A REVIEW ON SANDWICH AND NATURAL FIBER COMPOSITES

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Abstract: Sandwich composite is a particular form of laminated composite in which a combination of two different and stiff materials is bonded together. In these composites, properties of the sandwich specimens are enhanced by its individual constituents. Sandwich composites usually consist of two thin, stiff materials separated by thick lightweight cores. The cores that are generally used are honeycomb and foam cores. In this paper research work is carried out on the sandwich composites. The various tests are performed on the fabricated models and major applications are also discussed below.

1.0 INTRODUCTION:
A Composite material is a material that is made up of two or more constituent materials. The individual materials are bonded to produce a composite with characteristics superior to its constituents. In composites the individual properties of materials are retained. 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 sandwich composites possess properties like high strength and high stiffness to weight ratio.

2.0 TYPES OF SANDWICH COMPOSITES
1. Steel–concrete–steel (SCS) sandwich composite.
2. Glass fibre reinforced sandwich composite.

3.0 DESCRIPTION:
Here, various types of sandwich composites, based on steel concrete and glass fiber reinforced are discussed.

3.1 STEEL–CONCRETE–STEEL (SCS) SANDWICH COMPOSITE:
Zhen-Yu Huang et al. [1] investigated the ultimate strength behavior of SCS sandwich shell experimentally and analytically. Two pilot quasi-static tests on the lightweight SCS sandwich composite shells subject to patch loading are carried out. Tests show that the punching shear resistance depends on the control perimeter of punched concrete frustum and shear connectors. The membrane action of the outer steel plates provides post-hardening strength. Meng Chu et al. [2] investigates the structural performance of steel-concrete-steel (SCS) sandwich members comprising a concrete core sandwiched in between two steel plates which are interconnected by channel steel connectors with large interval. Angle steel is adopted to serve as the connection between channel steel and surface plates. The behavior of a series of 8 large-scale, simply supported tests was investigated, covering a wide range of applied shear span to depth ratios from 1.5 to 5.5. Other parameters include the interval...
of channel steel and axial tension force. Although critical inclined cracks appeared in most of the beams, the observed modes of failure were all ductile failure characterized by yielding of the tension steel plate. Unlike the negligible dowel action of longitudinal reinforcement in reinforced concrete members, the dowel action of steel plate in SCS member seems to play a decisive role. C. Abraham and K.C.G. Ong. [3] investigated the performance of steel-concrete composite panels, which consist of fiber-reinforced high-strength concrete (FRHSC) on the compression face and a specially configured steel sandwich as tension reinforcement. The performance of the composite panel is compared to similar ordinary reinforced concrete panels. The latter is reinforced with the maximum reinforcement ratio specified by the codes. The static response of the composite panel is obtained numerically using finite element modeling and experimentally under third point bending tests. M. Leekitwattana et al. [4] suggested a steel-concrete-steel (SCS) sandwich beam represents a special form of sandwich structure. It consists of steel face plates and concrete core which are connected together by means of a series of shear connectors. The state-of-the-art construction forms of SCS sandwich structures are double-skin sandwich construction (DSC), Bi-Steel sandwich construction (Bi-Steel), and alternative SCS sandwich construction. They are different only due to the pattern of their shear Connectors. O. Dogan and T.M. Roberts. [5] investigated Double skin composite construction consists of a layer of a plain concrete, sandwiched between two layers of relatively thin steel plate, connected to the concrete by welded stud shear connectors. This construction consists of a similar way to doubly reinforced concrete elements but the flexibility of connection between the steel plates and concrete gives rise to interface slip and additional overall element deflection. This results in a strong and efficient structure with certain potential advantages over conventional forms of construction. Steel–concrete composite systems generally consist of steel plate, concrete and reinforcement. Shear connectors are usually utilized to develop the composite action between steel and concrete. In steel-concrete composite members, the natural bonding, friction, and mechanical interlocking actions of shear connectors have a significant influence on the degree of interaction.

