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Summary MSc thesis Arvid Maarleveld

Welding induces residual stresses in a segment of an orthotropic steel deck

Welded details in orthotropic steel decks (OSD) are susceptible to fatigue cracks which are caused by local weld defects, geometric stress concentrations and residual tensile stresses. Residual tensile stresses are formed during the welding process and the distribution depends on many factors. Knowledge about the residual stress distribution is required for accurate fatigue assessment. The rib-to-crossbeam detail in the design of the new Schipholbridge does not meet the fatigue requirements according to Eurocode 3 when using a reasonable geometry. Therefore, high frequency mechanical impact (HFMI) post weld treatment will be used to improve fatigue resistance. Incorporating the residual stress distribution in fatigue life prediction models will improve their accuracy, which can lead to more favorable results which can avoid the use of HFMI.

The main objective of this master thesis is to determine the accuracy of a subsequently coupled thermo-mechanical finite-element model which predicts welding induced residual stresses in a segment of an OSD. The fatigue life prediction is not included in the scope of this thesis. The accuracy of the model was determined by comparing temperature and distortions with experimental data from three specimens consisting of a 900x400mm deck plate, a 350mm deep trapezoidal stiffener and a 600x15mm crossbeam web with a Haibach cope hole. During the welding, temperatures were recorded by a FLIR© E96 thermal camera. Welding distortions were obtained by subtracting the geometry before welding from the geometry after welding. The 3D geometry was obtained by the Artec© LEO scanner. The scans were post processed in Artec© studio software and data was extracted by the NumPy-stl package in Python.

The predicted temperature distribution and deformations corresponded well to experimental results. The maximum deviation in the temperature distribution 1.8s after welding was 67 °C and occurred at the last position of the welding torch. The maximum deviation between predicted and measured upward displacements of the deck plate 10mm from the edge was 0.2mm, with smaller deviations on average. Due to the good correspondence of experimental and numerical results, residual stresses were presented. On the deck plate in longitudinal direction, tensile stresses of yield strength magnitude were obtained after unclamping. At the rib-to-crossbeam connection, the stress in the direction perpendicular to the weld toe at the location of the weld toe was equal to the yield strength after unclamping. The stresses quasi-linearly go to zero through the thickness of the rib.

Link to thesis:

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