学 位 論 文 概 要

題 目 Buckling/Plastic Collapse Characteristics of Cracked Flat Panels and Stiffened Panels with U-beam Stiffeners

(き裂入りパネルおよびU字スティフナ付き防撓パネルの座屈/塑性崩壊挙動に関する研究)

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Ship structural components, i.e., hull girders, and stiffened panel structures are mainly composed of steel structural members such as beams, stiffeners and panels. Damage to the structural components affects the tensile, bending, buckling and ultimate strengths. Small defects will develop and finally cause large-scale damage to the structures when a cyclic load is applied to the components. In several researches the critical local buckling induced by the applied tensile loading of a cracked panel were investigated via experiment. The behavior of a cracked stiffened panel under compression through experiments have also been evaluated.

Generally, a hatch cover is not become a primary strength member in ship structures. However, if the hatch cover collapses in rough sea, water ingress may happen into the cargo hold, which may result in severe casualty. Based on this point of view, it is very important to assess the strength of the ship's hatch cover. Flat-bars, angle-bars, tee-bars and bulb flat-bars are usually used as stiffeners in ship and other marine structures. Additionally, U-beam stiffeners are started widely used in ship and marine structures. For example, U-beam stiffeners are now used in hatch covers of bulk carriers. In the stiffened panels, the effect of stiffeners to increase local buckling strength should be well analyzed. In Common Structural Rules (CSR) specified by International Association of Classification Societies (IACS), the formulas are given to estimate the buckling/ultimate strength of a top panel of a hatch cover. However, CSR does not give the formula for stiffened panel with U-beam stiffeners.

In this study, an experimental apparatus is developed for examining the buckling and collapse behaviors of an intact and cracked panels with different crack lengths subjected a sequential tensile and compressive loading. The maximum tensile load, ultimate strength and local deformation around the crack were examined and compared with the FE simulation results. Furthermore, characteristics of U-beam stiffeners are examined from the point of view of local buckling of stiffened panels. The CSR formulas regarding the hatch cover strength are assessed on the basis of eigenvalue and nonlinear finite element (FE) analyses. At the same time, alternative simple formulas for U-beam stiffeners are newly proposed modifying the existing simple formulas, and their applicability is demonstrated.

In accordance with experimental study it is confirmed that a newly experimental apparatus works well and the FE modeling is effective in simulating the buckling/collapse behaviour on the intact and cracked panels. The three half-waves buckling mode can be obtained as theoretically for an intact panel with all edges clamped. Additionally, it has been found that U-beam stiffener provides for the highest buckling stress and ultimate strength compared with angle-bar/flat-bar stiffeners.