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IIId 1

Experience obtained with Structures Executed in Hungary.

Erfahrungen bei ausgeführten Bauwerken in Ungarn.

Observations sur les ouvrages exécutés en Hongrie.

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Budapest.

The various methods of welding were already generally known in Hungary in pre-war times and have also been applied in special instances. This particularly applies in the case of Autogenous Welding (Oxyacetylene Welding) which in those times has secured for itself an almost decisive rôle and which has been frequently adapted in manufacturing special pipes and for different classes of repair work to machinery.

The different kinds of Electric Arc-Welding were then still only incompletely developed and of little importance as not being very economical.

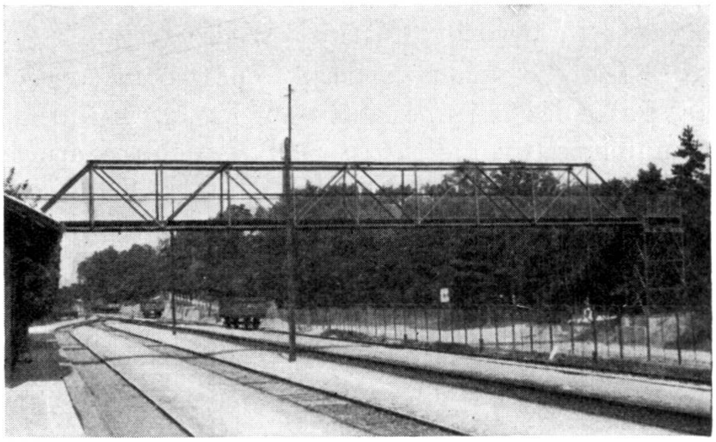

Fig. 1.

Welded connections on steel constructions were not employed until post-war times and only with the introduction of the Electric Resistance Welding Process did they become more widely used.

Fig. 1 shows an over bridge for pedestrians at the Railway Station of Balatonszemes, built in 1926. The upper boom and lower boom are made from angle-iron sections which run through the whole length of bridge without any interruption. The web members are welded on to the flanges of the angle-iron by means of front and side fillet welds.

Here as well as with other railway over bridges built at the same time, no unfavourable experience has hitherto been encountered.

At the beginning of this decade, welded connections were already frequently used with steel skeleton constructions as well as for halls and workshop buildings because the introduction of the Electric Resistance Welding Process has made welding economical and competitive as against riveted constructions.

The general adoption of welded constructions has naturally soon made necessary the establishment of regulations for welded structures. These regulations were issued at the end of 1933 and since then have proved to be very useful in practice. (See: "Stahlbau" issue No. 3, 1934. Kazinczy Gábor, Csonka Pál, Zorkoczy Béla: Concerning the new Hungarian regulations for welded steel structures". Also: Dr. B. Enyedi, Engineer: "Electro-Welding" issue No 11, 1934).

The frequent sample weldings prescribed by the regulations for training the welders and the care exercized when stipulating the permissible stresses have, and the good results obtained, created confidence, resulting in the general application of welding particularly for structures which are not subjected to alternating loading effects.

The great progress made in the quality of the Electrodes will probably very soon permit of increase in the permissible stresses.

The present standard and the practical experience of welding technique in Hungary can be summarized as follows.

1) Structural steel work.

The advantages of welded connections lie chiefly with steel skeleton constructions, composed of plated girders. The use of the welding process is particularly suited to this type of construction, since the unavoidable deformations and shrinkages, do not cause noteworthy difficulties in erection.

After erection, the steel skeleton is generally encased in concrete whereby the above-mentioned irregularities disappear and the carrying capacity of the construction is also simultaneously increased. Such structures are as a rule much simpler and easier to build with welded than with riveted connections. As an example of various constructions erected here of such a kind, reference may be made to (a). The Flats of the Social Insurance Institution in Budapest and (b) the new Boiler House of the Iron Works in Ózd. (a: Design: Architect. B. Arkay and Dipl. Engineer Eszter Péchy Execution: Márkus Lajos, A.-G. and Ganz & Co., A-G., Budapest. b. Design: Dipl. Engineer Willy Oprist and Dipl. Engineer Albert Prepeliczay. Execution: Ung. Waggon and Masch. Fabrik, Györ.) (Fig. 2 and 3).

In the case of structural steel work, both welded plate girders as well as lattice girders are frequently employed as main girders but experience shows that plate girders — owing to their being much less susceptible to deformations and shrinkages — produce more favourable results.

