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ABSTRACT

Sandwich beams are composite systems that have properties such as high rigidity, high strength and low weight. The sandwich system include glass fiber reinforced polymer (GFRP) skins and phenolic cores, and several layers of sandwich panels are bonded with an epoxy polymer matrix to manufacture the packages. In sandwich beam (LSB) layers, four horizontally oriented layers and the other four vertically oriented layers were tested. To understand the basic behavior of a multilayer sandwich beam, a 3D finite element model was developed using ANSYS. To explore the suitability of this new concept for structural applications, the flexural behavior of the layered sandwich beam is validated using data available in the literature, and the numerical model can be improved by incorporating shear and fatigue behavior which increases confidence in using this novel concept of beam in the civil construction sector.

Keywords: GFRP, Phenolic cores, ANSYS, Sandwich Panels.

1 Introduction

Sandwich composites are becoming more and more popular in structural design, especially for their ability to decrease weight significantly while maintaining mechanical performance. The concept to sandwich composite structures is high bending stiffness and high weight strength ratio. Recently, an Australian manufacturer has fabricated a new structural glass fibre reinforced polymer (GFRP) sandwich panel for the civil engineering applications which include slabs, pedestrian bridges, bridge girders, and railway sleepers. The sandwich panel is made of glass fiber for the top and bottom skins and a modified phenolic solid core material. In comparison to the conventional sandwich panels, the new GFRP sandwich panel has a better core density ensuing in an improved structural behavior. The GFRP sandwich panel offers many other advantages inclusive of high energy to weight.

Ratio, accurate thermal insulation, moisture resistance, and termite resistance. This panel is also incredibly sustainable. With its many advantages, composite sandwich structures have been widely used in numerous applications, and these composite materials is attracting a lot of interest in the construction industry and has now begun to be used for civil engineering applications. A sandwich includes three principal elements as illustrated in Fig.1.1. Thin, stiff, and strong faces are separated with the aid of a thick, light, and weaker core. The faces are adhesively bonded to the core to gain a load transfer between the additives. The ASTM defines as and which structure as a structural sandwich is a unique form of a laminated composite comprising of a combination of precise materials which is probably bonded to



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each other in order to utilize the properties of each separate component to the structural benefit of the whole assembly. The modus operandi of a sandwich is a lot much like to that of an I-beam, which is an efficient structural form due to the fact as lots as possible of the material is positioned inside the flanges positioned farthest from the center of bending or neutral axis. In a sandwich the faces take the area of the flanges and the core takes the area of the web. The distinction is that the core of a sandwich is of a special material from the faces and it is spread out as a continuous support for the faces rather than concentrated in a slender web. The faces will act collectively to shape an efficient stress couple or resisting moment counteracting the outside bending moment. The core resists shear and stabilize the faces towards buckling or wrinkling. The bond among the faces and the core need to be strong sufficient to withstand the shear and tensile stresses set up between them. The adhesive that bonds the faces to the core is therefore of crucial significance. Within the form of sandwich factors taken into consideration in this text the faces typically consist of thin and, in a classical which means, excessive appearing material at the same time as the core material is a thick, mild however incredibly low acting. The preference of constituents depends particularly on the particular application and the design standards set up by means of it. The design of a structural sandwich will not be considered one of geometry best however an incorporated manner of geometrical design and materials selection.

2 Literature Review

Wahid Ferdous et.al (2018) a new kind of composite beam, known as Layered Sandwich Beam (LSB) is brought on this study. The sandwich system includes of Glass Fiber reinforced Polymer (GFRP) skins and Phenolic cores, and numerous layers of sandwich panels are bonded collectively with epoxy polymer matrix for manufacturing beams. To explore the suitability of this novel concept for structural packages, the flexural behavior of LSB had been investigated. 8 LSB, with 4 having layers horizontally orientated and the other four vertically oriented, were examined under 4-point bending. A three dimensional finite element model was developed the usage of strand7 to in addition understand the essential behavior of the LSB. The outcomes confirmed that the LSB has an increased sectional stability by means of preventing wrinkling and buckling of the composite skins and indentation failure. This advanced the bending strengths of the vertical LSB through 25% and one 100 % respectively, in comparison with single sandwich beams in identical orientation. Even as horizontal LSB provided better bending stiffness because of the orientation of the skins. The finite element version can reliably predict the essential of the LSB in different orientations and loading configuration, within 10% to +14%.