3.2 GLASS FIBRE REINFORCED SANDWICH COMPOSITE

V. Crupi et al. [6] investigated the collapse of GFR-AFS occurred for the debonding of the aluminum faces from the core and is strongly influenced by the rigidity of glass fiber skin material, whereas the aluminum foam sandwiches collapsed for the foam crushing and their energy absorbing capacity and it is found that the lightweight aluminum sandwiches have good properties of energy dissipation and the amount of energy absorption under bending and impact tests can be improved reinforcing them by means of GFRP outer skins. Nicolas J. Lombardi and Judy Liu [7] studied GFRP-steel hybrid parametric to evaluate improvements on the GFRP honeycomb deck panel stiffness and concluded that in one direction, the hybrid concept results in a significant increase in both flexural and shear stiffness. In the other direction beam samples, the hybrid and Kansas Structural Composites, Inc. flexural stiffness results were about the same, apparently due to changes in the KSCI baseline beam. Amir Shahdin et al. [8] studied the entangled sandwich specimens having glass fiber cores and glass woven fabric as skin materials. The tested glass fiber entangled sandwich beams possess low compressive and shear modulus as compared to honeycomb and foam sandwich beams of the same specifications. The vibration tests show that the entangled sandwich beams possess higher damping ratios and low vibratory levels as compared to honeycomb and foam sandwich beams. The test results also proved that entangled sandwich specimens with shorter glass fiber lengths have high structural strength but on the other hand low damping ratios and higher vibratory levels when compared to entangled sandwich specimens with longer glass fiber length in the core. Tine Lanssens [9] analyzed the computational and experimental study on the mechanical behavior of a 3-dimensional GFRP sandwich panel with through thickness fiber insertions. Samples of the GFRP skin and glass fiber insertions were cut out from larger panels and are tested to determine basic material properties of the components of the sandwich panels. The results show that increasing the density of fiber insertions makes the panel
stiffer. An alternating pattern for the insertions also increased the overall panel stiffness. Varying the overall panel thickness between a minimum and a maximum thickness indicated that an optimal overall thickness could be established. Mechanical tests were performed on the sandwich panels and the components of sandwich panel: skin and fiber insertion. Experimental results on the components were used to create a nonlinear finite element model that can predict the large-scale mechanical deformation of the sandwich panels. The model can predict force–displacement behavior of the panel accurately under a variety of experimental conditions. J. ARBAOUI et al. [10] The first, tow face sheet of composite glass fibers (T800/M300)/polyester resin. The second part is a honeycomb polypropylene core. It is found that decrease in shear modulus with increasing core thickness and increases with number of layer increasing. The effect of variations in core thickness and intermediate layers from single to quadruple on mechanical properties of a polypropylene honeycomb core was evaluated and results show that mechanical properties increase with increasing core thickness and intermediate layers.