In contrast to the riveted constructions, a saving in weight of 15—20% is generally obtained; on the other hand, the standard price of welded structures in Hungary today is still 10—15% higher than in the case of riveted structures.

At present the use of the Welding offers economical advantages only in those instances where the construction is based on a thoroughly thought-out and appropriate design.

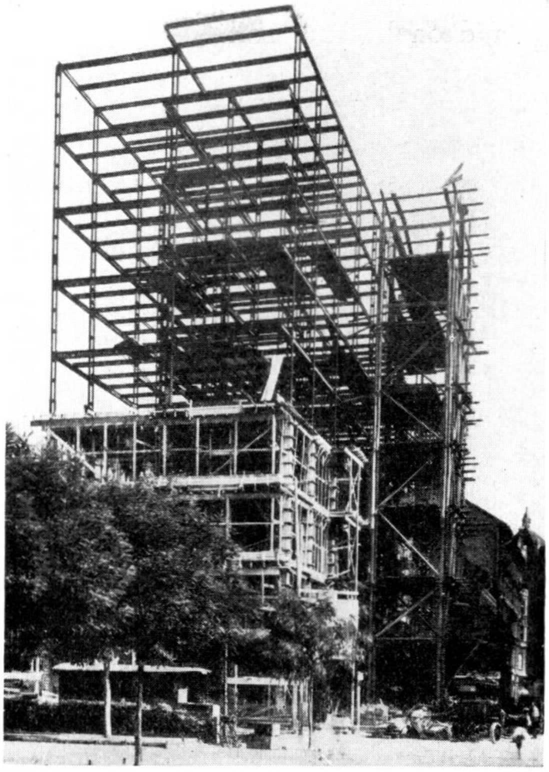

Fig. 2.

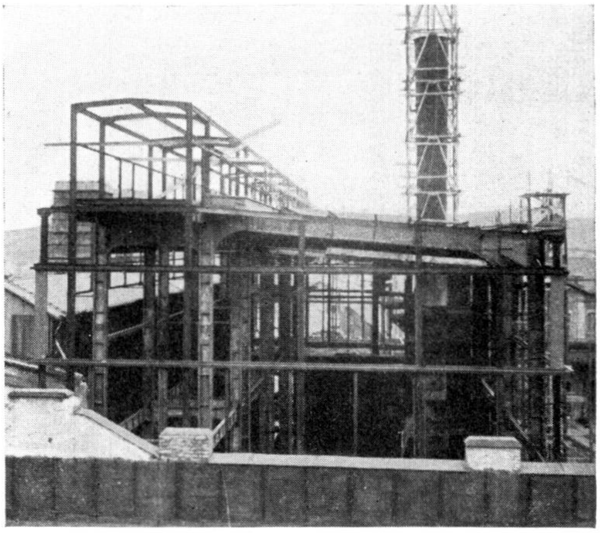

Fig. 3.

2) *Foundation work.*

Experience has been made in the case of welded steel caissons for pneumatic foundations. The experiences gained with the caissons for the great Danube Road Bridge in Budapest (Horthy Miklós Bridge, Margarethen Bridge) which is now under construction, are very satisfactory.

The steel constructions of caissons are especially suited for the application of welding because in this case, no frequently repeated stresses occur and even the permanently acting maximum stresses are eliminated after a short time. The carrying capacity of the caisson is for instance, only made use of for a week or two until the concrete filling has fully set when the caisson has already been lowered down to stand on bearing soil.

A few illustrations of steel caissons are here intended to serve as examples: Fig. 4 and 5: Steel caissons of the left river pier of the Horthy Miklós Bridge, at present under construction and Fig. 6: Steel caissons of the central river pier for the widening and re-construction of the Margarethen Bridge.