Da Chen et.al (2016) the nonlinear free vibration behavior of shear deformable sandwich porous beam is investigated on this paper in the context of Timoshenko beam principle. The proposed beam consists of face layers and a functionally graded porous core which includes internal pores following unique porosity distributions. On – uniform functionally graded



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distributions are considered on this paper primarily based at the equivalent beam mass, associated with a uniform distribution for purpose of evaluation. The elastic moduli and mass density are considered to vary alongside the thickness direction in phrases of the coefficients of porosity and mass density whose relationship is determined through using the everyday mechanical feature of open cell metal foam. The Ritz techniques of nonlinear strain-displacement relationship are applied to derive the equation system. A set rules is then used to clear up the governing equation system to are expecting the linear and nonlinear frequencies which might be presented through a detailed numerical study to discuss the consequences of porosity coefficient, slenderness ratio, thickness ratio and to evaluate ratio and to evaluate the various porosity distributions and nine boundary conditions, presenting a feasible way to enhance the vibration behavior of sandwich porous beams.

Isabella Giorgia Colombo (2015) A prefabricated concrete sandwich panel, with insulating material performing as a structural layer able to transfer the shear stresses, is investigated. The usage of an in-stress casting approach permits to avoid using glue and to prevent the deboning among the layers way to the good bond obtained all through the production. Sandwich beams characterized by means of thick internal accelerated polystyrene foam core and by using two thin glass textile reinforced concrete layers were experimentally evaluated consistent with four point bending scheme. The enormous role performed through the tangential nonlinear behavior of the EPS foam is proven.

Mustafa et al. (2013) studies on the dominant failure mode of composite sandwich panels, the prevention and obstacle of deboning failure between face sheet and core. The paper gives a semi-circular shear keys inserting between the skin and the foam core to enhance the shear performance and pores and skin-core debonding resistance for sandwich panels with foam core. Polyvinylchloride (%) and polyurethane (PU) foam core are decided on for the current observe and sandwiched among glass fibre reinforced polymer (GFRP) skins. A parametric investigation on the effect of the shear keys diameter on the in-plane shear overall performance has been carried out numerically. The finite element (FE) version of the regular sandwich panel became proven experimentally and proved its capability to represent the shear response of sandwich panel. The suggested design become numerically investigated to select the best diameter for the shear key under in-plane shear load. For all investigated sandwich version configurations the suggested shear keys have been able to prevent skin-core deboning and to redirect it to diagonal orientation with a massive improvement within the typical shear overall performance.

Akawut et al. (2012) executed work on sandwich layup consists of a closed cell polymeric foam layer located among thin carbon/glass fibre strengthened polymeric composite facings. attention in this paper become targeted on sea water outcomes at the interfacial mechanical reaction among foam and dealing with because of sustained sea water exposure the use of cautiously controlled laboratory conditions. Pre-cracked sandwich composite samples are



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soaked in sea water for extended intervals and interfacial fracture behavior compared towards dry specimens. Effects suggest that the delamination crack propagates close to the interface within the wet case, while it remains in the foam within the dry case. Large reduction in fracture toughness because of sea water exposure is observed and desires to be considered inside the layout of ship structures. The impact of sea water on values of strength release rates are determined experimentally and predicted the usage of analytical idea. A good settlement among records and predictions is executed, indicating a reduction in fracture durability through 30% because of sustained exposure to sea water.

Fosting et al. (2013) have experimentally studied the damping of composite sandwich beams with light-weight honeycomb core with carbon/epoxy layers. A new damping technique, consisting of selectively focused on the inflection factors of the bending mode shapes is proposed. It is determined that shearing deformation inside the beam is maximal and so is the strain in the viscoelastic layers. An evaluation of results acquired on this study with experimental and numerical outcomes determined within the literature results in the conclusion that the maximum efficient way of damping of sandwich structure is to modify or enhance viscoelastic properties of the core.

