

Estimation of Buckling and Collapse Behaviours of Stiffened Curved Plates Under Compressive Load

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ABSTRACT

Cylindrically curved unstiffened and stiffened plates are often used in ship structures. For example, they can be found at deck with a camber, side shell at fore and aft parts and bilge circle part of ship structures. It has been believed that such cylindrically curved plates can be modelled fundamentally by a part of a circular cylinder. From the estimations using cylindrically curved plate models, it is known that, in general, curvature increases the buckling strength compared to a flat plate under axial compression. Existence of the curvature is also expected to increase the ultimate strength as well as buckling strength.

In the present paper, series of Finite Element analyses are performed on stiffened curved plates varying several parameters such as curvature, panel slenderness ratio as well as web height and type of stiffener. The results of numerical calculations on stiffened and unstiffened curved plates are examined to clarify the influences of these parameters on characteristics of their buckling/plastic collapse behaviour and strength under axial compression.

KEY WORDS: Cylindrically curved plate, Axial Compression, Buckling strength, Ultimate strength, Curvature, Slenderness ratio, Stiffened curved plate, Initial imperfection

1. INTRODUCTION

Thin-walled cylindrical shell is very widely used as a structural element such as oil and gas storages, offshore structures, cooling towers and ship hulls. It is important to clarify the elastic and elastoplastic stability of cylindrical shells under various loading conditions. Especially, in ship structures, cylindrically curved plates are used, for example, at deck plating with a camber, side shell plating at fore and aft parts and bilge circle part. It has been believed that such curved plates can be modelled fundamentally by a part of the cylinder.

At the beginning, a brief review is made on previous research works related to buckling and/or buckling/plastic collapse behaviour and strength of cylindrically curved plates and stiffened plates.

Maeno et al. (2003, 2004) performed a series of elastoplastic large deflection analysis to investigate into the buckling/plastic collapse behaviour of ship's bilge strakes which are unstiffened curved plates subjected to axial compression. Based upon the results of nonlinear analyses, simple formulas were derived to calculate buckling/ultimate strength and to simulate average stress-average strain relationship of the bilge structure under axial compression. It was found that the bilge structure with a conventional shape and size reaches the ultimate strength by yielding before buckling. Therefore the hard corner elements could be used for bilge part in evaluation of the ultimate hull girder strength applying the Smith's method. However, buckling of the bilge part has to be accounted beyond the ultimate strength to accurately simulate the post-ultimate strength behaviour of the hull girder.

Yumura et al. (2005) investigated buckling/plastic collapse behaviour of cylindrically curved plates under axial compression. They, firstly, performed a series of elastic eigenvalue analysis varying the curvature of the curved plate to clarify the fundamentals in its elastic buckling behaviour. Then, giving a small initial deflection of a buckling mode, a series of elastic large deflection analysis was performed to investigate into the characteristics of post-buckling behaviour of a curved plate. Finally, a series of elastoplastic large deflection analysis was performed to clarify the buckling/plastic collapse behaviour and strength of cylindrically curved plates.

Park, H.-J. et al. (2005) performed nonlinear FEM analyses using a commercial code (ABAQUS) on actual stiffened curved plates of the container ship varying the curvature and spacing of stiffeners. In the analyses, initial shape imperfection and residual stress were considered and combined axial compression and hydrostatic pressure loads were applied.

Kwen et al. (2003, 2004) performed non-linear FEM analyses using commercial code (ANSYS) for unstiffened curved plates varying aspect ratio, slenderness ratio and curvature under various loading conditions such as longitudinal thrust, transverse thrust and shear load. Based upon the results of analysis, simple formulas are proposed for predicting the ultimate strength and then compared the calculated results with those by DNV buckling formulae with plasticity correction.