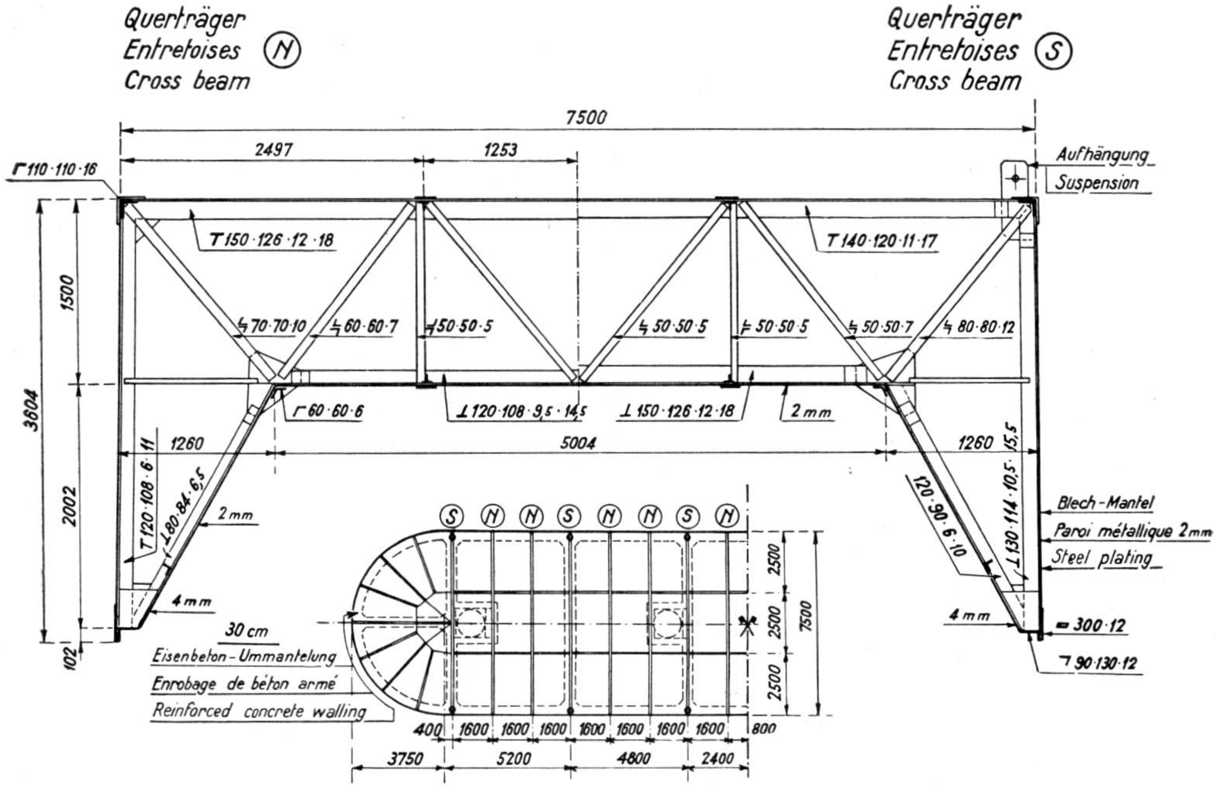

Fig. 4.

Cross section of welded steel caisson.

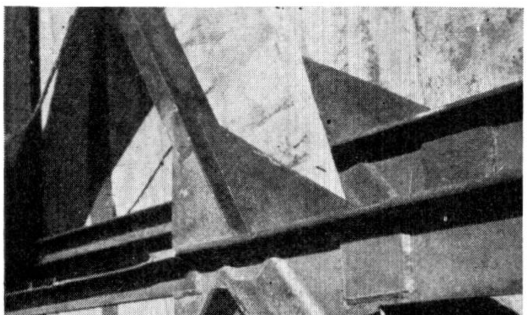

Fig. 5.

Fig. 6.

The weight of the welded steel construction of the caisson is 25% (180 kg/m²) less than that of a riveted steel construction and in addition to the advantage of lighter weight, thus also yields a saving in costs of 10—12%.

The caisson has been built up as a spatial lattice structure. The cross-beams were completely welded in the workshops and brought to site ready for erection. Subsequent work was carried out on a platform erected over two barges, in the Danube quite near to the pier-site. The interior and outer longitudinal connections and the whole sheet-metal plating was assembled on this platform. The welding work done on the site was thus greatly exposed to the immediate effect of the air and particularly the wind.

Owing to the strong air currents and the cooling action from the river, a rapid hardening and consequently an exceptional brittleness of the welds was to be feared. Nevertheless, by means of tests and caustic treatment of the finished welds, no disadvantageous effects could be noticed. The consumption of electrodes due to working in the open was, however, found to be 20—25% higher than for work done in the workshop.

The welding on the site is also much more unfavourable because most welding has to be done on perpendicular joints. The welding on the site incurred also considerable extra costs, about 20—25% more than the costs for work done in the shop.

