Effects of spew fillet on the static and buckling properties of adhesively bonded stiffened panels

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1. INTRODUCTION & OBJECTIVE

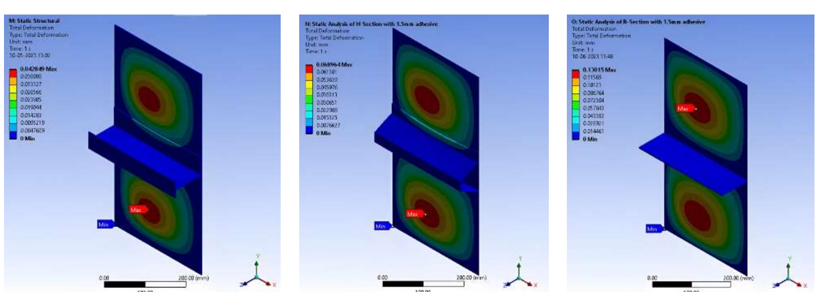
The current paper investigates the linear static and buckling (linear, non-linear, and post-buckling) responses of an adhesively bonded isotropic stiffened panel made up of Aluminium alloy using the Finite Element Analysis solver ANSYS. Stiffeners of different cross-sections (Hat, Rectangular, and I sections) are considered one at a time and adhesively bonded using Methyl Methacrylate as the adhesive agent. The mesh convergence and optimal thickness of the adhesive are initially established based on the linear static analysis and the results are validated with those available in the literature. Following which, the linear, non-linear, and post-buckling characteristics of different cross-sections of the stiffener are studied. Based on the preceding results, an optimal stiffener cross-section is chosen, and a spew fillet is incorporated into the design of the adhesive. It is observed that the introduction of a spew fillet in the adhesive design significantly reduced the stress concentration and improved the load-bearing capacity of the stiffened panel. Subsequently, fatigue design life is determined for the adhesively bonded stiffened panel with and without the spew fillet, and the results are documented.

Keywords: Adhesive bond; Stiffened panel; Linear buckling; Non-linear buckling; Post-buckling; Spew fillet; Design life.

2. RESULTS & HIGHLIGHTS OF IMPORTANT POINTS

Linear static analysis – Adhesively bonded stiffened panel

Linear static analysis for the adhesively bonded stiffened panel is carried out in the current section. The deformation and von Mises stress obtained from the current study, in which the panel is subjected to a static pressure load of 1000 Pa are compared with those available in the literature [1]. It can be observed from Fig. 1 and Table 1 that the maximum deformation and von Mises observed is the least in the case of I-stiffener.



a) I – Stiffener   b) Hat Stiffener   c) Rectangular Stiffener

Figure 1. Deformation contour of the stiffened panel under pressure loading

The usage of adhesive bonding significantly reduced the von Mises stress in the case of Rectangular and Hat cross-sections as well when compared with the non-adhesive case.

Table 1 Deformation and von Mises stress for the stiffened panel

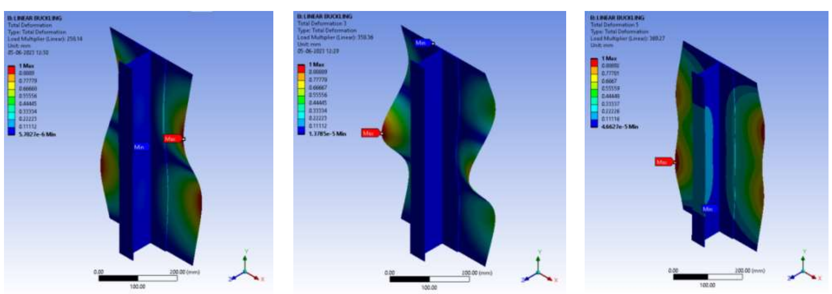
Stiffener Cross-section used	Maximum Deformation (mm)			Von Mises stress (N/mm^2)		
	Reference - without adhesive [1]	Present study without adhesive	Present study with 1.5 mm adhesive	Reference - without adhesive [1]	Present study without adhesive	Present study with 1.5 mm adhesive
I	0.036	0.042	0.042	1.93	2.00	1.93
Hat	0.076	0.062	0.069	4.70	3.91	3.22
Rectangular	0.110	0.130	0.130	5.86	4.28	4.20

Linear buckling analysis – Adhesively bonded stiffened panel

Stiffened plates are widely employed in weight and strength-sensitive structures due to their high load-carrying capacity and weight advantages [2]. Hence, in addition to the linear static analysis performed in the preceding section, the adhesively bonded stiffened panel is also subjected to linear buckling analysis. The critical buckling loads for the different stiffener cross-sections are shown in Table 2. It is observed that I-stiffener has the highest load bearing capacity at 25.81 kN among all the stiffeners. The buckling mode shapes 1, 3 and 5 for the I-stiffener are shown in Fig. 2.

Table 2 Critical load of linear buckling analysis for the adhesively bonded stiffened panel

Stiffener Cross-section used	Critical buckling load (kN)
I	25.81
Hat	22.89
Rectangular	8.09



a) Mode 1 b) Mode 3 c) Mode 5

Figure 2. Contour of mode shapes 1, 3 and 5 for the I-stiffened panel

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