Useful information about stud welding in building construction

Standard shear connectors according to DIN EN ISO 13918 lend themselves to a great variety of applications, especially in composite construction of bridges, multi-storey car parks, industrial and office buildings. They are the connecting links between steel girders and concrete slabs which ensure the combined functionality of both types of components. They offer the advantages of compact, rigid construction and simple fire protection in concrete-lined chambers and mounting of shear connectors by a fast, efficient welding process. Dimensions and manufacturing requirements are based on appropriate norms, in particular the current Eurocode 4.

Shear connectors are also frequently used as fastening elements to connect supporting steel components with concrete. For this purpose, they are welded onto anchoring plates or other steel components and then set in concrete, so that they are flush with the surface. Here, the general regulations laid down for manufacturers by the European Organisation for Technical Approvals, issued in Germany by the German Institute for Building Technology (DIBt), such as ETA-03/0039 and ETA-03/0040, must be complied with.

(*The following paragraph is valid in Germany only.*)
Threaded studs and shear connectors according to DIN EN ISO 13918 are specified under section 4.8.17 in the building regulations list A, part 1. Therefore only those studs for which the suppliers have furnished proof of compliance with the technical regulations (Ü-label) may be used for supporting connections. In the case of substantial deviations, the ÜZ procedure must be applied, i.e. an application for a general permit or an individual building permit must be lodged.

The bearing capacity of welded studs is basically equivalent to the original bearing capacity of unwelded studs. However, stud welds in areas subject to regulations can only be carried out by licenced contractors. To obtain such a licence, contractors must pass a qualifying examination carried out by a recognized authority according to DIN EN ISO 14555. The operators of the stud welding equipment involved must be certified according to EN 1418.
(*The following sentence is valid in Germany only.*)
Stud welding licences are generally granted as an addition to an already existing qualification according to DIN 18800-7 (formerly major or minor verification of suitability) (for example in Class C).

Apart from holding an appropriate licence (based on qualifying examination), stud welding contractors must carry out normal weld tests prior to commencing work on any individual construction or group of similar constructions, including visual inspections, bend tests and provision of two macro-examination specimens. At the beginning of every shift three studs must be examined by visual inspection as well as bend tests.

In the course of production, all welded studs must pass visual inspection. An even, fully closed weld collar with a shiny surface and a sufficient quantity of material melt from the stud (the nominal length of the stud is reached only after welding) are considered as signs of satisfactory welding quality. A weld collar of uneven height indicates a blowing effect which can be avoided or at least reduced by appropriate measures.

If sufficient strength of a connection is in doubt, either a bend test (15°) or a corrective measure, for example a fillet weld around the faulty connection, must be carried out. Of course bend tests can only be carried out on shear connectors that can be left in their slanted position after the test. In the case of threaded studs it is preferable to test for tensile stress with a limited load, in which case the minimum tensile strength of the stud must be reached.

The question is repeatedly raised whether it is also possible and/or permissible to weld shear connectors onto steel components by processes other than drawn-arc stud welding, which is the appropriate process for this purpose. In this connection, the following points must be kept in mind: DIN EN ISO 14555 allows stud welding by means of another process “in special cases”, by which the MAG-welding, manual stick welding or TIG processes are meant. In all such cases the welder must hold a valid licence for the process applied, and the pre-calculated weld geometry must be achieved.

No definition of such special cases is given. They would certainly include, for example, the case of a few shear connectors in composite bridges that must be welded on at the building site, although no sufficiently strong power supply is available on site, or the welding position does not allow drawn-arc stud welding. However, the studs involved here are only few compared with the total number of studs used in any construction.

Eurocode 4 clearly stipulates that the dimensional regulations only apply where shear connectors have been welded on by an “automatic welding process”, which certainly includes drawn-arc stud welding, but not MAG (metal active gas) welding. Here also, deviations in a small number of studs should have no detrimental effect. However, welding all shear connectors onto a composite girder by fillet welds is a process outside the norm even in case of an extremely small building with only few shear connectors.

The above mentioned European Technical Approval for steel components set in concrete with welded-on shear connectors prescribe just as clearly drawn-arc stud welding as the appropriate welding process. It is therefore necessary to obtain a special permit in each individual case where, for example, the MAG process is used to weld shear connectors onto anchoring plates, as is often practised with small numbers of units or where no stud welding equipment is available.

Apart from formalities, there is also a technical side to this issue. Studs according to DIN EN ISO 13918 mostly consist of cold hardened materials. With drawn-arc stud welding the yield strength of these materials is generally preserved, thanks to the extremely short welding time involved. In the case of fillet welds - sometimes multi-run welds – the material’s yield strength is reduced to that of non-hardened materials not only in the welding zone but throughout the whole area exposed to heat, which now becomes extremely wide. The yield strength is reduced to about 235 N/mm², which is two thirds of the value for cold hardened materials (350 N/mm²). Often the distortion of build-

ing components caused by the considerably higher heat exposure compared to drawn-arc stud welding is also no longer negligible.

It must also be emphasized that manual fillet welding is totally inefficient. Comparative studies have shown again and again that an assistant is often required just to hold the stud in position while the burner or welding electrode is being applied. The completion of a fillet weld around a 22 mm shear connector takes approximately one minute. During the same period (and without an assistant!) at least 5 studs (in the case of steel components) or up to 10 studs (in the case of composite girders) can be processed by drawn-arc stud welding. The higher speed in case of composite girders is due to shorter secondary process times. Quite often up to 200 studs must be welded onto one composite girder, while no more than two to six studs are usually required for mounting parts.

By complying with these rules, contractors will not only ensure deliveries of satisfactory quality, but also avoid the risk of recourse claims that could endanger their very existence. Moreover they will contribute to promoting cost-efficient, safe composite construction processes in building construction.

Rainer Trillmich

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Dipl.-Ing. Rainer Trillmich (EWE/IWE)

Köster & Co. GmbH Bolzenschweißtechnik

Spreeler Weg 32

58256 Ennepetal

www.bolzenschweisstechnik.de