The fixing of the 2 mm thick steel sheet plating and the joints of same were also electrically welded on the site. After successfully overcoming the difficulties in the beginning, it was possible to make perfectly watertight sheet-covering.

Figs. 5 and 6 show a few peculiarities of the caissans for the river pier of the Horthy Miklós and Margarethen bridges.

3) Bridge construction.

The general introduction of Welding in bridge construction is treated with great caution by most engineers. Nevertheless, we have also examples executed in this field, which, however, are only to be considered as trials.

Apart from many smaller constructions, the steel construction of the Rába Bridge in Györ (53 m clear span, Figs. 7 and 8) design: Royal Hungarian Ministry of Commerce and Traffic, Bridge Building Dept., and Dipl. Engineer

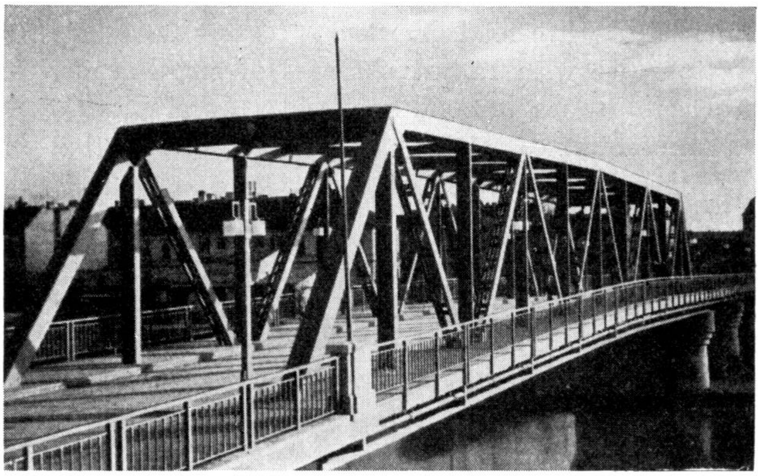

Fig. 7.

Josef Lengyel, erection: Ung. Waggon and Masch. Fabrik, Györ), and the two central removeable spans of the Theiss Bridge in Tiszapolgar (25 and 17.5 m clear span, pontoon bridge) design: Royal Hungarian Ministry of Commerce and Traffic, Bridge Building Dept., erection: Ganz & Co., Budapest) have been made as completely welded structures. The first mentioned was built on the principle of trapezoidal lattice girders and the second of single web plate girders.

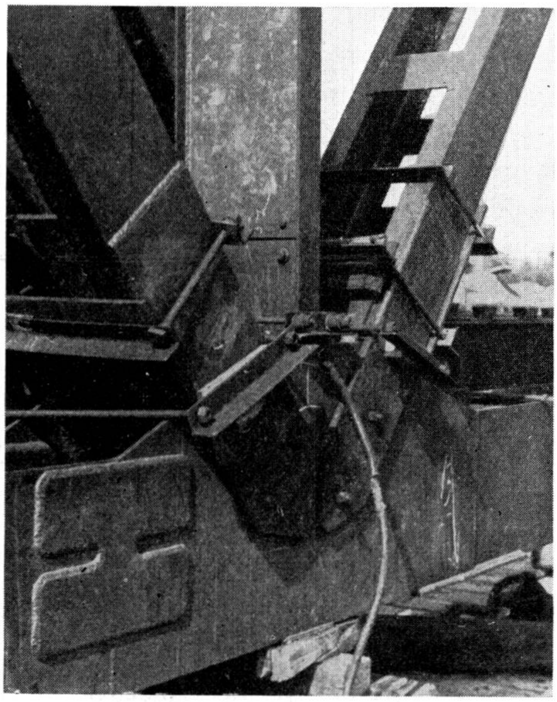

Fig. 8.

As is well known, the behaviour of lattice structures subjected to repeated changes of loading on the one hand has not yet been thoroughly investigated by tests and on the other hand, the tests carried out in this direction have not given fully satisfying results.

In the first place, doubts are with welded lattice structures which are subjected to great alternating loading effects.

As is well known, the effect of frequently repeated loading is all the more unfavourable, the more the stresses due to dead load are exceeded by the stresses resulting from alternating live load effects.

This is mostly the case with railway bridges of small spans, to which has to be added the other unfavourable condition that it is always the live load which creates the maximum stresses. It was therefore decided that in Hungary no welded railway bridges shall be built for the present.

