Welding Residual Stresses in Offshore Steel Structures

DR. MICHAEL JOACHIM ANDREASSEN

Department of Civil Engineering, Technical University of Denmark

ABSTRACT

Supersize monopiles are being developed and have already been deployed and installed on several offshore wind farms in European waters. The demand for fabrication of cans with wall thicknesses from 50mm and up to 120mm is high. However, the implications on design and especially the joining of cans by circumferential welding with these wall thicknesses are not yet fully understood. Particularly, the welding induced residual stresses needs special attention. The stresses have a negative impact on the integrity of the welded joint as they promote distortion, reduce fatigue life, and attribute to the corrosion cracking and brittle fracture in the weld components. The research within the field of welding residual stresses is important as the size of welds are rapidly increasing and to be able to follow the demands from steel fabricators when deeper foundations are needed by design.

This research deals with the influence and impact of welding method on the welding induced residual stresses. In this relation, it is also investigated whether the assumption that residual stresses up to yield strength magnitude are present in welded structures as stated in the Eurocode 3, DNV and IIW design guidelines. The fatigue strength for welded joints is based on this assumption which may be to too conservative when it comes to large butt welded joints such as for offshore wind turbine foundations. A reduced factor might result in the use of less material, thus making manufacturing, assembling and transporting relatively easier. Furthermore, the body of guidelines, codes and recommendations has become of age and simultaneously manufacturing processes, material and mechanical properties and design solution have improved. Thus, making the thickness effect and welding method newsworthy and a very promising field to investigate. The two welding methods investigated are submerged arc-welding (SAW) and hybrid laser-arc welding (HLAW). Both welding methods are applied for a full penetrated butt weld of thick plates made of thermomechanical rolled low-carbon fine-grain S355ML steel in accordance with the European standard DS/EN 10025-4.

By investigating the welding residual stresses in relation to the plate thickness and to two different welding methods by means of computational welding mechanics, experiments and in accordance with existing production procedures, an optimization of the fatigue design is expected, leading to a more efficient and improved design. In this context, this research is expected to benefit the offshore industry by leading to an improved design which consequently can be included in present norms and standards. Further, it will optimize the correlation between numerical simulations and physical models.

ABOUT THE SPEAKER

Dr. Michael Joachim Andreassen is an Associate Professor in the Structural Engineering section of the Department of Civil Engineering (DTU Byg) at the Technical University of Denmark. He is specialized within the field of distortional mechanics and stability of structures and has practical experience with design of steel and concrete structures. Currently, his focus and research is on welding residual stresses in offshore steel structures. He has expertise in advanced experimental work, including measurement techniques and teaches courses in basic and advanced steel structures.