SOME STRUCTURAL ASPECTS OF COLLISIONS BETWEEN SHIPS AND OFFSHORE CONCRETE PLATFORMS

H.Y. Low

Abstract

In recent years designers of offshore platforms have become increasingly aware of the need to design for accidental loads arising from ship impact. This dissertation seeks to contribute to a clearer understanding of the deformation properties of a ship structure in collision with the concrete shaft of an offshore platform (assumed rigid), from which design forces may be determined.

The basic approach adopted is to divide the complex ship structure into simpler elements, the response of which is investigated well into the large deflection regime (incorporating post-collapse behaviour). The work thus brings together a wide range of structural analysis problems.

Analysis for a beam loaded through a rigid circular indenter to large deflections has been developed. This analysis is relevant to the behaviour of the side plating of a ship which may be analysed as a series of beams spanning between main transverse frames or bulkheads. Both rectangular and unsymmetrical beam sections are considered. Experiments in small scale steel beams of rectangular section are described. The experimental and theoretical results shoe encouragingly good agreement.

A fresh approach to analysing the behaviour of a longitudinally stiffened deck at finite out-of-plane deflections is proposed. This involves the development of an upper bound plastic analysis for the load-end shortening relationship if an axially loaded strip. Assessment of the post-buckling strength of frame corners by means of an upper bound plastic analysis involving tension field theory (following Calladine*) is suggested. Transversely stiffened deck platings are treated by means of an effective width approach using existing effective width formulae.

Experiments on simplified structural models of parts of ships on a scale of approximately 1:10 are described. Eight models with different stiffening arrangements were loaded through a rigid concrete indenter of part circular section. Good agreement was obtained between the experimental results and the theoretical predictions using the simple analyses described above. Model tests conducted by Nagasawa el al** Japan are compared with the present test results. The theoretical predictions using the present work also agreed well with the results of the Japanese tests.

The understanding gained from the testing and analysis of simplified laboratory models of parts of ships is applied to the analysis of two actual offshore supply vessels. Force-indentation, force-energy and force-contact area curves are given for four cases of sideways collision and two cases of stern collision. Design forces are then suggested for both sideways and stern collisions, the former for the design against local bending failure and the latter for local punching shear failure. The collision forces determined for the stern collisions suggest that local punching failure of existing concrete shafts of typical offshore platforms with multiple supports could occur.

---

*Calladine, C.R. A Plastic Theory for Collapse of Plate Girders under Combines Shearing Force and Bending Moment, Structural Engineer, Vol. 51, 1973, pp. 147-154

** Nagasawa, H. et al A Study on the Collapse of Ship Structure in Collision with Bridge Piers (in Japanese), Trans. Soc. Naval Arch. of Japan, Vol. 142, 1977, pp. 345-354