Welding of main girders does not come into consideration for bridges of large spans owing to unsurmountable difficulties in the design and construction of panel points.

For road bridges of medium and small spans, the ratio of dead weight to live load is certainly not favourable either, but what is to be regarded as a favourable circumstance in this instance is the fact that the live load, which produces maximum stresses in the construction, occurs only rarely.

In spite of this circumstance, complete confidence cannot be placed in road bridges of welded lattice construction owing to influence of repeated stresses and the unfavourable effects of shrinkage and deformation stresses, and on account of the absence of a perfectly safe method for testing the welds.

The manufacture and particularly the erection work at the site of lattice girder bridges have still many unsolved or only partly-solved problems which justify the above mentioned reasons for caution.

Experience up to now shows that the sequence of assemblage operations deserves particular attention and study.

All members shrink and shorten due to welding therefore the sequence of assemblage must be chosen such that no adverse initial stresses are set up in the members. All members have to be manufactured slightly longer than actually required.

Deformations and shrinking actions play an important part and on this account, the following two main points should be considered:

1) The seam welded first, causes considerably greater deformations than those made subsequently.

2) Thinner elements suffer greater deformations than thicker ones.

Consequently, the thicker elements must be welded first and then the thinner ones in proper sequence, such that the deformations compensate one another if possible.

It can generally be said that it is still practically impossible even to-day, to eliminate initial stresses due to deformations and shrinking. This is especially the case when welding constructional parts on the erection site, which should be avoided if possible or only done with the greatest care.

Testing of finished welds is still done mostly by means of caustic treatment or drill-holes but these methods do not give sufficient guarantee as to the homogenity and absolute uniform nature of the welds.

According to the opinion of the writer, the paths of the development of welded structures should not only be sought in the development of welding technique.

What ought particularly to be considered is rather the possibility of using new steel sections particularly suitable for welding and what is more, an endeavour should be made to produce an entirely new type of structural arrangements that are especially adapted to welding, as the present welded constructions are designed in a wrong sense, viz: generally in accordance with the principle of riveted constructions.

These modern constructions must exploit the advantages offered by welding and be formed in such a way that at the places of welding, those loads which are dangerous for welded connections, are eliminated as far as possible.

As an example, I may take the liberty of briefly describing the design of a bridge for which full details were worked out by me and which is intended to be built shortly.

The construction is designed on the principle of a "Langer's" beam (bow string girder type) Fig. 9. In this case the tie is of a special design.

As was already mentioned above, the connection of web members to the booms generally requires complicated panel points — corresponding to the riveted structures — which cause appreciable difficulties both in the design as well as in execution.

According to the opinion of the writer, the "Langer" beam, and two hinged arches with tie, and Vierendeel girders, are more suitable for welding and of greater advantage than the usual lattice type.

