The measures which may be taken for avoiding shrinkage stresses are the adoption of small cross sections of seam, the supporting of the parts to be welded in such a way that they can move and follow the shrinkage, and the limitation of the heat input per unit of time. By suitably designing the structure and by paying special attention to the sequence of the welding operations, the shrinkage stresses can be kept low.

9) In plate web girders it is preferable to form the flanges of thick plates rather than of several layers of thin plates.

10) It is desirable that important butt welds should be examined by X-ray, and that sample point tests should be made in longitudinal beams. In the case of thick butt welds it is desirable that the X-raying should be done when only a portion of the welding gap has been filled, in view of the fact that shrinkage cracks are particularly liable to arise in the initial runs. The magnetoscopic method, also, is well adapted for detecting cracks close to the surface. In certain cases mechanical methods of testing may be used with advantage.