Mithra& Raja (2012) have analyzed the face-core delamination problems of sandwich composite structures comprising of a thin composite face sheets of E-glass/epoxy with a low density Polyvinylchloride (%) foam core. A modern cost-powerful methodology of placing remanufactured shear keys in foam-core grooves has been proposed in the paper. The authors also have developed several measures to enhance shear resistance capability of sandwich structures comprising of thin composite face sheets of E-glass/epoxy and low density percent foam core, however these methodologies are both highly-priced or result in harm to the sandwich composites before being placed for manufacturing. A unique, modern value-effective method of introducing fibre glass shear keys attached to face skins to enhance the stiffness and power of the sandwich composite panel is being explored. Manufacturing of the sandwich composite panels at the side of experimental and numerical investigations have been accomplished to illustrate the ability of the proposed easy method which may be applied for shear-sensitive layout and evaluation of sandwich composite systems and /or components. A parametric study has also been achieved to determine the impact of alternate in shape, length, spacing and material of the shear keys on the sandwich composite panel worldwide response. Sandwich systems are utilized in naval craft and thereby are uncovered to sea water environment and temperature fluctuations over extended intervals.

Y. Swathi et.al (2012) This research deals with the static and dynamic evaluation of a sandwich beam, which include a viscoelastic core layer and a couple of-face layers, every with four FRP layers, subjected to a simply supported and clamped-clamped boundary situations. The problem is analyzed using three-dimensional Finite detail method and is modelled in ANSYS software program. Static and dynamic reaction of the beam is studied



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through varying the parameters of the center layer including its geometry and damping coefficient. It's far discovered that the thickness of the core layer affects both static and dynamic response, and the damping coefficient is useful to control the dynamic response of the beam. This form of analysis is beneficial in choosing the materials and their arrangement for the safe design of sandwich systems in view of strength, stiffness and sufficient damping to manipulate the harmonic response.

3 Experimental Methodology and Investigation

ANSYS is an American computer-aided engineering software developer head quartered in United States. ANSYS publishes engineering analysis software across a array of disciplines they are finite element analysis, structural analysis, computational fluid dynamics, explicit and implicit methods, and heat transfer. ANSYS Mechanical is a well-known finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This type of computer simulation gives finite elements to model behavior, and supports material models and equation solvers for a wide variety of mechanical and structural design issues. ANSYS computer simulation tool used for simulating the response of materials to short duration severe loadings from impact, high pressure or explosions. ANSYS also has a module called Explicit Solver using Autodyn which is easier to use compared to the Autodyn solver and has all the capabilities of Autodyn solver. Several modules are provided within the ANSYS Workbench environment making the software capable of handling a wide range of problems including finite element analysis, static structural analysis, implicit as well as explicit dynamic analysis, thermo dynamic analysis etc. The analysis work for this is done using the ANSYS Work bench 18.0 software in the static structural solver.

3.1 Model Descriptions

The validation of the model analysis has been done using the journal “Flexural behaviour of layered sandwich beam”. The FEA was implemented using the ANSYS workbench software. The polymer matrix, phenolic core, loading plate and supports have been modelled as three dimensional eight-node brick element even as the skins of the sandwich panel were created as plate element. The sandwich panels have been made from GFRP skins and phenolic core .The thickness of each skin was 1.8 mm with fibre volume fraction of 45% while the core was 16.4 mm thick. In each skin, the fibres were oriented in the longitudinal and transverse directions. The bio-based phenolic core came from non-food based totally natural plant merchandise derived from vegetable oils and plant extracts. The sandwich panel density was approximately 990 kg/m³.The different properties of GFRP skins in longitudinal and transverse directions suggested to consider an orthotropic material behavior

3.2 Alternating Stress Mean Stress

The fatigue or endurance limit of a material is described as the maximum



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amplitude of completely reversed stress that the standard specimen can maintain for a vast number of cycles without fatigue failure. The maximum value of completely reversed bending stress that a material can withstand without any failure for finite number of cycles. For fatigue analysis the software uses an S-N curve to evaluate the fatigue results. An S-N curve defines the alternate stress values verses the number of cycles to failure at a given stress ratio. When defining the reference studies, one can specify a material that has fatigue data already inputted for the material. In the solid works material database, the material that have SN appended to the name already have an S-N curve defined. For these material, the S-N curves is based on a fully reversed load. If the reference studies do not have S-N data tied to their materials, the one can manually input this data .Here we have alternate stress verses number of cycles tabular data for Grip, phenolic and epoxy. As the stress go on decreasing the number of cycles will go on increasing for the member.

