ABSTRACT

Recently, a new composite sandwich structure with a hybrid core has been developed by Li and Cheng [1]. The hybrid core is made of an advanced fiber reinforced polymer orthogrid that is filled by syntactic foam in the bay area. It has been proved theoretically that a positive or constructive composite action can be developed between the grid skeleton and the filled foam. The hybrid core sandwich structure can achieve similar structural capacity to its laminated composite counterpart with a significant saving in fiber reinforced polymer composite materials. In addition, it is envisioned that (1) Each filled cell or bay has a small size and small weight, which leads the cell towards quasi-static impact response; (2) the boundary of each cell is elastic, which again leads the cell towards quasi-static response; (3) the grid skeleton, the primary loading carrying component, has 2-D in-plane continuity and helps in transferring impact energy elastically in the whole panel; the foam, the secondary component, is responsible for absorbing impact energy through “self-sacrifice”.

The purpose of this study is to experimentally validate this novel sandwich structure through fabrication and test. In this study the various impact parameters like initiation energy, propagation energy and peak load are evaluated for impact occurring on the nodal, rib and the bay area in order to understand the effect of bay configuration on the impact response. Three different grid geometries with bay area size of 0.5”×0.5” (Group 1), 1”×1” (Group 2) and 2”×2” (Group 3), all having a thickness of 0.6”, are considered.

Foam filled grid panels of size 18”×18” were fabricated and then cut into 6”×6” square specimens. Composition of the foam was 60% of DER 332 epoxy resin and 40% of Q-Cel 6014 glass microspheres by volume. Vacuum bagging was used in order to obtain high quality specimens with low porosity. A wooden mold was used and pins were put into the mold at the required points and then a layer of bidirectional glass fabric was placed on top of the non-porous Teflon sheet. Then the dry fiber is wound around the pins to form the grid having 6 layers of fiber. Foam is then poured into the mold and covered with the top glass fabric. The whole setup is then put under vacuum using two layers of vacuum bag, one on each side and sealing it with tacky tape. It is then allowed to cure for 48 hours under vacuum. The sample is then cut into 6”×6” specimens using a bandsaw.

Three different groups of samples having different bay areas were prepared. Since the volume fractions of the fiber reinforcement had to be kept constant the number of fiber strands in each layer had to be varied for the three geometries as shown in Table 1. The volume fraction of fibers in Group 1 samples is slightly smaller than that in the other two groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Bay size</th>
<th>Number of Strands</th>
<th>Volume Fraction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5”×0.5”</td>
<td>2</td>
<td>10.69</td>
</tr>
<tr>
<td>2</td>
<td>1”×1”</td>
<td>5</td>
<td>11.52</td>
</tr>
<tr>
<td>3</td>
<td>2”×2”</td>
<td>7</td>
<td>11.52</td>
</tr>
</tbody>
</table>

Figure 1. Load & Energy Traces

Two types of control specimens - One with the pure foam as the core (Group 4 without the grid) and another with pure grid having a 1”×1” bay area (Group 5 without...
any foam in the bay area) were also prepared in order to analyze composite action. Impact tests were conducted using an impact testing system DYNATUP 8250HV. It consists of a drop tower equipped with an impactor and a variable crosshead weight arrangement. The testing was conducted with a constant hammer weight of 24.5kg and three different velocities of 2m/s, 3m/s and 4m/s, corresponding to energies of 50J, 110J and 200J. Testing was conducted on three different locations-Node, Rib and the Bay area. The typical load-energy traces obtained from the impact test are shown in Figure 1 for a Group 2 specimen tested at 2m/s on the bay area.

The variation in the initiation energy and propagation energy for the three groups of hybrid core specimens when subjected to nodal impact at different velocities is given in Table 2 and Table 3, respectively. It can be seen that the initiation energy is the highest for the Group 1 specimens and the least for Group 3 specimens. Group 2 specimens have initiation energy comparable to Group 1 specimens for 2m/s impact velocity; for higher velocities the initiation energy drops below that of Group 1. For the propagation energy it is seen that it increases consistently from Group 1 to Group 3 for 3m/s and 4m/s velocity impacts. This suggests that the larger the bay area, the less the energy required for initiating the damage and the larger the energy absorbed for propagating damage.

The location of impact also has a significant influence on the initiation and propagation energy. This can be seen from Table 6 and Table 7 which respectively give the initiation and propagation energy when subjecting Group 1 specimens to impact at different velocities at different locations. It is seen that the bay area is the weakest region and the nodal area is strongest. The failure mode in Figure 2 show the difference in the extent of failure when subject to impact on the bay, node and rib regions.

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**REFERENCES**