3.3 OTHER SANDWICH COMPOSITES

Jiayi Liu et al. [11] investigated the effect of temperature on the bending properties and failure mechanism of pyramidal truss structured carbon FRP core sandwich structures with carbon epoxy prepeg and found that bending failure load decreased by 92.27% when the temperature increased from 293K to 473K, which was mainly due to the degradation of the matrix properties and fiber-matrix interface properties. In addition to the decreasing of the bending failure load, the failure mode of composite sandwich structure also changed with temperature. M. Botshekanan Dehkordi & S.M.R. Khalili [12] performed frequency analysis of sandwich plate with active SMA hybrid composite face-sheets and temperature dependent flexible core bonded using epoxy resin. They proposed the result that using the pre-strained SMA wires the stiffness of the sandwich plate can be improved and therefore has a positive effect on the natural frequencies of the sandwich plate. P. Nagasankar et al. [13] assayed the role of different fiber orientations and thicknesses of the skins and the core on the transverse shear damping of polypropylene honeycomb sandwich structures. They inferred that increasing the thickness of PPHC core increases the damping loss factor since it undergoes greater transverse shear deformation. Also they found that 0° fiber oriented sandwich with large thickness is considered as the best choice since large damping loss factor, natural frequency and stiffness are obtained. Sindu Satasivam and Yu Bai [14] investigated mechanical performance of bolted modular GFRP composite sandwich structures using standard and blind bolts. These sandwich specimens are used in beam and slab applications. The major conclusions made are: (i). The bending stiffness of all the sandwich specimens with bolts as shear connections decreased as the load increased due to the decrease in composite action between the panels and web sections with increasing load. (ii). As the bolt spacing increased, both the stiffness and degree of composite action were reduced. (iii). Standard through-bolts were shown to cause premature local buckling at large bolt spacing, and this premature buckling was avoided with the use of blind bolts. This is because blind bolts couple the upper or lower panels with the adjacent flange of the core profile. (v). All-composite GFRP sandwich systems with bolted shear connections had superior performance to a one-way spanning reinforced concrete slab of similar dimensions, including a significant reduction in self-weight and an improvement of load-carrying capacity. In addition, the use of bolted shear connections allows for easy assembly and disassembly. M. Samadpour et al. [15] conducted vibration analysis of thermally buckled SMA hybrid composite sandwich plate with the temperature dependent laminated composite face sheets and inferred that during austenite phase transformation, the conspicuous tensile recovery stress is generated so that increasing the pre-strain leads to raising recovery stress intensely. This increasing of pre-strain leads to natural frequency decline in the post-buckling domain, which is due to lower deflection in this domain. A. Anjang et al. [16] assayed post-fire mechanical properties of sandwich composite structures and their experiment reveals that the core plays an important role in insulating the back skin, and this has significant influence on the post-fire properties. There was a large reduction
to the compression stiffness and strength following exposure to the thermal flux, even for short times (e.g. 60 s) followed by a rapid reduction in the tension modulus and strength within the first 200 s, which is the time taken to decompose the front skin exposed directly to the thermal flux. Guo-dong Xu et al. [17] presented a new method for forming the graded corrugated truss core sandwich structures based on an auto-cutting and mould-press process and analyzed the bending stiffness, strength and failure mechanism of the specimens. Finally, they found that the strength of the graded corrugated truss core composite sandwich beam with strong struts in the middle region is much higher than the one with weak struts. The main failure mode of the graded corrugated truss core composite sandwich beam with weak struts in the middle is core member delamination induced by the indentation failure.

4.0 NATURAL FIBRE COMPOSITES

VijayaRamnath et al. [18] studied the property comparison of abaca-jute hybrid composite and abaca composite and discovered that while abaca-jute hybrid composite had better tensile and shear properties, abaca had better flexural and impact properties. Srinivasan et al. [19] investigated the mechanical and thermal properties of banana-flax based natural fibre composite and discovered that hybrid composite has far better properties than single fibre glass reinforced composite when tested for flexural and impact loads. Manickavasagam et al. [20] observed that fibre orientation plays an important role in determining the mechanical properties of the composite by testing an intra layer abaca jute glass fibre reinforced composite. VijayaRamnath et al. [21, 22, 23] discovered that hybrid natural composites have excellent tensile and flexural properties investigating the properties of a jute flax based glass fibre reinforced composite. While testing of the mechanical properties of banana jute hybrid composite discovered that, overall, the hybrid composites had better mechanical properties than mono composites containing the same materials [22]. It was observed that observed a significant improvement in mechanical properties of composites due to the presence of twisted fibre and this also reveals the influence of fibre orientation on mechanical properties [23]. Navin Chand et al [23] investigated the effect of sisal fibre orientation on electrical properties of sisal fibre reinforced epoxy composites and discovered that there was a significant effect on the properties observed. Lucas et al [24] investigated the pronconcentration of copper in tobacco leaves samples using a minicolumn of sisal fibre loaded with alizarin blue and discovered that the achieved concentrations varied from 0.15 to 0.52 µg g⁻¹. Rashnal Hossain et al [25] studied the tensile behavior of environment friendly jute epoxy laminated composite and discovered that the properties are very defect sensitive. Belaadi et al [26] researched the fatigue in sisal fibre reinforced polyester composites and discovered that failure is reached within a few cycles for high loading levels while it is only partial for lower loading levels. Yan Li et al [27] gave us a succinct and thorough review on sisal fibre and its composites as well as recent developments in the field. Dwivedi et al [28] investigated the influence of MA-g-PP on abrasive wear behavior of chopped sisal fibre reinforced polypropylene composites and discovered that the sample having 2% by weight of MA-g-PP offered maximum wear resistance.

5.0 CONCLUSION

The purpose of this review was to study about the various majorsandwich structures, tests performed on them and their properties. It is clear from the review that various types of sandwich composites have been studied and analyzed on the basis of the tests conducted upon them.

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