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Effect of Shear Stresses on the Ultimate Strength of the Hull Girder of a Containership

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When using large models, building a comprehensive finite element (FE) numerical model able to simulate the portion of a containership whose extension in length is sufficient to properly evaluate combined loading effects is rather time consuming, and assigning proper boundary conditions representing the distribution of actual forces and moments on the hull girder is a challenging task. In this paper, the effect of shear stress distribution on the structural components of the hull girder is analyzed. At first, finite element (FE) models simulating a suitable length of the hull girder are considered. Later, smaller models of stiffened panels are extracted from the hull girder models and analyzed. The aim of this work is to investigate the shear stress distribution originating in the entire cross section and to build a smaller model extracted from a selected portion of the ship where hull girder collapse is supposed to initiate.

INTRODUCTION

The present work aims to investigate the effect of combined loads on the ultimate response under in-plane thrust of a partial model representing a portion of the side of a large containership, with particular attention paid to the effect of tangential acting stresses.

The numerical models simulate the longitudinally stiffened panels supported by transverse primary frames of the double hull and bilge areas. Several factors contribute to generate combined global effects when the hull girder response is taken into account. In particular, the nonuniform distribution of weights and buoyancy forces along the longitudinal axis of the ship generates global still water bending moment and shear force distributions acting on the hull girder. Moreover, when operating at sea, the interaction of the hull with waves modifies the weight and buoyancy loading profile along the hull girder, generally adding significant contributions to both global bending moment and shear forces. Nonsymmetric conditions, which, for example, may be due to the nonuniform transverse payload distribution typical of containerships or to hydrostatic and wave pressures originating from encountering the beam sea associated with ship rolling and pitching motions, may also give rise to lateral bending and torsional effects (Hughes and Paik, 2010).

In the first stage, the present work takes into account the effects of such combined loads on the typical midship structure of a large containership, aiming at identifying the most critical loading conditions and the areas where the collapse originates. Finite element (FE) models extending between transversal primary elements, i.e., constituting a hull portion included between two transverse bulkheads, simulate the structural behavior of a significant length of the hull girder. This allows the identification of the local loading conditions and, in turn, the most critical stiffened panels. Buckling condition is the main cause of failure of ship structures as reported by, e.g., Shama (2013).

Thereafter, the work mainly focuses on submodels extracted from the larger hull girder models, on investigating the proper definition of boundary conditions, and on the application of various load combinations. A similar model was extracted and investigated by Ringsberg et al. (2013) because of the local significant stress contribution from wave-induced sea pressure loads, warping stress, and the stresses caused by vertical and horizontal bending. The aim of the present work is to assess the ultimate thrust force that the submodel is able to sustain under combined loading, particularly considering the effect of the applied shear, as well as to define a suitable modeling procedure for similar cases.

The results of the submodels are compared to the results obtained from the larger model in the considered local area to provide guidelines for properly applying shear loads on partial models, especially considering the boundary conditions satisfactorily representing the surroundings, not modeled parts of the structure.

HULL GIRDER MODELS

Origin and Justification of the Current Research

Combined loads, as investigated by Paik and Thayamballi (2003) among others, typically cause the collapse of ship structures. In the present work, the hull girder vertical still water and wave shear forces and moments obtained from classification society rules (IACS, 2014) are initially combined with suitable design

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