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International Journal of Current Research
Vol. 9, Issue, 08, pp.55586-55588, August, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

EVALUATION OF FLEXURAL PROPERTIES OF FRP HONEYCOMB CORE SANDWICH COMPOSITES REINFORCED WITH CNT

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ARTICLE INFO

Article History:
Received 28th May, 2017
Received in revised form
23rd June, 2017
Accepted 04th July, 2017
Published online 31st August, 2017

Key words:

Fiber-reinforced plastic (FRP),
Carbon Nanotubes (CNT),
E-Glass, carbon fiber and
Hand Lay-up method,
Vacuum bagging technique.

ABSTRACT

A sandwich-structured composite is a special class of composite materials that is fabricated by attaching two thin but stiff skins to a lightweight but thick core. The core material is normally low strength material, but its higher thickness provides the sandwich composite with high bending stiffness with overall low density. Nowadays, sandwich structures with different face sheet and core materials are increasingly used in various applications. Sandwich structures have many advantages, including high stiffness-to-weight and strength-to weight ratios, high damping capacities, good thermal insulation properties, excellent water and vapor barrier performance, good corrosion resistance, and low cost. To characterize the flexural properties of the sandwich composites, a series of 3-point bending tests were conducted, in accordance with the ASTM D7264 standard on the sandwich panel with different percentage of CNT. The variation of CNT percentage will affects the bending properties of the sandwich beam in the three point bending tests. A holistic approach will be conceived to identify the applicability of sandwich construction, allowable core bending strength. Increasing the percentage of CNT in FRP honeycomb sandwich composites increases the strength of the structure to certain extant. However addition of CNT behind 2% decreases the strength.

Citation: Suresh Babu, K. S., Bylappa, B. K., Dr. Shivanand, H. K., Rakshit Divakar Naik and Sunil Kumar, K. V. 2017. "Evaluation of flexural properties of frp honeycomb core sandwich composites reinforced with cnt", *International Journal of Current Research*, 9, (08), 55586-55588.

INTRODUCTION

In many fields, the desired material needs to be both light weight and strong for functionality, while economic considerations require the characteristics of low cost and ease of manufacture. Ideal materials have a combination of properties that allow multi-functionality, where a single component can perform a number of roles. Composite materials should have been developed as part of this pursuit, with the capacity to have enhanced properties when compared to the constituent materials. Composites are normally made by incorporating some reinforcement such as fibers in a bulk material known as the matrix. The Properties of composites can also be tailored according to specific design requirements, directional and spatial properties. At present composite materials have found wide spread applications in aeronautics and space sector due to their lightweight and high strength. Almost all modes of transportation and the sports equipment also use a considerable amount of composites, due to their capacity to withstand harsh loading conditions.

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Developments in aviation posed the requirement of lightweight and high strength materials. Sandwich structured composites, fulfilling these requirements, became the first choice for many applications have including structural components. Now, their structural applications spread even to ground transport and marine vessels.

MATERIALS AND METHODS

Hand Lay-up method: This is a manual approach, in which layers of fabric and resin are successively applied onto a mould. The mould is first designed to the shape of the final composite structure. The fiber layers are oriented in such a way, as to develop the desired strength and stiffness. After each layer of fabric is placed, a roller is used on the composite, so that a strong bond results, and excess resin is squeezed out. The stacking of the fabric materials and resin is done until the required thickness is achieved. This method is labor-intensive and only suitable for production in low volume.

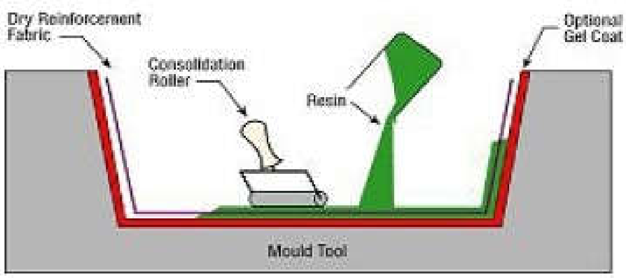


Figure 1. Hand Lay-Up Process

Resin Transfer Moulding method: In Resin Transfer Moulding (RTM), resin is injected into a mould in which the fibers and the core material areplaced in the desired position. The resin is fed under gravity or external pressure Curing occurs within the mould, often assisted by heating. The mould is usually made of metal, which gives good heat transfer and lasts for many moulding operations. Relatively large parts can be manufactured in this way.

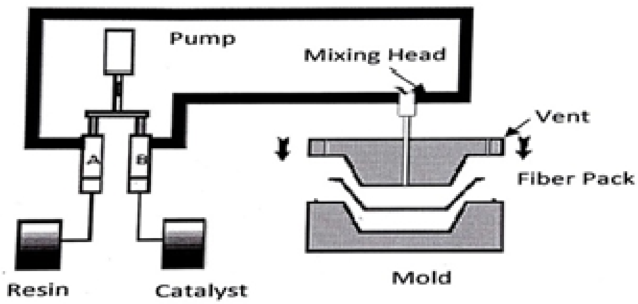


Figure 2. Resin Transfer Moulding

Vacuum bagging technique: Take a typical hand lay-up for making composites one step further with vacuum bagging. Once layers of reinforcement and resin are laid-up by hand, the laminate is sealed in an air-tight environment, like a vacuum bag, and connected to a vacuum source. Vacuum is applied, creating mechanical pressure on the laminate throughout the cure cycle.

