BUCKLING/COLLAPSE BEHAVIOUR OF CYLINDRICAL SHELLS IN BILGE REGION OF SHIP HULL GIRDERS UNDER INPLANE COMPRESSION

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1. General

In this paper, the results of a series of elastoplastic large deflection analyses on a specific cylindrical shell part of the ship hull girders under inplane compression is reported. Nonlinear finite element method is applied in the calculations. It is revealed that the assumption of elastic-perfectly plastic behaviour for this part of the ship hulls is not realistic and may result in very optimistic predictions of the ship hull overall strength.

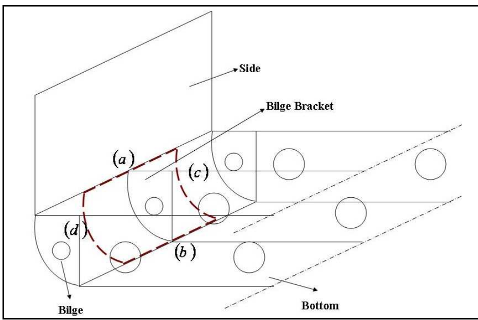
2. Introduction

Flat and curved stiffened plates are the key elements in the construction of ships and offshore structures. In a transition region between the bottom and side shells of the ship hull, there is a cylindrical part that is so-called *bilge*, Figure 1 (left). In most of the research works concerning with the ultimate strength of the ship hull girders under extreme sea conditions, the behaviour of this part is assumed to follow an elastic-perfectly plastic regime. No serious assessment has already been made or published on the strength and behaviour of this cylindrical shell part.

A series of full range elastoplastic large deflection analyses is performed on a parametric model of the bilge shell plating. The nonlinear finite element approach is applied for the investigations. Buckling and collapse modes are detected for the models. Also the average stress-average strain relationships of the models are summarised in a format to get a deep insight into the behaviours. Finally, it is revealed that the assumption of elastic-perfectly plastic behaviour for this part of the ship hulls is not realistic and may result in very optimistic predictions of the ship hull overall strength.

3. Model for analysis

The extent of the model for analysis is shown in the left part of the Figure 1. It is located between the two mid-span lines of the bilge brackets. Proper boundary conditions derived from real situations are applied to the edges of the model. Mechanical and geometrical characteristics of the parametric model are given in Table 1. A typical FE model for analysis with incorporated boundary conditions is shown in the Figure 1 (right). The model also is imperfect and initial deflections based on the real measurements are included in it.



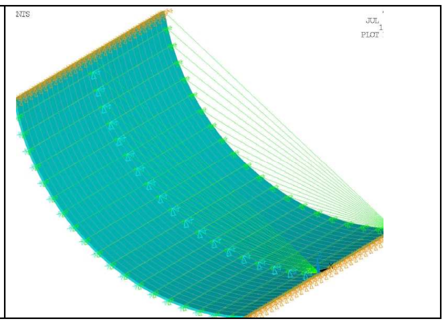


Figure 1. Extent of the bilge part for analysis (left) and its FE model (right).

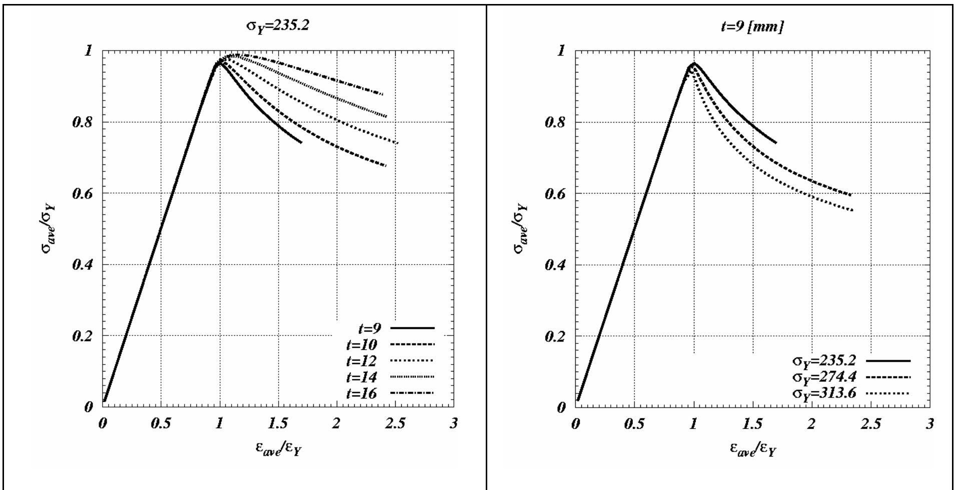
Length (L) [mm]	2250
Radius (R) [mm]	1800
Thickness (t) [mm]	9,10,12,14,16
Yielding Stress (σ_Y) [MPa]	235.2,274.4,313.6
Young's Modulus (E) [MPa]	206000
Poisson's Ratio (ν)	0.3

Table 1. Mechanical and geometrical characteristics of the model.

4. Results and conclusions

A series of elastoplastic large deflection analyses is performed applying nonlinear finite element method. An extract of the results are shown in Figure 2. Some of the key results are:

The average stress-average strain relationships for the models are the same in a pre-collapse or pre-ultimate strength level, regardless of the changes for thickness or yield stress. With the increase of the shell thickness or decrease in the yield stress, the slope of the post-ultimate strength part of the curves would be decreased. In the case of very extremely thick plates of a regular yield stress, a behaviour near to the elastic-perfectly plastic behaviour might be observed. It is finally concluded that the assumption of elastic-perfectly plastic behaviour for this part of the ship hulls is not realistic.



(a) the results for the case of $\sigma_Y = 235.2 MPa$ (b) the results for the case of $t = 9 mm$

Figure 2. Average stress-average strain relationships of some analysed cases with different values of thickness or yield stress.

5. References

[1] S. Timoshenko and S. Woinowsky-Krieger (1991). *Theory of Plates and Shells*, 2nd ed. McGraw Hill, New York, 122–131.

[2] J.K. Paik, B.J. Kim and J.K. Seo, (2007). *Methods for ultimate Limit State Assessment of Ships and Ship-shaped Offshore Structures: Part 3 Hull girders.* Ocean Engineering.