FLEXURAL BEHAVIOUR OF BIO AND SYNTHETIC FIBER REINFORCED PU SANDWICH STRUCTURES

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Abstract

Flexural behavior of sandwich structures of polyurethane foam (PUF) core and biofiber (jute and bamboo) and synthetic fibre (glass fibre) reinforced plastics (FRP) outer skins were carried out using three point bending test according to ASTM-C393. Nine types of specimens, namely glass, jute, bamboo, glass/jute, jute/glass, glass/bamboo, Bamboo/glass, jute / bamboo and bamboo/jute were considered for investigation. The flexural response of all the nine types of sandwich structures exhibited two distinct regions, namely, steady region and deteriorating region. Bamboo/glass hybrid structure yield higher value of core shear stress and facing bending stress., which is higher than of both pure glass, bamboo. This shows how effectively hybridization can effectively use.

Introduction

The sandwich structure is a composite configuration that consists of high strength composite facing sheets bonded to lightweight foam or honeycomb core. Examples of these structures include skins made of glass/carbon/Kevlar fibers in vinyl ester/epoxy matrix bonded and separated by an aluminum honeycomb or polyurethane foam. Sandwich structures have extremely high flexural stiffness to weight ratios and widely used in mechanical structures such as airplanes and ships. The design flexibility offered by these and other composite configurations is obviously quite attractive to designers, and the potential now exists to design not only the structure, but also the structural material itself.

Palle [1] has studied heat transfer behaviour of PU sandwich construction of bonded pipe in pipe system with steel jacket pipe. Anon [2] has introduced PU sandwich plate system in shipbuilding, claiming significant benefits in performance, cost and safety compared with conventionally stiffened steel plate structures. Lockheed Martin Michoud Space Systems have used PU sandwich structures for the super lightweight space shuttle fuel tank (46.2 m long, 8.62 m diameter, and 530,000 gallons capacity) for holding cryogenic fuel. In all these cases, the sandwich structures helped realizing the best combination of thermal resistance, mechanical properties [3], creep [4] and buckling strength [5]. This paper is focused on flexural strength of sandwich structures considering their bending strength of all nine**.**

Material preparation

The sandwich specimens were fabricated according to standard specifications. The specimen consists laminates of glass fiber/epoxy, jute /epoxy, bamboo/epoxy and PUF as core. The primary chemicals used to produce the PUF were methylene di-isocynate (MDI) and polyether polyol (PP).

Amount of MDI and PEP liquids were taken in separate clean and dry glass cups. Inner surface of wooden die (250mm x 250mm x 25mm) was covered with a Teflon sheet. MDI and PEP were mixed using a stirring rod in a separate glass vessel. The mixture was poured into the die. The die was covered with a wooden plate and a pressure of 5 tons was applied using hot press. PU rigid foam was taken out of the die after curing for 30 min. A Glass /Jute/Bamboo fiber mat was laid-up on PUF core. A resin and hardener on each face of the Glass/Jute/Bamboo fiber mat was laid-up. Reinforcement fibers on each side of the rigid foam were laid-up. The specimens were cured at ambient temperature for 24 hours applying pressure

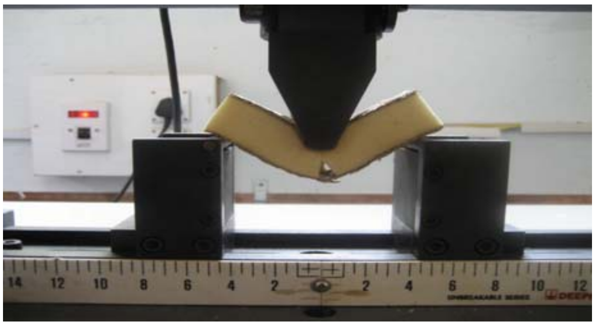

Fig. 1. 3 point bending test

using hot press

The test procedure for three-point bending was according to ASTM C393 standards. Span length of the specimen for 3PB is 100mm and was maintained constant for all the specimens. The testing was done under controlled loading conditions. Specimen size and Loading fixtures were as per ASTM standards as shown in Fig. Apply the load to the specimen with loading fixture at a constant rate of movement of cross-head at 2 mm/min. During the test, load displacement data has recorded for all the specimens under all the conditions.