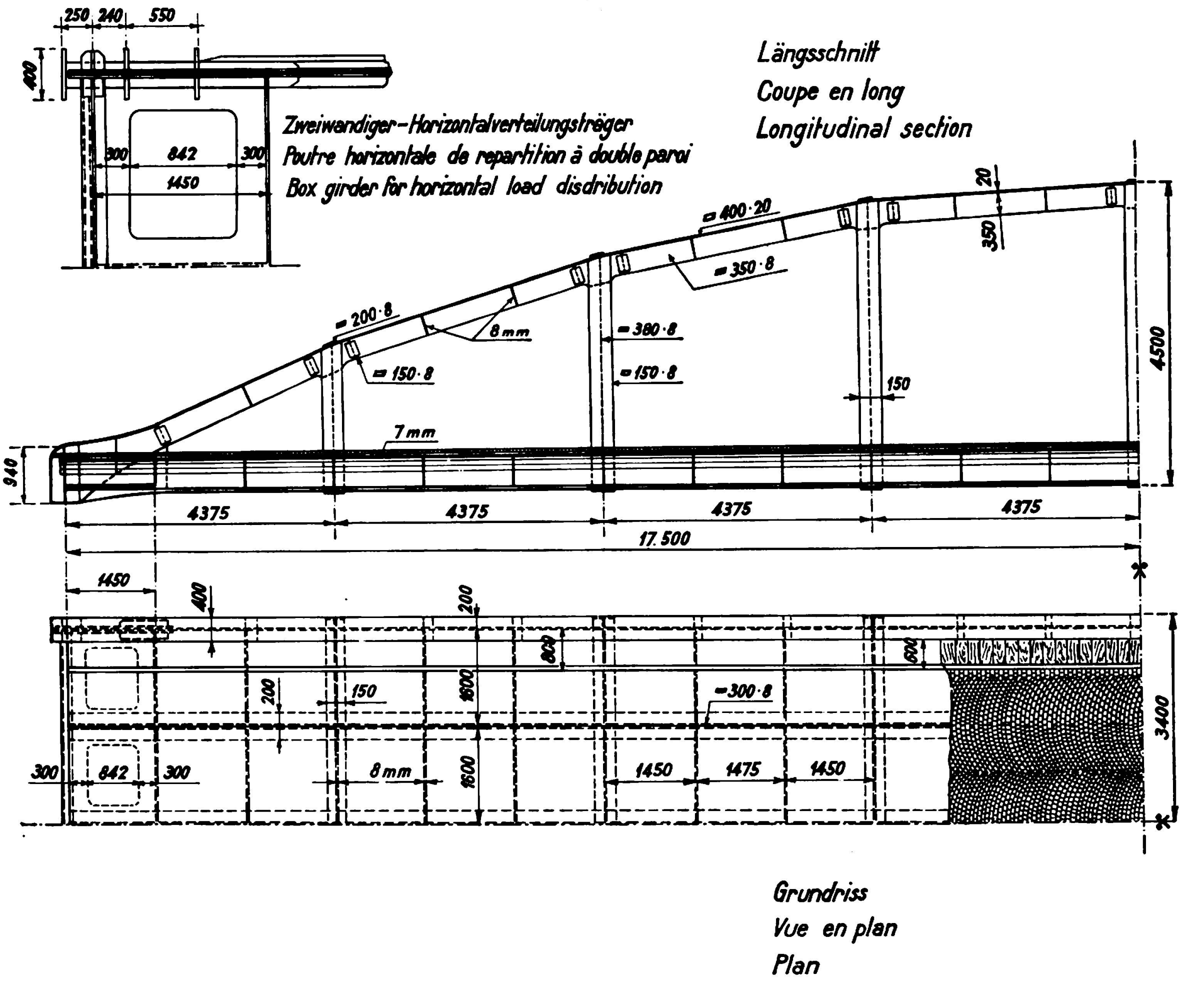

Fig. 9.

General arrangement for new type of bridge construction.

The upper compression boom of the proposed bridge construction is of the usual T-section. The lower boom, however, is designed in a new way. (Fig. 10.)

The whole section accross the full width of the bridge consisting of four buckle-plates lying side by side strengthened with web-plates and lower-flange plates and stiffened with cross-pieces are united to a single compound section, serves as lower-chord of the bridge. As will be seen from the illustration, this lower boom simultaneously serves as a longitudinal beam, decking carriers, deck plating, lower wind bracing and as stiffening girder for the Langer beam. The effect of this new type of constructional element is somewhat similar to a barrel arch.

The upper chord transmits tension forces at both ends of the bridge to the lower boom. As the lower chord spreads itself over the whole width of bridge, it was necessary for uniform distribution of the tension forces to provide two very rigidly built horizontal distribution beams one at each end of the bridge. The uniform distribution of the vertical forces to lower boom is effected by means of cross-girders.

