Local Bending Containment in Impact Damaged Sandwich Panels

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Abstract. A repair technique involving the containment of local bending of sandwich facesheet by strategically filling honeycomb core cells has been explored to improve the damage tolerance of impact damaged sandwich panels. The experimental results indicate that filling honeycomb cells at the center of the damage region in addition to those at the edge of the damage region produces the maximum benefit. The test data and final failure mode of the repaired specimen under in-plane compression loading indicated that the present repair technique can help recover the undamaged strength of the sandwich panels.

1. Introduction

The compressive residual strength and behavior of impact damaged sandwich panels are governed by the amount of non-visible core damage underneath the facesheets [1,2]. The failure modes under in-plane compressive loading are either due to crack precipitation from the damage zone or unstable dimple propagation across the width. In both cases, the local bending of face sheet (dimple) triggers the final failure sequence. Thus, containment of this local bending by reinforcing the core cell(s) in the damage region will mitigate the failure initiation and thus increase residual properties. In order to arrest the local bending under compressive loading, a small hole was drilled in the damage area and the honeycomb cell was filled with resin. The filled cell acts as a localized support and reduces the bending of the facesheet over the damaged core. The effects of drilling and filling resin with a single hole at center of the impact damage region and multiple holes on the same region have been investigated.

2. Experiments, Results and Discussion

Sandwich specimens (10.5"tall×4.2"wide) were fabricated using Cycom 7714A/5HS T650-35 material for facesheets (45°/0°/45°) and Hexcel Kevlar honeycomb core of 0.5inch nominal thickness. Cytec FM-94 film adhesive was used for bonding the facesheets to the core. Sandwich specimens were impacted using a 1.0" diameter impactor with an impact energy of 40lb-in, that produced sub-surface core damage. Sandwich specimens with and without impact damage and repaired specimens were tested under edgewise compression to obtain the residual strengths. Three repair schemes were used in this study as illustrated in figure (1). Sandwich specimens were repaired by drilling 0.125" diameter holes and filling the honeycomb cell(s) with epoxy resin. The compression testing was performed under quasi-static loading (0.05 in/min) at NIAR. The boundary conditions and loading method is illustrated in figure (2). The actuator displacement, load, and strain data were recorded and the results are reported. The load-displacement and strength comparisons for specimens with and without damage, and for specimens with impact damage and different repair types are summarized in figures (3) and (4). It can be observed that the in-plane compression stiffness changes are negligible between specimen types, but a noticeable increase in strength can be observed for repaired specimens. The three-hole repair configuration was observed to restore/exceed the strength to the undamaged value. The face sheet fracture mode which was observed to emanate from the damage region was found to move away from the damage region for the repaired panels as shown in figure (5).

3. Conclusions

Based on the experimental results, it can be concluded that using a three-hole repair configuration, the residual strength can be restored to the undamaged value. Thus, containment of local bending can be used as an effective repair method for impact damaged sandwich panels with subsurface core damage. The effectiveness of repair for other loading scenarios and under fatigue loading must be investigated to make the repair method suitable for practical use.

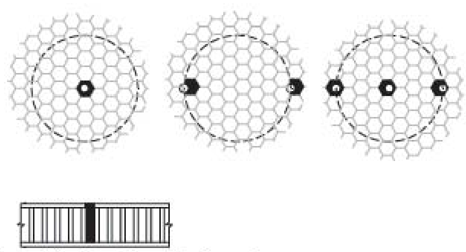

Figure (1): Repair methods used

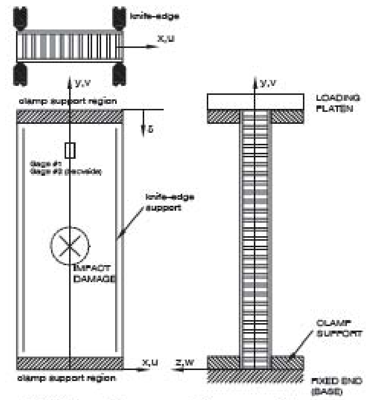

Figure (2): Boundary conditions used in compression test

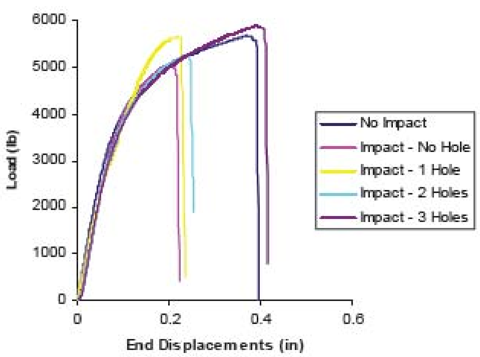

Figure (3): Load Vs End Displacement

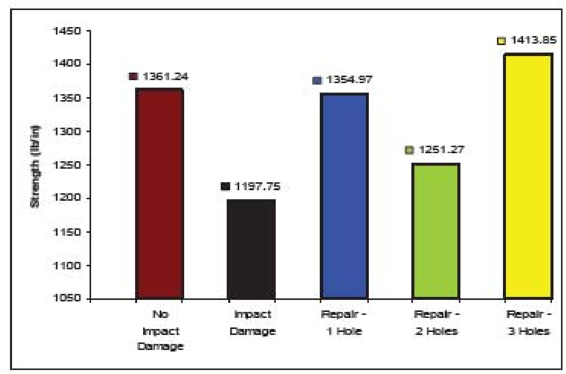

Figure (4): Comparison of Strengths

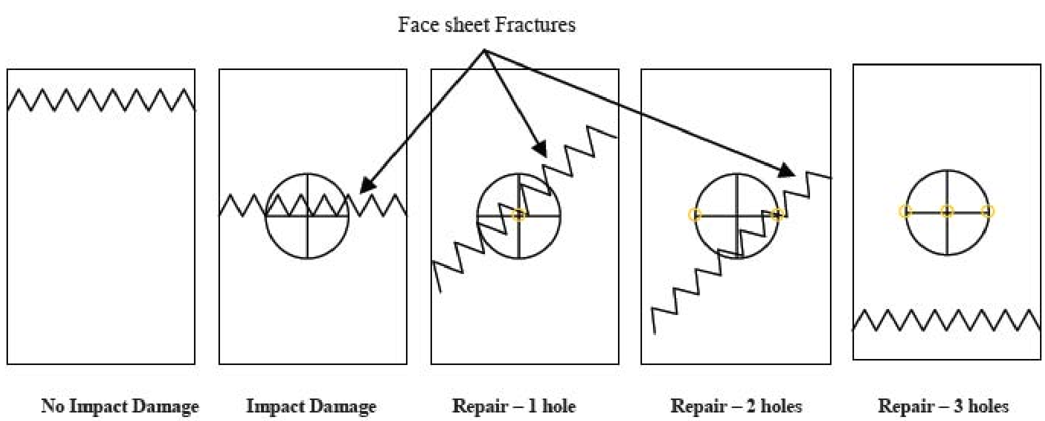

Figure (5): Different failure modes of specimens with varying number of holes

References

[1] Impact Damage Characterization and Damage Tolerance of Composite Sandwich Airframe Structures – Phase II: Tomblin John, S. Raju K S, Acosta J F, Smith B L and Romine N A.

[2] Impact Damage Characterization and Damage Tolerance of Composite Sandwich Airframe Structures: Tomblin John, S. Raju K S, Liew J and Smith B L.