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Experience obtained with Structures Executed in Denmark.

Erfahrungen bei ausgeführten Bauwerken in Dänemark.

Observations sur les ouvrages exécutés au Danemark.

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Up to the present, only arc welding has been used in Denmark for welding steel structures. The experience gained during recent years is such that there is no longer any hesitation in adopting electric welding for steel structures; in many cases such structures are preferred to riveted ones, on account of their pleasing appearance and economy.

The firms who have taken up electric welding have naturally had to pay the greatest attention to equipping their workshops in such a way as to be capable of dealing with welded structures. More and more an endeavour is being made to adopt suitable auxiliary means to bring the parts into the most favourable position to allow welding to be done quickly and well. It is of course not always possible to weld on site under equally favourable conditions. For structural steel work there is no hesitation in adopting vertical and overhead welding.

Light lattice structures, such as roof trusses, are as a rule made with T sections for the top and bottom chords, whereby the web members, consisting of two angle iron pieces, are welded with side fillets welds. In these constructions the members are held and the welding is done in such a way that the shrinkage stresses are compensated, and that warping and the subsequent rectifications entailed by it can be avoided. The welding of web members to the web of the chords is begun about 10 mm inside from the free edge of the web. For top and bottom chords either cut-through I sections or T sections of two flat steels welded together are adopted. When welding these flat steels together, it has hitherto been difficult to avoid warping (buckling of the web plate). These are straightened by local heating (welding flame) before being connected to the rest of the members.

In roof trusses where the web members are connected to the flanges by butt welding, greater difficulties of the kind above mentioned have been encountered, and very much labour was consequently entailed in obtaining accurate fitting.

Plate girders in which the welded joints can be arranged symmetrically to the web offer no great difficulties. "Nose"-sections particularly have but a slight tendency to warp. As a rule a thin layer of weld metal is first of all deposited on the vertical web (method: welding simultaneously on both sides with step

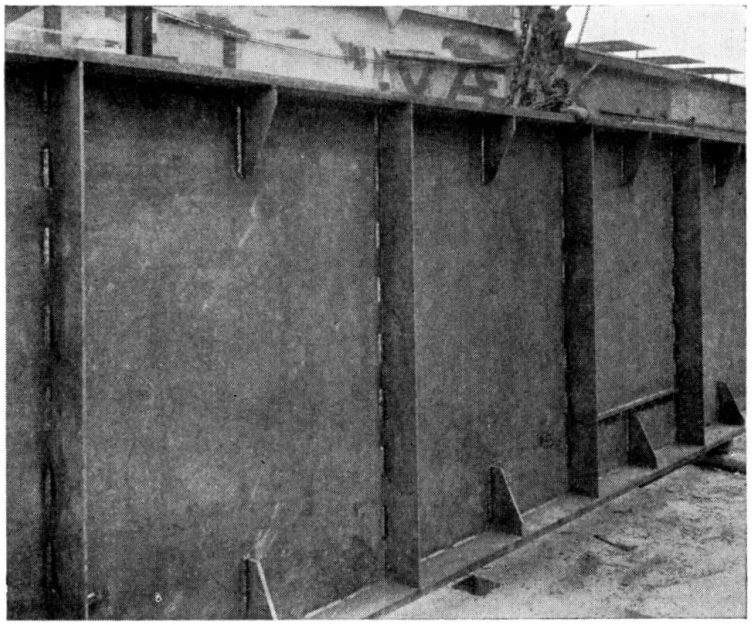

Fig. 1.

back welding), and afterwards the girder is turned through 45°, one side welded complete, and so on.

X-ray tests of some welded railway girders ("nose"-sections) which had been welded in this manner, showed that penetration was excellent. It has therefore been considered that particular care must be taken to obtain good penetration, especially in butt welding (X and V welds).

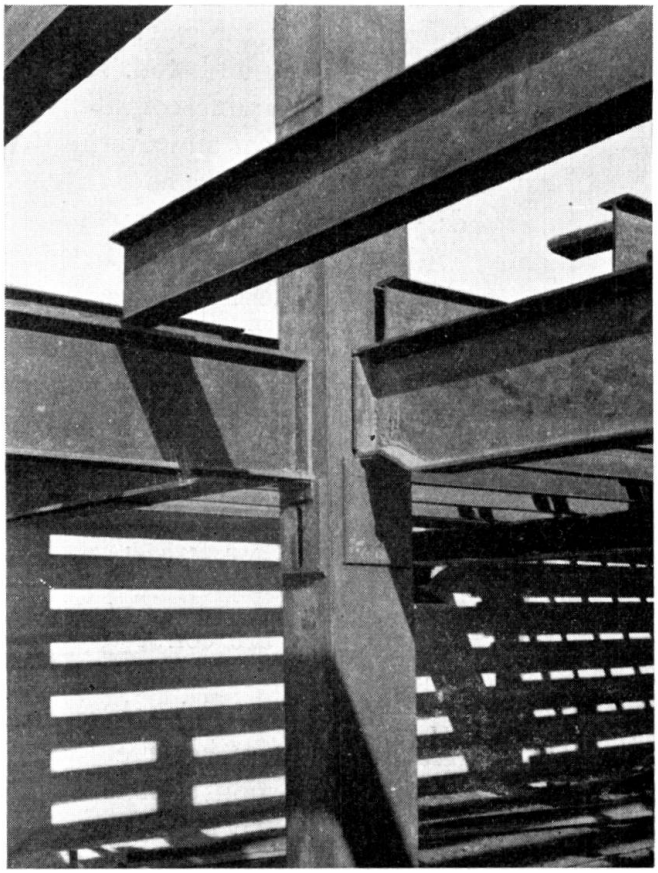

Fig. 2.

