EFFECT OF MANUFACTURING METHODS ON THE BEARING STRENGTH OF PINNED JOINTS FOR WOVEN COMPOSITES

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Abstract

Bearing strength of pinned joints for woven-glass reinforced epoxy composites was investigated. To understand the effect of manufacturing methods on the strength of pinned joints, specimens were manufactured using Vacuum Assisted Resin Transfer Molding (VARTM) and Hand Lay-up Methods. Effect of geometrical parameters such as diameter of pin-hole (d), edge distance (e) to pin hole diameter (d) ratio and, width (w) to pin-hole diameter ratio (d) were also studied. It was observed that specimens manufactured using the VARTM method sustained more force compared to specimens manufactured using the Hand Lay-up method. Specimens manufactured using both techniques resulted in very similar failure modes for the hole diameters of 6mm and 7.5mm. The manufacturing methods had significant effect on failure modes when the hole diameter was 9 mm.

Introduction

The mechanical joints such as pinned and bolted joints are widely used in composites. Compared to adhesively bonded joints, they are prone to stress concentrations. Therefore failure modes observed for joints were studied extensively. The effect of various parameters such as geometry [1], lay-up sequence [2], bolt-hole clearance [3] and, resin properties [4] were investigated. The manufacturing method might also have significant effect on the performance of these joints. In this study effect of manufacturing methods on the bearing strength of pinned joints were studied.

Experimental procedure

The composite material used in this research was manufactured using woven E-glass fabrics (Hex Force 7500) with 319 g/m^2 of weight and 0.3 mm thickness. Matrix material was 125 Resin/229 Hardener laminating epoxy resin and supplied by Pro-Set. The composite was processed and machined in the materials laboratory of New York City College of Technology. Composites were manufactured using Vacuum assisted resin transfer molding (VARTM) and Hand Lay-up methods. Ten layers of fabric were used in both types. Fiber volume fraction was 55%. The final thickness of the composite panels was approximately 3 mm. The specimens were first cured at room temperature for 15 hours and then at 83^{o}C for 8 hours.

Composite test specimens had a dimension of 25.4mm in width and 127 mm in length. The hole diameters were 6 mm, 7.5mm and 9mm. For each diameter three specimens at 25.4mm, 19.05 and 12.7mm edge distance were manufactured. Total nine e/d ratios and three w/d ratios were obtained (Fig 1(a)). The specimens were tested using the fixture shown in Figure 1(b).

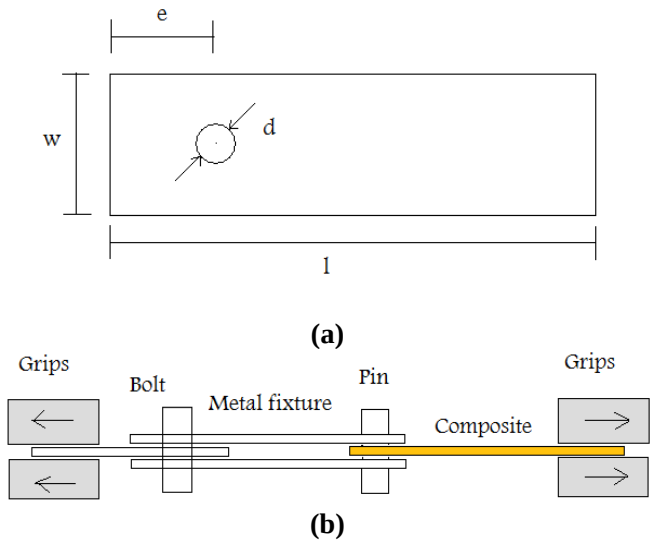
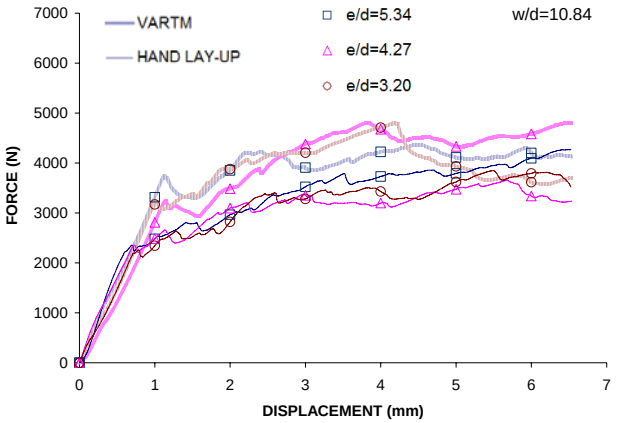


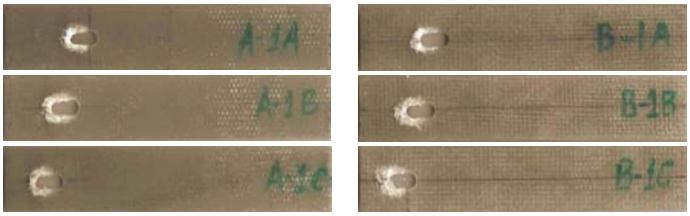
Fig.1 The schematic view of specimen geometry (a) and testing set-up (b).