Figure 3. Vacuum bagging technique

Manufacture of face sheet: Bi-woven glass 'E' cloth, which is commercially available is used for making the face sheet and is shown in Figure 4. The cloth ply was trimmed to the correct size and impregnated in an adhesive made from a mixture of LY556 epoxy resin and HY 951 hardener, mixed in the ratio of 100:10. The ply was stacked in 0º/90º orientation and was built to a thickness of around 2.0 mm. The Vacuum hand lay-up technique was used to make the facings and is shown in Figure 5. A Vacuum level of 500Hg/mm^2 is maintained for 1 hour to avoid surface undulations and also to avoid air pockets at the interface. The coupons were allowed to cure for about 24 hours at room temperature.

Figure 4. Bi-woven glass 'E' fabric

Figure 5. Hand lay-up technique

Manufacture of Honeycomb core: For the manufacturing of the honeycomb core the matrix used is epoxy resin LY 556 mixed with a hardener HY 951 and the reinforcement is glass 'E' fabric. The resin and hardener are mixed in the weight ratio of 10:1. To maintain the optimum strength, the resin glass ratio is found to be 35:65. The molding tool used is hexagonally machined split molding tool made of chromium plated mild steel.

Figure 7. Fabrication of honeycomb sandwich panel

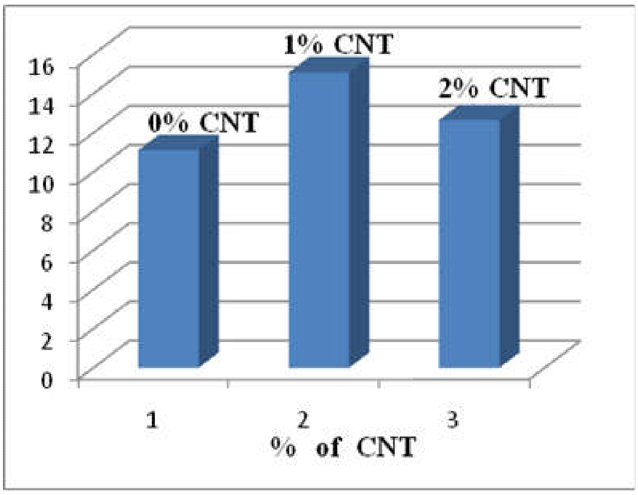
Testing of Composites

Flexural/bending Test

Bend test machines are typically universal testing machines specially configured to evaluate bend strength. Bend tests tend to be associated with ductile metals and metal products. Bend test equipment and test procedures are similar to flexure test equipment. Flexure tests are commonly associated with brittle materials including plastics, polymers, composites, glass and ceramics. That said, bend test and flexure test terms are used interchangeably in the testing industry. A bending test was conducted on the sandwich panel to determine the bending strength of the composite sandwich panel, as per the ASTM D7264. The test specimens were sectioned from the composite panels with the width of 12.7 mm, thickness of 7 mm and length of 125 mm.

RESULTS AND DISCUSSION

Flexural/bending Test: To determine the bending strength of the honeycomb sandwich core, a series of bending tests are conducted on the Sandwich panels with different percentage of CNT. Bending tests of the CNT reinforced FRP honeycomb core sandwich composites specimens are carried out as per the ASTM D7264.



Graph. Bending strength (N/mm2) Vs % of CNT

Table. Bending Test Results

Specimen designation ASTM D7264	Specimen dimensions in (mm)	Length in (mm)	Breaking Load/ Peak load (KN)	Bending strength (N/mm2)	Average Bending strength (N/mm2)
FRP/A (0% CNT)	12.7 x 7.0	125	1.009	11.36	11.12
FRP/B (0% CNT)	12.7 x 7.0	125	0.968	10.89	
FRP/A (1% CNT)	12.7 x 7.0	125	1.434	16.14	15.09
FRP/B (1% CNT)	12.7 x 7.0	125	1.248	14.04	
FRP/A (2% CNT)	12.7 x 7.0	125	1.096	12.33	12.66
FRP/B (2% CNT)	12.7 x 7.0	125	1.154	12.99	

A careful examination of the bending strength of all specimens is general observation. Increasing percentage of CNT from 0 to 1% in FRP honeycomb core sandwich composites is trend with an increasing the bending strength and further increasing the percentage of CNT from 1 to 2% is associate with a decreasing bending strength. So, it is evident that the percentage of CNT affects the bending properties of sandwich beam in the three point bending tests.

Conclusions

- Sandwich composite panel with E-glass/Epoxy and different percentage of CNT honeycomb core cell size of 7mm were fabricated. And mechanical tests are carried out by as per ASTM standard.
- Increasing the percentage of CNT from 0 to 1% in FRP honeycomb core sandwich composites is trend with an increasing the bending strength and further increasing the percentage of CNT from 1 to 2% is trend with a decreasing bending strength. From the above discussion, we conclude that increasing the percentage of CNT beyond a certain limit (2% here) reduces the interfacial area due to agglomeration of CNT. In addition, aggregated CNTs act as stress concentrators.

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