When welding buildings of several storeys and girders with rolled sections, the welded stresses do not, as is well known, give rise to any great difficulties. But it is occasionally necessary, for example when several gussets have to be welded to the web of a column, to avoid the warping of the web by heating it (for example by means of the welding flame applied to the side of the web opposite to the welded joints).

Fig. 3.

In other cases warping is avoided by adopting special methods of holding the work.

For testing welders and electrodes, the usual welding tests specified in the "Rules for welded steel structures" are adopted.

For testing the joints after welding, *Schmuckler*'s method is generally used. For testing some welded "Nose"-sections (encased girders for the Danish State Railways), which are at present under construction, X-ray photography has been employed. This excellent method will undoubtedly be quickly introduced in the case of bridge construction. Mainly in bridge building, particular importance is attached to careful cleaning of the parts to be welded. Sand blasting is very often used to remove the rolling skin completely.

With regard to economy, the experience hitherto made has been excellent. In addition to the considerable saving in weight as compared with riveted structures, it has been found that savings can in many cases be made in wages in the workshops, especially when constructing plate girders. The "nose"-section flange plates are particularly suitable for work in the shops.

When erecting buildings with several storeys, it very often proves economical

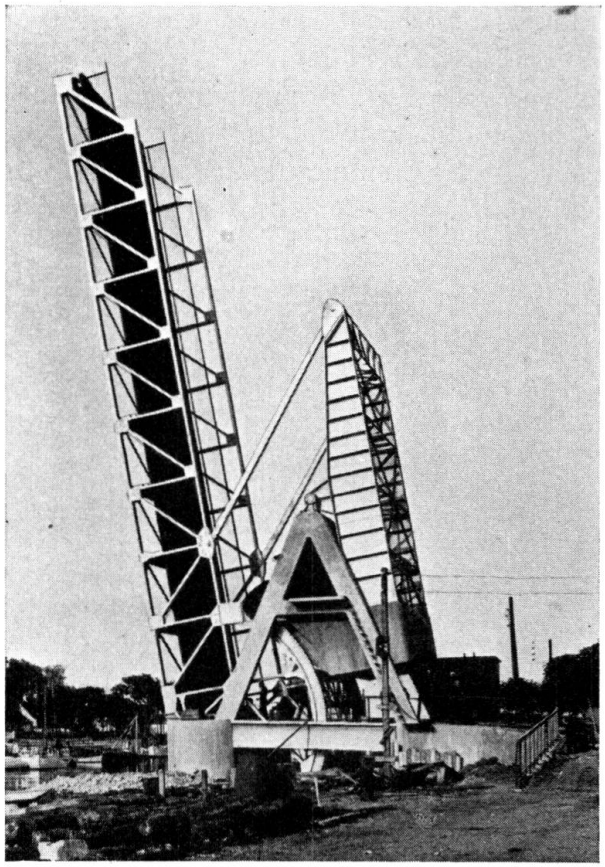

Fig. 4.

to carry out the greater part of the welding work on site, since transport charges can thus be saved.

Maintenance costs (painting) are as a rule somewhat less for welded than for riveted structures. Finally, the comparatively insignificant work entailed in making drawings should be mentioned.

For welding steel structures, covered electrodes are, as far as is known,

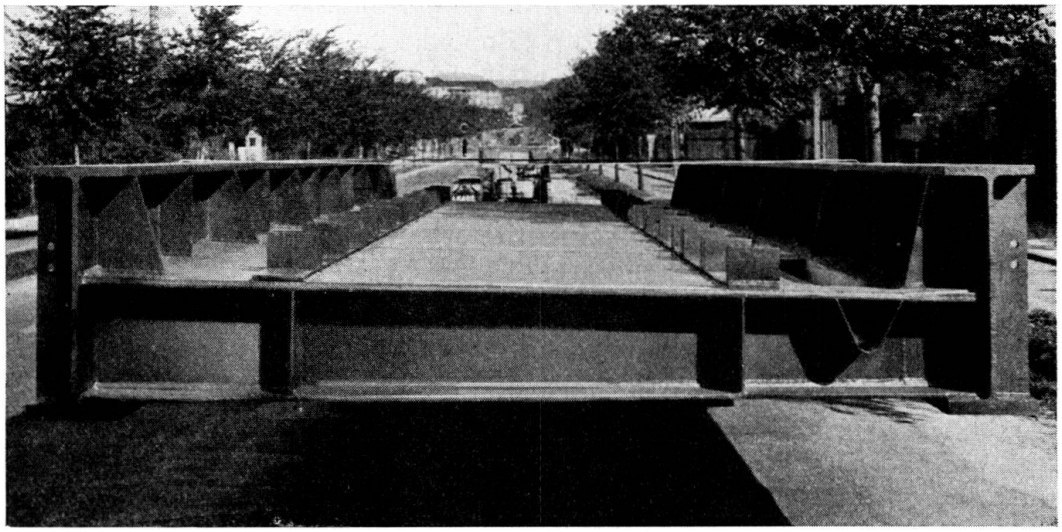

Fig. 5.

exclusively used. The adoption of bare electrodes would hardly be allowed at present.

The accompanying figures give some examples of structures already completed. Figs. 1—3 show some structural steel work. The bascule bridge shown in fig. 4 was only partly welded; the bascule arms are built up from "nose"-sections. Fig. 5 shows a small railway bridge which was constructed complete by electric welding in the workshops.

The comparatively large number of welded structures at present in hand in Denmark is a clear proof of the greatly increased interest taken in welding. The present difficulties in connection with the importation of steel have also tended to increase this interest, because of the great saving in weight.

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