論 文 の 要 旨

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 and offshore structures are in general fabricated with thin plates and stiffeners are provided to increase the strength and the stiffness of thin plates. As for stiffeners, flat-bars, angle-bars, tee-bars and bulb flat-bars are fundamentally used. Crack-like defects may occur during the service period due to various factors, e.g., fatigue and local buckling. These defects are preferentially generated in welded joints, structural discontinuities and stress concentration parts. Damage to the structural components affects the tensile, bending, buckling and ultimate strengths. When a cyclic load is applied to the components, small defects will develop and finally cause large-scale damage to the structures. The finite element method (FEM) has been used to investigate the mechanical characteristics of cracked panel structures in some researches. Additionally, the collapse and ultimate strength behaviour of crack damaged stiffened panels under compressive loads were discussed from the viewpoint of establishing a damage tolerant procedure for the stiffened structure under compression loading. The critical local buckling induced by the applied tensile loading of a cracked panel was investigated via experiment. The behaviour of a cracked stiffened panel under compression through experiments have also been evaluated.

A plenty of research works have been performed on buckling and ultimate strength characteristics of stiffened plates with the angle-bar stiffeners/flat-bar stiffeners. However, not so many researches were performed for stiffened plates with U-beam stiffeners especially in the field of marine engineering. One of the disadvantages using U-beam stiffeners for stiffened panels composing tanks and/or holds in ship structures is the reduction of tank/hold capacity. Because of this, U-beams have not been used as stiffeners in stiffened panels composing hold and/or tank walls. However, U-beam stiffeners are widely used in the hatch covers of bulk carriers and container ships nowadays. As for the use of U-beam stiffeners in hatch covers of bulk carriers, they are used in 95% of hatch covers of bulk carriers of more than 80,000 tones and in 40% of those of less than 80,000 tones in Japanese new shipbuilding market each year. Now, more than 1,900 vessels with hatch covers having U-beam stiffeners are sailing all over the world.

In this study buckling/plastic collapse of a hatch cover with U-beam stiffeners is considered. Previously, an experimental apparatus is developed for examining the buckling and collapse behaviour of an intact and cracked panel 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.

The results show that a newly experimental apparatus works quite well and the FE modeling is effective in simulating the buckling/collapse behaviour on the intact and cracked panels. The presence of the crack and the length of the crack are strongly affected to the ultimate strength and buckling/collapse behaviour of the panels. It is shown that three half-waves buckling mode can be obtained as theoretically for an intact panel with all edges clamped. Additionally, it is confirmed that proposed simple formula accurately estimates the buckling stress increasing ratio of stiffened panel with U-beam stiffeners subjected to transverse thrust. Existing correction factor formula which accurately estimates the buckling stress increasing ratio in case of angle-bar/flat-bar/tee-bar stiffeners is modified, which resulted in better estimation of the correction ratio.

It has been found that U-beam stiffener provides for the highest buckling stress and the highest ultimate strength compared with angle-bar/flat-bar stiffeners. Simple formulas newly proposed can be applied to stiffened panels with both angle-bar/flat-bar and U-beam stiffeners regardless of the aspect ratio, a/b, of the local panel. These formulas are on the basis of a physical model which can be easily understood, and can be applied to the cases of which collapse behaviour is the same.