Design and execution of welded structures

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Design and Execution of Welded Structures.

Ausbildung und Herstellung geschweißter Bauten.

Projet et exécution des ouvrages soudés.

Dr. Ing. St. Bryła,
Professor an der Technischen Hochschule Warschau.

Secondary and shrinkage stresses occur in every welded joint in the weld and the parent metal. The internal stresses of the weld are set up by the difference of temperature between the weld and the neighbouring metal. They are independent of the method of clamping of the members to be welded and always appear in the weld, even when the parts to be welded are not clamped together. Their origin lies in the heating and the shrinkage of the heated area. The cool or only slightly heated metal surrounding the weld entirely prevents any shrinkage in the latter during cooling.

In the metal of the parts to be assembled, stresses are set up through the edges of the parts being gripped by means of hand clamps, in order to prevent any shifting while being heated. The greater the area heated, the smaller the stresses in the weld and the greater those occurring in the structure. When flame welding is employed, the greater stresses occur in the structure, those in the weld being greater when electric-arc welding is adopted, in which case they may often reach the yield point. However, the yield point may rise to an appreciable degree, in consequence of the resistance to deformation set up by the irregular rates of shrinkage.

The thickness of the parts to be welded has a great influence on the amount of the internal stresses. Stress reactions do not increase in direct proportion with the thickness of the parts, though, nevertheless, they do become considerably greater. Shrinkage stresses also increase with the length of the weld. The longer the weld, the less uniform is the distribution of stress and, consequently, the resistance of the weld. The tests carried out by the author and Dr. Ing. *Poniz* at Lwow (Lemberg) have shown that the stresses at the end of the weld are much greater than (often twice as great as) the stress midway along the weld[1]. For a given length of weld, a limit is reached beyond which the resistance of the weld remains practically constant. Shrinkage stresses operate only in definite directions and it is not until the girder begins to be strained that the total stress is reached in the joint. The important and, even in certain cases, predominant influence of the shrinkage stresses shows that similar effects develop in the case of interrupted welds, where the welds at the end are subjected to much

[1] The stresses in the welded members are similarly distributed.

greater stress reactions than those at the centre. Nevertheless, the stress distribution is much more uniform in the case of interrupted welds.

However, these strong internal stresses in the weld are not dangerous; chiefly because, as a rule, the external forces act only in one direction and the internal stresses due to shrinkage act in three directions, and also in consequence of the plastic properties of steel. As proof, reference may be made to the results of all the tests carried to rupture point, and also to the quality of well executed welds.

Even when cracking occurs in the weld — which happens very rarely — the cause is not to be found in the stresses due to shrinkage, but in the brittleness of welds carried out with unsuitable material or in an indifferent manner.

As is shown by our tests, a weld behaves better when its properties approximate most nearly to those of the parent metal, and, primarily, has an identical yield point. The use of electrodes composed of material having a resistance far exceeding that of the metal to be welded cannot therefore be always recommended. The production of welds having the same elastic properties is far more important. The use of sheathed electrodes, which give much better results than bare electrodes, can therefore be recommended.

There are several methods for the treatment of welds with a view to the reduction of internal stresses. All our attempts in this direction are, however, negative, because the trouble entailed is uneconomical. The lowering effect on the shrinkage stresses is relatively slight, and in consequence, is devoid of import when these methods are employed. In view of the innocuous behaviour often displayed by these stresses, there is nothing to justify subsequent attempts for their reduction. These methods have a rather different significance; cold working, for example, producing a finely grained structure and therefore augmenting the resistant capacity of the material. A weld on two sides also acts, in a certain degree, like cold working and enables faults in welding to be rectified. The same applies to the different passes in the case of electric-arc welding, the earlier passes being consolidated by their successors.

The stresses of construction (erection) are the internal stresses set up in the parent metal, during welding, in consequence of the parts to be welded being gripped by means of clamps.

Although by using these latter the deformations of the structure are reduced to a minimum, or even eliminated entirely, the said clamps set up internal stresses in the parts to be welded, which are proportional to the deformations and shifting that is to be prevented. The extent of such shifting depends upon the size of the pieces to be heated and welded. That is why the stresses of construction increase in a manner corresponding to these factors.

The stresses of construction are devoid of spatial characteristics and form planar and even linear systems. They do not raise the yield point of the material and their values are very much lower than the shrinkage stresses in the weld.

