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Cyclic design of tension bars with end threads taking into account the influence of size and the manufacturing process AiF No.: 19800N

Summary of the research project AiF No.: 19800N

The fatigue verification of a tension bar with end threads made of structural steel must be carried out according to the current standard DIN EN 1993-1-9 with fatigue classification 50. The method of manufacturing the thread – cut or rolled – is not covered in the verification format. Especially for the larger diameters relevant for construction practice, the size effect contained in fatigue classification 50 is not statistically covered.

In the project “Cyclic design of tension bars with end threads”, extensive investigations were carried out on tension bars of various manufacturing methods. The diameters M16, M48, M68 and M100 were examined. The results of approximately 240 fatigue tests show increased fatigue strengths for rolled tensile bars. For tension bars with cut threads, the fatigue classification 50 with size effect could be confirmed for all investigated diameters, including large ones. Based on the investigations, rolled and bare tension bars are classified in fatigue classification 80, and rolled and subsequently hot-dip galvanized tension bars with end threads are classified in fatigue classification 71, each taking the size effect into account.

The proposal for the application of fatigue classification 80 for rolled threads is partly based on tests that failed in the connection area. In order to utilize the increased fatigue strength of rolled tension bars in practice, connections must be developed that do not fail prematurely. And with these reinforced connections, the threaded rods must be tested again to truly unlock their potential. It is also necessary to clarify how hot-dip galvanizing affects bars with rolled threads and whether a thread with a reversed production se-quence (first galvanizing, then thread ap-plication) has any advantages.

The thread geometries were checked by micro-grinding. This results in deviations when recutting galvanized threads, and in a series of tests, a significant undercutting of the standard radius in the thread root. Extensive investigations into the cyclic material behavior of the S460N raw material for the tensile bars have been carried out. Based on strain-controlled tests, the cyclic stress-strain curves, the strain-Wöhler curves and the damage parameter Wöhler curves were determined for the raw materials of the different manufacturers and diameters.

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The fracture lives were calculated using the notch strain concept and Paris's law on an axisymmetric model of the tension rod connection validated by DIC measurement. An extensive numerical parameter study identified the most important manufacturing and assembly tolerances of tension bars with end threads. In particular, a reduction in the fillet radius in the thread root shows a significant reduction in fatigue strength. For thread lengths of the connecting element less than 1.2 times the thread diameter, the numerical analysis shows a lower calculated service life.

In order to further improve the existing potential of rolled threads for users, further statistical validation through additional fatigue tests on rolled tension bars is required, including with regard to the influence of hot-dip galvanizing. However, it must be ensured that the connections used also have the necessary fatigue strength. Since the fork heads and sleeves used in the project also failed in part before the tension bars, investigations into the fatigue strength of connecting components are necessary Special thanks go to Anker Schroeder ASDO GmbH, Pfeifer Seil- und Hebetechnik GmbH and Mürmann Gewindetechnik GmbH as well as all other companies involved in the project for providing test specimens.

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