Aalto University
School of Engineering

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Equivalent shell element for passenger ship structural design

Title of the dissertation	Equivalent shell element for passenger ship structural design
Contents of the dissertation	Predicting the strength and vibration response of a large passenger ship is a challenging task, with several contributing factors. The calculation methods need to be computationally light to enable design optimization, but still accurate enough to describe both global and local behavior in a way that the design constraints are properly assessed. The common approach to evaluate structural response of a passenger ship is to use the finite element method, where the entire ship is described with very coarse mesh and the stiffeners together with plating are modelled using equivalent, homogenized, elements. Since the available equivalent elements do not or only partly consider the bending properties of the stiffened panel, the local response needs to be analysed separately using time-consuming sub-modelling technique. The limitations become even more problematic in propeller- and machinery-induced forced vibration analysis, where the global coarse mesh model is not accurate and the couplings between the global and local models are difficult to define. This dissertation introduces a more advanced equivalent element modelling approach, which helps to overcome the named limitations. In this thesis, the stiffened panel is considered as a three-layer laminate shell element, where the first layer represents the plate, the second layer the stiffener web and the third layer the stiffener flange. The element follows Equivalent Single Layer (ESL) First-order Shear Deformation Theory (FSDT), which constitutive properties are found through a homogenisation process. Despite that the local plate bending effects between the stiffeners is neglected, the dissertation also presents the methods how they can be reincluded in static and vibration analysis. This enables significant computational savings in design and further in the optimisation problem, as layer-wise formulation enables stiffened panel scantlings to be changed without remeshing the model, as well as accurate assessment of the stresses.
Field of the dissertation	Marine Technology
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