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USE OF WELDING

IN THE CONSTRUCTION OF RAILWAY BRIDGES

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AMENDMENTS

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1 - GENERAL

1.0 - This leaflet applies to the construction of new railway bridges made of steel, the various components of which are joined by welding.

It also applies when connections of individual girders or sections are riveted or bolted.

1.1 - Welding can be used both in the workshop and on the site. The site must have installations similar to those in the workshops.

1.2 - The use of welding in the construction of railway bridges offers the following advantages :

- economy of material,
- greater simplicity of structural detail,
- better possibility of solving difficult problems of construction,
- economic fabrication,
- increased protection against corrosion by correct detailing,
- reduction in maintenance costs,
- improved appearance.

1.3 - The use of welding in the construction of railway bridges means that special measures must be taken. The main requirements are as follows :

- a weldable steel, resistant to brittle fracture, and suitable welding consumables,

- overall design suitable for welding,
- limitation of permissible stresses or raising of the necessary safety factors, taking into account fatigue strength, particularly due to the notch effect likely to occur as a result of welding,
- guarantee of the quality of welding work.

1.4 - For construction purposes, the following arc welding processes are generally used :

- manual welding with coated electrodes,
- submerged arc welding,
- gas shielded welding.

Other welding processes may also be used, provided they have been approved by the Railways on the basis of appropriate tests.

2 - REGULATIONS AND STANDARDS

2.1 - Welded railway bridges should only be designed and constructed to standards or regulations ratified by the Railways.

2.2 - Only contractors having shown proof of their qualification for such work may be used for the construction of welded railway bridges. Such qualification must be covered by special provisions by the Railway. See also : point 5.1.

2.3 - Contractors must have at their disposal equipment for inspecting materials and welds.

3 - DESIGN

3.1 - Railway bridges must be designed to have sufficient strength for the loads fixed by the Railways. Checking of the strength always includes checking the fatigue strength. (Checking of the service fatigue life).

3.2 - To check railway bridges with regard to fatigue, it is recommended that the principles stated in UIC Leaflet No. 778-1 should be complied with.

3.3 - Welding can be used for the connection of rail-bearers with cross-girders or cross-girders with main girders.

However, for bridges where the track is to be laid direct on the deck, rail-bearers and cross-girders should preferably be connected by high strength bolts or rivets. See also UIC Leaflet No. 771-3 on this subject.

3.4 - If the flanges and connecting gussets are situated in the same plane, they should preferably be connected by butt welds.

It is necessary to reduce the stress concentration effects by rounding the corners at the intersection.

On this subject, see the ORE reports on Question D.86 and UIC Leaflet No. 778-1.

3.5 - Flanges should preferably be made of one plate thickness.

If, for design reasons, thicker flanges are necessary (1), it is possible to superimpose several plates. A common joint can be effected on the site in exceptional cases, if perfect workmanship and inspection can be guaranteed.

3.6 - For lattice girders, it is preferable to use:

- closed box-sections of U-sections open at the bottom for the booms (2),
- box-sections or I-sections for the diagonals,
- I-sections for the verticals.

3.7 - Joints can be made with :

- butt welds,
- high strength bolts,
- or rivets.

3.8 - The combination of welds and high strength bolts for transmitting the same force in a connection is permitted.

On this subject, see also UIC Leaflet No. 770.

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- (1) At present, on most Railways, the maximum thickness of flange plates is 50 to 60 mm.
 - (2) In the case of sealed box-sections, it is necessary to check that they are airtight.

3.9 - Constructional arrangements leading, as a result of weld shrinkage or applied loads, to severe stresses through the thickness of plate, must be avoided. If this is not possible, steels conforming to ISO-DP Standard 7778 (1981 draft) should be used.

3.10 - Appendices 1 to 9 give details of the constructional details of welded railway bridges as in current use on the various Railways.

4 - MATERIALS

4.1 - For the construction of welded railway bridges, it is advisable to use steels in categories corresponding to Fe 360 or Fe 510, in accordance with UIC Leaflet No. 771-1.

Stronger steels, also special corrosion resistant steels, may only be used with the agreement of the Railway. Suitable tests to check the quality of the welds must be carried out.

4.2 - For load carrying components, particularly because of corrosion, it is advisable not to choose excessively thin plates, sections and bars.

The following values are intended as a guide :

- plates $t \geq 10$ mm,
- rolled steel sections ≥ 8 mm,
- webs of rolled steel sections $t \geq 6$ mm.

It is recommended that welds should not be less than 4 mm in thickness.

4.3 - Welding is only permitted under certain conditions for cold formed steel sections, bearing in mind the risk of strain ageing.

4.4 - Various categories of steel may be used, both for the various sections and for the same section, provided this gives technical or economic advantages.

When welding several steels together, the welding consumables (electrodes, welding wire, welding powder) must correspond to the properties of the base materials. In this case, it is necessary to specify the steel, to the properties of which the welding consumables must correspond. In principle, this will be the steel with the best possible mechanical and chemical characteristics.

The welding consumables shall be described in the welding procedure. Preference shall be given to electrodes with a low hydrogen content (basic electrodes).

4.5 - All the categories of steel, components for connections and welding consumables used for load carrying parts of railway bridges must be approved by the Railway.

5 - WORKMANSHIP

5.1 - Contractors must possess suitable welding equipment. The contractor must guarantee quality assurance with regard to the employment of experienced and tested welders, the use of equipment and the inspection of welds. A specialist trained in weld preparation, technique and inspection (welding engineer) must be available.

5.2 - To guarantee reliable manufacture of the components and impeccable workmanship of the welds, suitable installations must be used.

5.3 - The parts to be welded must be dry and free from scale, rust or oil. The weld preparation must be laid down separately.

5.4 - The welding procedure adopted must enable any straightening of finished components to be avoided as far as possible.

It is recommended that the parts should be preset before welding, to obtain the intended shape after welding.

If it is not possible to dispense with straightening operations, these must be limited to a minimum. Straightening shall be carried out either mechanically or by local heating.

5.5 - Depending on the local conditions (for example, temperature below 5°C, influence of wind), and on the grade of steel and thickness of the material, care must be taken to ensure that preheating is used when cutting and welding, to avoid hardening by tempering of the steels, in the heat affected zones.

5.6 - A welding procedure should be prepared, showing :

- the welding processes,
- the qualities of the base materials and welding consumables,
- the order of welding (tack welds),

- the weld sequence,
- the maintaining in position of parts and components during welding,
- observance of the geometrical shape,
- details relating to preheating,
- details on the measures to be taken in the event of straightening,
- inspection of welds.

5.7 - Work on the structures must be supervised and approved by the Railways.

The results of this supervision and approval should be set out in reports.

5.8 - Inspection of butt welds shall be carried out by X-ray. In the case of very thick plates, it is recommended that an ultrasonic inspection should also be carried out.

Ultrasonic inspections make it possible to detect any defects in the plates (for example, rolling defects).

5.9 - At the time of supervision and approval by the Railway in the workshop, the following should be checked in particular :

- observance of the technical documents,
- observance of the manufacturing tolerances,
- quality of the welds,
- geometrical conformity,
- fit-up of the parts at connections with a view to erection,
- supporting documents concerning the quality of the materials, welding consumables, the use of welders, the results of the inspection carried out by the contractor, the quality of the welds.