Results and Discussions

When the w/d ratio was 10.84, the composites manufactured using the VARTM method sustained more load compared to hand laid-out composites for all three e/d ratios (Fig 2(a)). Damage initiation in hand laid-out composites started at lower loads. All three specimens exhibited bearing type of failure. The manufacturing method did not have significant effect on the failure modes (Fig.2 (b)). For the case where the w/d ratio was 8.55, specimens manufactured using the VARTM method again sustained more loads compared to the second type (Fig.3(a)) The failure modes observed for all three e/d ratios were similar (Fig.3(b)). The composites with 7.06 w/d ratios exhibited very different damage pattern (Fig.4 (a)). Even though specimens manufactured using VARTM sustained more load, all three specimens exhibited net-tension failure (Fig.4 (b)). The failure was observed at smaller displacements. Hand laid-out specimens sustained less load but they exhibited bearing type of failure mode. It was also observed that increasing w/d ratio increased the level of the load sustained by the composites. The statement was true for both types.

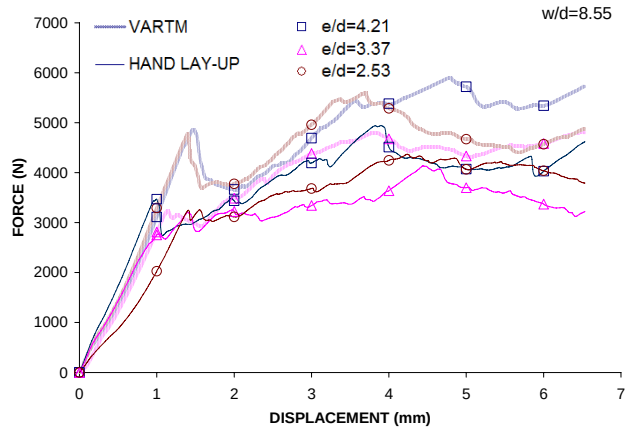


(a) Force-displacement relations

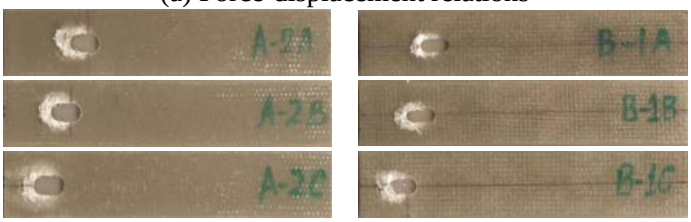


(b-1) VARTM (b-2) Hand lay-up

Fig.2 Force-displacement relations of woven-glass/epoxy composites with 6 mm hole (a). Optical pictures of tested specimens manufactured using VARTM (b-1), and hand lay-up methods (b-2).

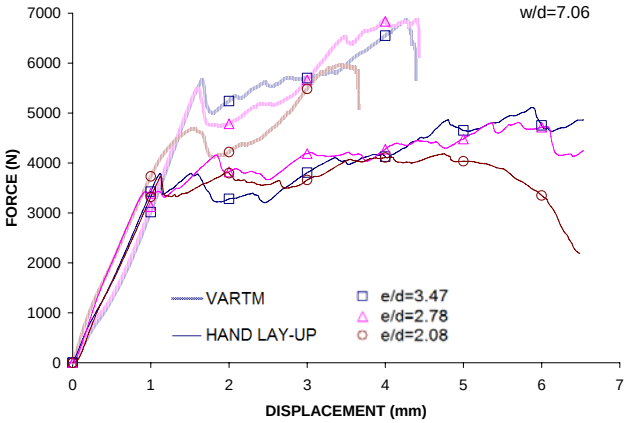


(a) Force-displacement relations

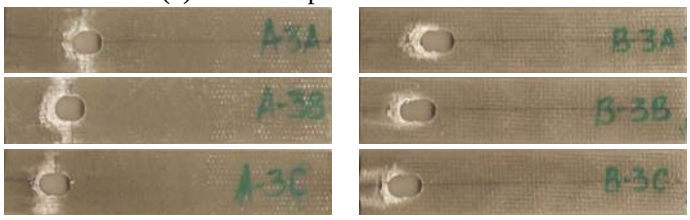


(b-1) VARTM (b-2) Hand lay-up

Fig.3 Force-displacement relations of woven-glass composites with 7.5 mm hole (a). Optical pictures of tested specimens manufactured using VARTM (b-1), and hand lay-up methods (b-2).



(a) Force-displacement relations



(b-1) VARTM (b-2) Hand lay-up

Fig.4 Force-displacement relations of woven-glass/epoxy composites with 9 mm hole (a). Optical pictures of tested specimens manufactured using VARTM (b-1), and hand lay-up methods (b-2).

Conclusion

Composites manufactured via VARTM sustained more load compared to hand laid-out specimens. Damage initiation in Hand laid-out composites was observed at early stages. In both types of composites, increasing w/d ratio resulted in increase at the level of the sustained load. The failure modes were identical for the cases where w/d ratios were 10.84 and 8.55. In case of w/d=7.06, the net-tension failure was observed for VARTM specimens and bearing type of failure mode was observed for hand laid-out specimens.

References

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