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Investigations on Ultimate Strength for a Container Vessel under Combined Loads

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Ship structures are subjected to various types of loads during their lifetime. Different numerical methods exist to determine the ultimate bending moment of ships by taking the strength reduction of structural members into account. The Finite Element Method (FEM) as well as Smith's method are feasible tools to perform progressive collapse analyses of large structural systems under consideration of material and geometrical nonlinearities. The influence of initial imperfections due to welding has to be considered for ultimate strength prediction.

In this paper, nonlinear finite element analyses are performed to determine the ultimate strength of a container vessel under vertical, horizontal and biaxial bending. The implicit ANSYS solver is applied successfully for the different load cases. A parametric finite element model is developed and the influence of different approaches for nonlinear material model, mesh size and model length on the ultimate hull girder strength is demonstrated for hogging and sagging conditions. An appropriate parameter set with respect to numerical efforts and accuracy is used to analyze the horizontal bending and combined biaxial load cases. Displacement controlled nonlinear finite element analyses are performed to ensure constant rotation ratios of the cross section in biaxial bending. Convergence is reached by using the full Newton-Raphson scheme as an incremental iterative solution approach. The results are validated against the well-established Smith method.

The cross section of the container vessel is composed of stiffened plate panels. The stiffeners are connected by fillet welding to the plating and butt welding is used to connect the plate panels. Due to the welding process initial deflections and residual stresses are produced. For the proposed finite element model initial deflections of plating and stiffeners have been considered. Furthermore, the influence of welding residual stresses on the ultimate hull girder strength is analyzed for the different load cases.

Primary authors: Dr LINDEMANN, Thomas (University of Rostock, Chair of Ship Structures, Rostock, Germany); Prof. KAEDING, Patrick (University of Rostock); WILLSCH, Alexander (University of Rostock); Mr LA FERLITA, Alessandro (American Bureau of Shipping, ABS Europe Ltd., Hamburg, Germany); Prof. BOOTE, Dario (University of Genova)

Presenter: Dr LINDEMANN, Thomas (University of Rostock, Chair of Ship Structures, Rostock, Germany)

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