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Sensitivity analysis on ultimate strength of aluminium stiffened panels

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Abstract

This paper presents the results of an extensive sensitivity analysis carried out by the Committee III.1 "*Ultimate Strength*" of ISSC'2003 in the framework of a benchmark on the ultimate strength of aluminium stiffened panels.

Previously, different benchmarks were presented by ISSC committees on ultimate strength. The goal has typically been to give guidance to the designer on how to predict the ultimate strength and to indicate what level of accuracy would be expected.

This time, the target of this benchmark is to present reliable finite element models to study the behaviour of axially compressed stiffened aluminium panels (including extruded profiles). Main objectives are to compare codes/models and to perform quantitative sensitivity analysis of the ultimate strength of a welded aluminium panel on various parameters (typically the heat-affected zone).

Two phases were planned. In *Phase A*, all members analysed the same structure with a defined set of parameters and using different codes. It was expected that all the codes/models predict the same results. In *Phase B*, to boost the scope of the analysis, the different members

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(using their own model) performed FE analyses for a range of variation of different parameters (sensitivity analysis).

Keywords: Ultimate strength; Sensitivity analysis; Aluminium stiffened panels; Axial compression; Heat-affected zone

1. Introduction

Multi-stiffened aluminium panels are increasingly used in a variety of marine structures, with applications such as hull and decks in high-speed ferries and catamarans, and superstructures for ships. Other applications are box-girder bridges, walls and floors in offshore modules and containers. This development has primarily been driven by the demand for reduced structural weight, increased payload, and higher speed and reduced fuel consumption. The competitiveness of such structures is principally due to modern extrusion technology, new joining technologies such as friction stir welding and efficient manufacturing processes.

A relatively little experience has been accumulated from large aluminium structures, and the existing design recommendations for aluminium panels are often based on experience from steel structures. Therefore, the alloy-dependent material properties and the detrimental effects of welding are not always fully accounted for in codes. Often effects of improved tolerances, possibility of more efficient stiffener design and welding technology (as friction welding) are not adequately taken into account in the design recommendations.

Compared to steel panels, the ultimate strength of aluminium structures is sensitive not only to residual stresses and initial deformations, but to deterioration of mechanical strength in heat-affected zones (HAZ) also. During the thermal cycle of welding process, softening of the material readily creates a HAZ. The level of the strength decrease is dependent on alloy type, temper, welding process and welding parameters. The extent of the reduced strength zone is mainly depending on the welding process, the welding parameters and the material properties. Because of the good heat conductivity of aluminium, the HAZ is much wider than for steel (usually 20–25 mm).

The available literature on numerical analyses of the ultimate strength of stiffened aluminium plates is quite limited. Numerical analyses of aluminium panels have been carried out in several studies, using different approaches. The ultimate strength of stiffened aluminium AA6082-T6 plates under the axial compression was investigated by Aalberg et al. [1,2] using numerical and experimental methods. Kristensen and Moan [3] demonstrated numerically the effect of HAZ and residual stresses on the ultimate strength of rectangular aluminium plates (AA5083 and AA6082) under the bi-axial loading of plates. Some initial experimental and numerical simulations on torsional buckling of flatbars in aluminium panels have been also presented by Zha and Moan [4–6].