Although, given suitable metal and satisfactory welding, the shrinkage stresses are not in themselves dangerous, yet it is essential to eliminate, as far as possible, secondary stresses in all metallic structures. This same necessity also exists in the case of welded structures and their shrinkage stresses. It is advisable to perform the welding of the parts in such a way that so far as is possible, they are free from any pre-existing stresses. The suitability of various influences which in a certain measure are mutually destructive, should be considered. This counteraction occurs, for example, in thick welds (see above) in which, however, the determination of the various magnitudes of such influences

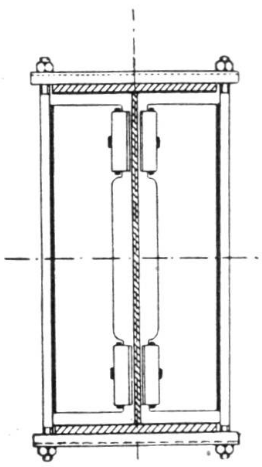

Fig. 1.

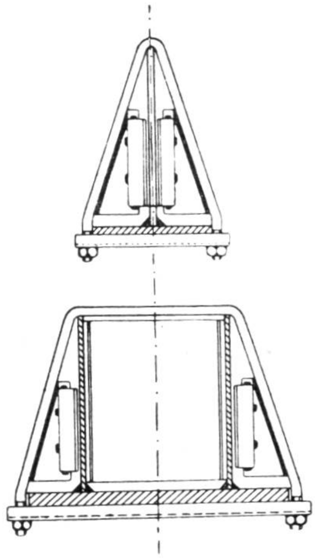

Fig. 2 and 3.

is not altogether easy. Thin welds should also be longer, which can be considered as a negative factor from the point of view of shrinkage stressing. The variety of opinions regarding the employment of thick or thin welds should not, therefore, occasion surprise. On the basis of numerous tests, the author is rather

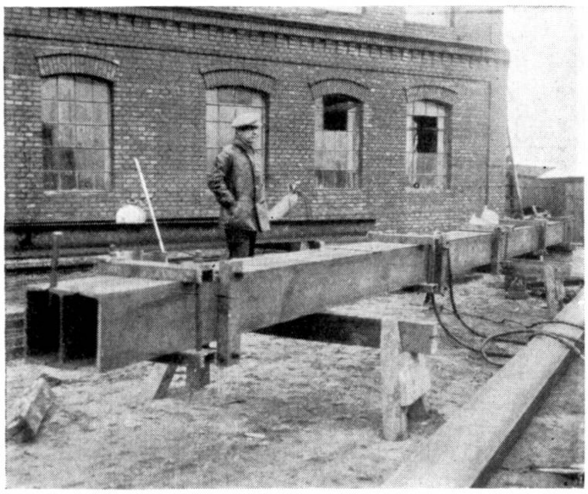

Fig. 4.

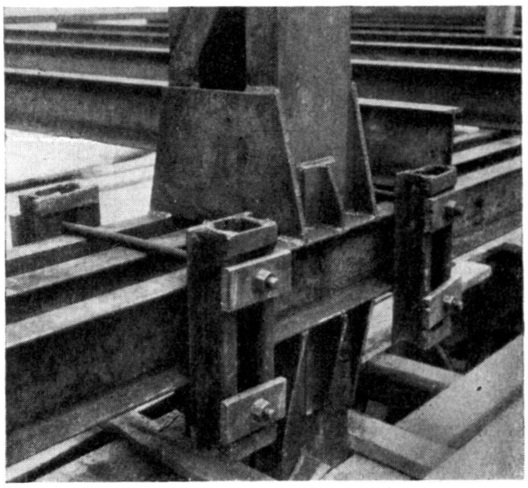

Fig. 5.

inclined to consider thin welds better and stronger, besides being cheaper. The negative influence of their unavoidably greater length can be overcome by making them in short sections, subsequently filling up the gaps which probably remain.

A second hint, which is applicable in all cases, is that the electrodes used should, so far as is possible, consist of a metal similar to the parent metal, particularly in respect of elasticity. The increased resistance, though very important, is less significant. The use of sheathed electrodes can be recommended.