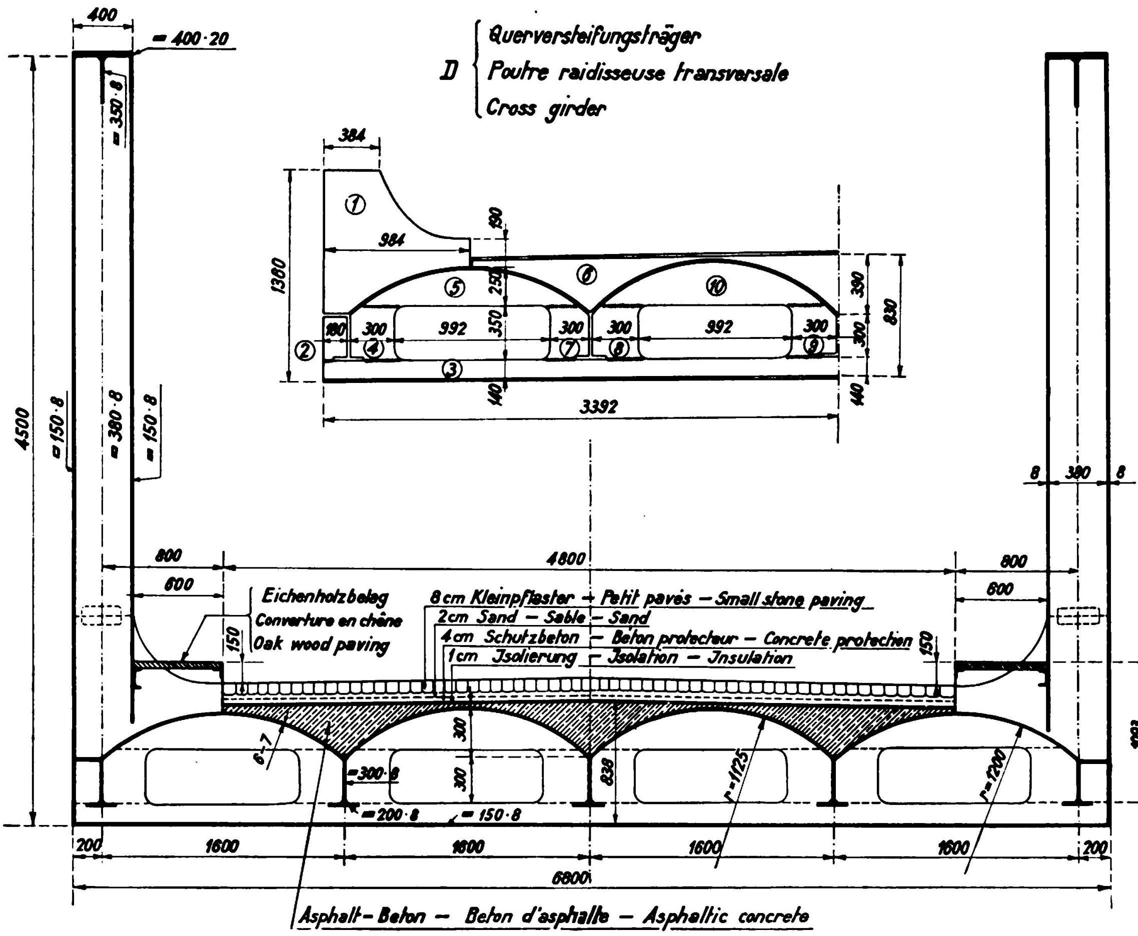

Fig. 10.
Cross section of a new type of bridge construction.

The new type of structure illustrated offers considerable economical advantages in addition to the fact that its different elements are very easily welded.

The main principle of the construction is that the lower tensile boom (at the same time stiffening beam), instead of being designed in the usual way as two main beams lying in the plane of the vertical walls, solidly formed from thick elements, has been designed as a section consisting of thin easily weldable elements spread over the whole width of the bridge. The formation of complicated panel points is entirely avoided.

The greatest part of the welds is arranged to be at the same level as the neutral axis, which results in very advantageous stresses. The side fillet welds running through between web plate and flange plate can also be very reliably done with thin electrodes.

The joints of the stiffening boom (buckle-plates) are arranged at such places where the stress for the boom, acting as decking beam, almost disappears, as the bearing capacity is not completely made use of and the smaller stresses permitted for the butt welds can stand the required bearing capacity. For this reason, butt welds alone are sufficient.

In conclusion, I should like to communicate details of weight for a double-track road bridge with a span of 35 m as a proof of the economic advantages of the construction described.

In the accompanying table are specified the steel weights of different types of bridges for comparison. They were all calculated on the basis of the Hungarian regulations for the construction of road bridges, with a span of 35 m and a width of 6 m with load of the first standard order.

Table.

Type of construction $l = 35$ m	Total Steel Weight of Bridge
Riveted lattice main girder	66.—
Welded lattice main girder	57.—
Riveted "Langer" beams, usual type	60.—
Welded "Langer" beams, usual type	51.—
Riveted "Langer" beams, new type	45.5

The results show that the above-mentioned construction, in addition to welding technical advantages, also offers appreciable saving in costs.

The sections of the buckle plates were owing to lack of results from experience, carefully dimensioned. When further experience has been gained, it will be possible to obtain additional saving in weight.

The construction described here is only intended to represent one of the many possible ideas by means of which one may come nearer to the nature of welding when designing structures.