Summary

Research project IV 1-5-637/91

„Fatigue strength of endplate connections with double-bevel butt joint with root face and fillet welds“

The rigid endplate connection with prestressed bolts of high strength (grade 10.9) is commonly used in steel construction and general mechanical engineering application. It is increasingly used under fatigue loads.

The structural behaviour and the effect of actions of the individual components of the connection have to be assessed reliably, in order to evaluate the fatigue strength secured.

This study reports about experimental and numerical analyses of stress distribution in endplate connections with double-bevel butt joint with root face and fillet welds. Fatigue tests have been performed in order to determine the fatigue strength of the welded joint as well as the crack initiation point.

According to the current standards (Eurocode 3) the notch in the weld root of the partial penetration K-butt weld determines the classification in the detail categories as well as the fatigue strength of the whole connection. The assessment of the weld root as well as the classification into detail category 36* is based on test results of cruciform joints.

The major differences in the force distribution of a bolted T-joint compared to a cruciform joint questioned the current assessment of the weld root.

Fundamental questions of the geometrical shape of the examined welded joint and the influence of imperfections on the fatigue strength had to be clarified. First of all the nominal stress was calculated taking into account the stress concentration due to the bolted joint. Furthermore the influence of measured geometrical imperfections on the fatigue strength of the welded joint with reference to current standards had been assessed.

Three failure modes had been evaluated in respect to the location of a possible crack initiation: the weld toe of the tension plate, the weld toe of the endplate and the weld root.

Fatigue tests were performed to determine the fatigue resistance of the endplate connection with double-bevel butt joint with root face and filled welds. The experimental investigation consisted of 25 fatigue tests with pulsating tensile stress and constant stress ratio \( R = 0 \). The specimens with an endplate thickness of 25 mm and 30 mm were kept in welded condition.

The fatigue crack always started at the weld toe of the endplate growing into the plate-material. No cracks were found on the side of the tension plate or at the weld root. It can be concluded that this spot determines the fatigue strength of the connection.

For the investigated series of tests fatigue resistance curves (S-N-curves) on the basis of Eurocode 3 were established.

The influence of several parameters on the stress distribution, such as the dept of root face, the reinforcement of the weld as well as the thickness of the endplate, had been investigated by numerical analysis using the FE method.

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Notch stresses were calculated following the concept proposed by Radaj. As a result, notched-bar impact values could be derived from the stress distribution of the FE-model. The result of the combination of notched-bar impact values and the experimental fatigue strength value is the local fatigue strength of the material.

The following suggestions for the classification of the T-joint in the detail categories of Eurocode 3 can be made:

The weld toe of the endplate-side with bending stress in the endplate should be classified as detail category 80. The weld toe of the side of the tensionplate with longitudinal stress is confirmed as detail category 71. The classification as detail category 36 is not recommended for the weld root as no cracks occurred here.

Both the fatigue tests and the numerical studies showed that the notch in the weld root is not determining for this type of connection.