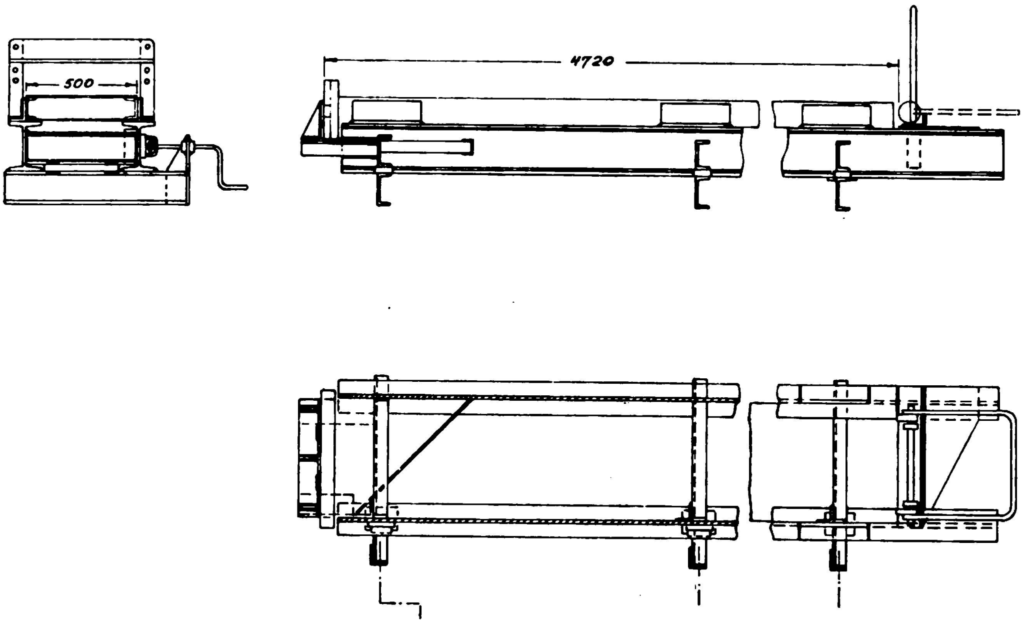

Fig. 6.

Bracing arrangements for the fabrication of columns for the Jagellon Library in Cracow.

Thirdly, the shape of the weld should be, if possible, smooth and devoid of angles.

Other influences reducing shrinkage stresses must be considered of secondary importance.

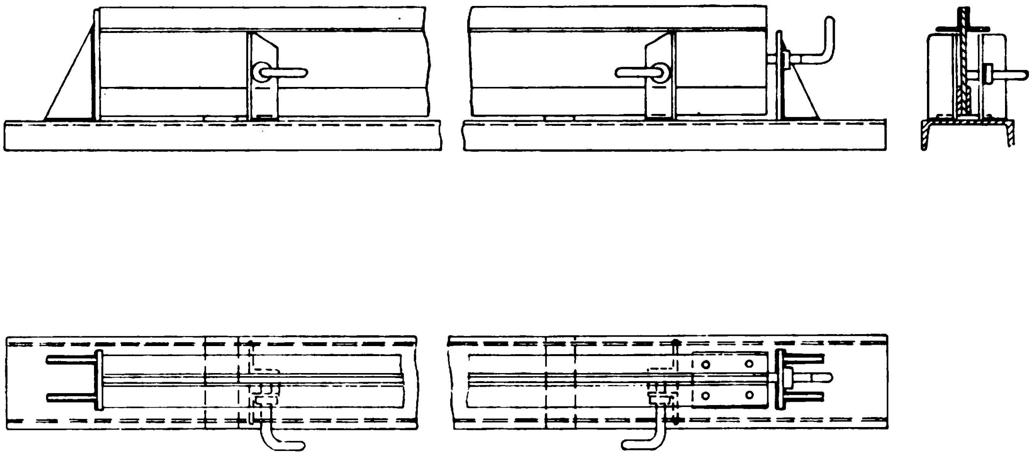

Fig. 7.

Clamping arrangement for the fabrikation of beams and girders for the Jagellon Library in Cracow.

The deformations produced by the stresses of construction are more important in their effects than the said stresses themselves. The author is not of opinion that all the deformations should be avoided at all costs. Clamps are, however, always necessary because the character of the parts to be welded — composed, as they are, of several pieces — demands them. Plate girders, the members of framed girders and their welded parts, are not provided with angle sections which, like those in riveted structures, are adapted to serve as junctions and, at the same time, fix the relative position of the plates. This is often one of the factors which enable a saving of material to be made in the case of welded structures; but, on the other hand, this fact makes the assembling of the pieces more difficult and entails the use of hand clamps. It also results in a tendency to deformations due to erection stresses, so that, for placing the sections in position, some clamps are still necessary in order to lessen these deformations.

This circumstance is decisive as regards the shape and construction of the clamps jaws, which should be precisely adapted to the shape of the parts to be assembled in such a way that the latter can be inserted. For this reason the clamps are generally provided with self-locking pieces — as a rule, a threaded iron bolt and nut. An example of such clamps is the type used as early as 1926 for assembling the cross girders and members in building the bridge over the Studwia at Lowics (Fig. 1) and which proved so successful that clamps of the same type were used in 1934 in the construction of the bridge on the Wiesbaden-Frankfort road (1935 N). A second example is afforded by the type used in the case of the Post Office Savings Bank at Warsaw (Fig. 2). Still another example is given in Fig. 3. In conclusion, Figs. 4 and 5 illustrate more complete, but also more complicated, clamps which were used in building the Jagellon Library at Cracow, where perfectly smooth shapes were particularly needed, and where the complete elimination of all deformations was essential.

Summary.

The Author starts his paper with a description about secondary and shrinkage stresses, and continues by explaining the means which have to be adopted for reducing these stresses. He describes a number of various types of clamps which are used in Poland for the purpose of reducing such stresses in welded constructions.

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