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Discussion

Buckling/Plastic Collapse Behaviour and Strength of Stiffened Plates Under Thrust. T. Yao, M. Fujikubo and D. Yanagihara (IJOPE, Vol.7, No.4, pp. 285-292)

J. Amdahl (Norwegian University of Science and Technology, Trondheim, Norway). The authors are to be congratulated for a very interesting contribution to the research of the behavior of stiffened plates compressed up to and beyond the ultimate strength.

Stiffened plates are common strength components in marine structures and good prediction capabilities of the ultimate strength are therefore essential for a safe design. However, the buckling and post-collapse behavior is not well understood, notably the interaction between different failure modes: plate buckling, interframe stiffener buckling and torsional stiffener buckling.

The analysis is also complicated by the fact that the ultimate strength is significantly affected by imperfections such as residual welding stresses and initial deflections. Residual stresses are neglected in the present study, but initial deflections are accounted for with an amplitude of 0.01t = 0.1 mm, both in the global and the local mode of deformation. It would be interesting to know the motivation behind the choice of these values.

Some information on residual stresses and initial deflections in ship structures does exist, but is far from being complete. Alternatively, if development of design rules is aimed at, initial deflections may be based on tolerance limits given in design codes. This is a consistent approach in the sense that ultimate strength formulas are often based upon equivalent, initial deflections equal to tolerance limits. (In the case of tubulars, experience from calibration of numerical predictions to column curves indicates that equivalent, initial deflections also account reasonably well for the effect of residual stresses.)

In DnV Classification Note 30.1 (1995) the following tolerance limits are given:
In the global mode of deformation:

$$w_{0.\text{stiff}} = 0.0015a$$

In the local mode of deformation:

$$w_{0,\text{plate}} = 0.01b$$

For the present cases this yields $w_{0,\text{stiff}}$ = 3.6 mm and $w_{0,\text{plate}}$ = 8 mm.

In addition, maximum misalignment (lateral deflection) of stiffener flange equal to $w_{0,\text{stiff}}$ = 3.6 mm is also given.

It appears that the DnV tolerance limits are considerably larger than the initial deflections used in the present study. It is therefore to be expected that the numerical predictions of ultimate strength significantly exceed design code values. This is confirmed in Fig. 1, where the ultimate strength for the different panels is compared with the design formula given in DnV Class. Note 30.1. It is interesting to note, however, that the relative strength is quite well preserved, except when torsional buckling of the stiffener is important. The DnV formula, which is based on a beam-column analogy, distinguishes between plate-induced and stiffener-induced failure. The stiffener-induced failure mode also accounts for possible torsional buckling. For all A-models plate-induced failure governs. Stiffener-induced failure, influenced by torsional buckling, is the governing failure mode of models F1, F2 and F3, whereas the failure modes are virtually of equal importance for model F4. This seems to be in quite good agreement with failure modes predicted numerically and illustrated in Figs. 5 and 9 in the paper.

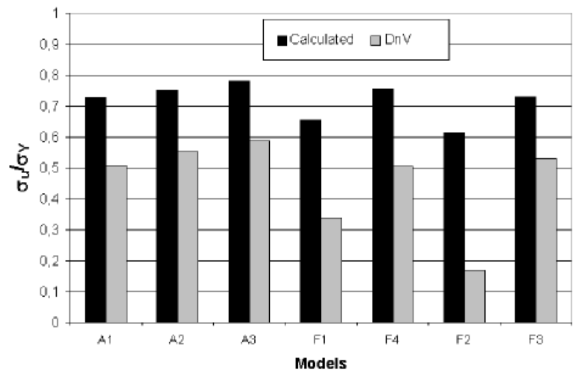

Fig. 1 Comparison between numerical predictions and DnV Class. Note 30.1

In spite of the apparently good agreement obtained for the present models, the relative significance of the various buckling modes as well as mode interaction may be biased if "unrealistic" imperfections are used. I take therefore the opportunity to suggest that future investigations address this problem as well as residual stresses. If successfully resolved, results from parametric studies could then constitute the basis for development of improved design formulas, which would be very much welcomed.

REFERENCE

Det norske Veritas (1995). "Buckling Strength Analysis," Classification Note 30.1.

AUTHOR REPLY

The authors are grateful to Prof. Amdahl for his useful comment on this paper. The aim of this study is to examine the influence of the cross-sectional geometry of stiffeners on the buckling/plastic collapse behaviour of a stiffened plate under thrust. As Prof. Amdahl pointed out, the buckling/plastic collapse behaviour of a stiffened plate is highly influenced by initial imperfections as well as a type of stiffeners. In the present study, however, in order to examine the influence of stiffener types separately, we considered the stiffened plate which was fundamentally free from any initial imperfections. The amplitude of initial deflections was thus selected as the minimum required value to stabilize the elastoplastic large deflection FEM analysis.

We completely agree with Prof. Amdahl that more realistic initial imperfections including welding residual stresses must be considered to discuss the significance and interaction of various buckling modes and thereby to improve the design formula. Regarding the initial deflections of plate and stiffener, their shape