3.3 Fatigue Properties

For the fatigue analysis of layered sandwich beam in ansys stress life fatigue analysis is used to predict the total life. Mean stress theory is Goodman. According to Goodman theory, the material is considered safe as long as the stress falls below the straight lines that extend from the endurance limit on alternating stress axis to the ultimate tensile strength on mean stress. Fatigue strength factor is 1.This is default, which means there is no surface flows, surface imperfections, cracks which exist on the surface of the geometry or the model. Loading type is fully reversed, means that stress which vary from compressive to tensile or vice-versa.

3.4 Material Properties

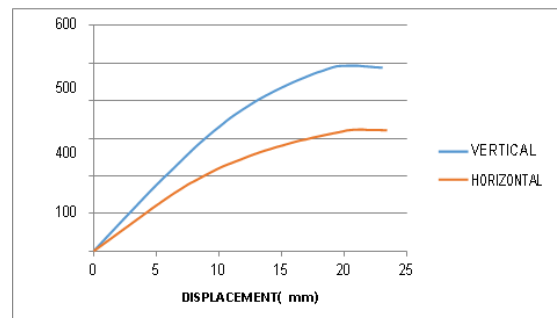
This study investigated the shear behaviour of composite beams manufactured from layers of sandwich panels that are bonded together with the epoxy polymer matrix. The sandwich panels have been bonded either in a horizontal or vertical orientation to evaluate the behavior of LSB. The sandwich panels were made up of GFRP skins and phenolic core. The thickness of each skin was 1.8 mm and the core was 16.4 mm thick. The density of sandwich panel is about 990 kg/m³. Two distinctive sectional configurations were considered on this study the fibre composite sandwich panels, which were the main reinforcing elements of the beam, were placed either horizontally or vertically. The horizontal LSB is 90 mm width, and 105 mm depth whereas the width and depth of the vertical LSB were 105 mm and 90 mm, respectively. The motive of selecting this dimension is to make the depth and width of the section as equal as viable. The shear test of the composite sandwich beams was performed using an asymmetrical beam shear test. The specimen was eccentrically loaded at two trisected points and the supports were placed at the remaining two points. The total length of the beam is 700 mm and 600KN load was applied.



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4 Result and Discussion

The fig 6.9 gives the shear failure of layered sandwich beam which oriented in horizontal and vertical directions. It can be seen that vertical layered sandwich beam is failed at higher loads than the horizontal layered sandwich beam for a particular shear span at the same level of load confirming the higher load to fail the fibre composite skins in shear



5 CONCLUSION

The conclusion of various analysis of the present studies on layered sandwich beam are listed below. The finite element software ANSYS workbench is used to do various analysis on sandwich beam. The strength analysis on layered sandwich beam includes the studies on flexural, fatigue and shear behaviour of layered sandwich beam. Flexural analysis of layered sandwich beam has been done using ANSYS software to understand the behaviour of layered sandwich beam in different sandwich orientations. The vertical LSB deflected much higher than the horizontal LSB for a particular shear span at the same level of load. The lower deflection is due to the higher bending stiffness of the horizontal layered sandwich beam than the vertical one due to the extreme top and bottom horizontal skins being more efficient in flexure.

The present study is extended to the fatigue and shear analysis of layered sandwich beam. The minimum fatigue life of vertical layered sandwich beam is higher than the horizontal layered sandwich beam. Based on the fatigue results it can be used in various civil engineering applications where the structure can undergo repeated or complete reverse fatigue load. In the shear analysis of sandwich beam the vertical layered sandwich beam is failed at higher loads than the horizontal layered sandwich beam at the same shear span. This is because the vertical layered sandwich beam is strong in shear due to the high shear strength of the fibre composite skins which prevented the shear failure. The outcome of this study pursuits at contributing to the scientific information of understanding the behaviour of LSB in different sandwich orientations which can help to increase the confidence of this novel beam concept in civil engineering and construction such as manufacturing bridge girders, structural beams, railway sleepers, and other comparable application.



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