Results

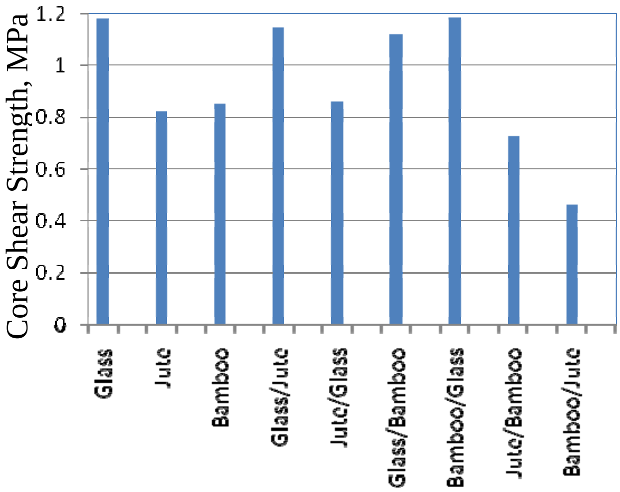

Fig. 2 Core shear strength of different fiber skinned sandwich structures

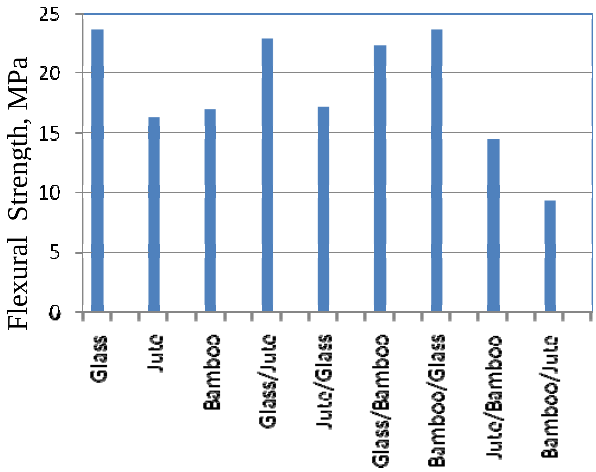

Fig. 3 Flexural strength of different fiber skinned sandwich structures

The variation of core shear stress (CSS) v/s type of sandwich structure and Facing bending stress v/s type of sandwich structure in three point bending is depicted as shown in Fig. 2 and Fig. 3 respectively. Bamboo/glass sandwich structure possess higher of CSS and facing bending stress, where as Bamboo/ jute possess lower value. In the figure or table for example glass/bamboo means upper/lower facing in sandwich structures respectively. The facing bending stress and core shear stress of Bamboo/ glass sandwich structure is 1.0006, 1.43775, 1.3876, 1.03173, 1.63419, 2.53355 times higher than glass, jute, bamboo, glass/jute, jute/glass, jute/bamboo, bamboo/jute sandwich structures respectively

Discussion

The bending strength of sandwich structures depends upon the strengths of outer skins, foam and interface between the skin and the foam. The failure of any one of these would cause failure of the sandwich structures. It is reported that the bending strength of the sandwich panel is influenced by the skin strength and thickness, as skin buckling is an important failure phenomenon. The radii of curvature of the upper skin, the foam and the lower skin assumed different values resulting in shearing at the interface between the skin and the foam to initiate debonding of layers. Thus, failure of sandwich structures is not only because of fatigue stress but also shear stresses at the interface. Hence, the fatigue failure in sandwich structures is multi modal due to the tensile, compressive and shear stresses.

The shear force dominates over the adhesive forces at the interface between the core and the skin. Hence, the failure of sandwich structures is always not at the centre of the structure but towards the ends. The crack initiated at the middle of the upper interface layer and did not propagate. But at the lower interfacial layer the crack initiated and propagated at the supporting reaction. Hence, the failure is expected at the lower interface, which is in conformance to the delamination observed in the lower skin of the sandwich structures.

Conclusions

In Three points bending test of sandwich structure, bamboo / glass hybrid structure yield higher value of core shear stress and facing bending stress, which is higher than of both pure glass, bamboo. This shows how effectively hybridization can effectively use.

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