ABSTRACT

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Overload and variable amplitude load effects on the fatigue strength of welded joints

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In this thesis, overload and variable amplitude load effects on the fatigue strength of welded joints are studied using both experimental and analytical methods. The main methods of the study are fatigue testing of welded structures and analytical calculations using the effective notch stress method with the novel 4R notch stress approach. Residual stress measurements are also included in the experimental testing. The effect of the overload is studied by applying a tensile overload on the welded joint before fatigue testing. The overloads are tested on two levels 60 % and 80 % of the nominal yield strength. Variable amplitude loading is tested with Gaussian load spectrum consisting of a high peak load and following decreasing cycles.

The joint type under examination is a welded non-load carrying longitudinal joint with double-sided gussets. The main material in the study is structural steel S700. Steel grades S355 and S1100 are acting as a control group for the overload cases to evaluate the possible differences or correlation in the results. A total of 39 fatigue tests are conducted in this thesis.

The results indicated that the overload relaxes the residual stresses and therefore increases the fatigue strength of welded joints. The higher-level overload had a more notable effect on the results in comparison with the lower one. In the case of steel grade S700, overload of 0.8 yield strength resulted in 1.6 times higher mean fatigue strength. It was also noted that steel grade S1100 gained benefit most from the pre-applied overload and steel grade S355 the least.

The application of the 4R method to overload and variable amplitude load cases was also evaluated. The 4R method was able to conduct mean stress correction and more accurately estimated the fatigue strength of welded structures under overload and variable amplitude loading with respect to traditional methods.