

# Design and Analysis of Honeycomb Sandwich Panels for Boat- Review Study

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**Abstract**— Aluminum Honeycomb Panel is flat and has excellent rigidity. The core layer is the hexagonal aluminum honeycomb, adhered to the face plate and the sole plate by adhesive glue. The diversionary honeycombs can bear the pressure coming from the plates which provide the superior flat and rigidity, if the plates are very large. The panels are light weight and saves energy. Under 1/5th, 1/6th and 1/7th weight of wooden board, glass and aluminum in the same volume that reduce the cost of transportation and energy and at the same time making installation very easy. The Aluminum Honeycomb Panel is good for the environment as it is free from release of harmful gases and is easy to clean and recycle. The product is moisture proof and it is coated with PVDF paint which enables the color to be durable and free from mildew and deformation in damp environments. From high performance off-shore racers to the recreational run about, honeycomb composite panels have superior strength-to-weight ratios, better toughness, and moisture and corrosion resistance for demanding applications.

**Key words:** Boat, Aluminum honeycomb panel

## I. INTRODUCTION

That critical qualities are must have for hulls, decks, bulkheads, and more. Low density option matched with superior mechanical properties make honeycomb core products more desirable than traditional balsa wood and foam products, it has high strength and stiffness characteristics during regular loading conditions, the shear failure mode of honeycomb allow it to continue the function after its yield strength has been exceeded. Unlike some competitive core materials the immediate loss of function does not occur. Thus, we are proposing the use of honeycomb material in marine applications over the regular aluminum sheets.

To replace the existing aluminum sheet from the body of small boats with the Aluminum honeycomb panel of equivalent strength so as to reduce the weight of the structure without compromising the strength.

### A. Objectives of project are

- To reduce the weight of the boat.
- To increase the strength of the boat.
- Increased performance.
- Increased payload capacity.
- To reduce the cost of the boat.

## II. LITERATURE REVIEW

### A. Bending Behavior of Aluminum Honey Comb Sandwich Panels

K. Kantha Rao, K. Jayathirtha Rao, A.G. Sarwade, B. Madhava Varma

Aluminum sandwich construction has been recognized as a promising concept for structural design of light weight

systems such as wings of aircraft. A sandwich construction, which consists of two thin facing layers separated by a thick core, offers various advantages for design of weight critical structure. Depending on the specific mission requirements of the structures, aluminum alloys, high tensile steels, titanium or composites are used as the material of facings skins. Several core shapes and material may be utilized in the construction of sandwich among them; it has been known that the aluminum honeycomb core has excellent properties with regard to weight savings and fabrication costs. This paper is theoretically calculating bending behavior, of sandwich panels and to compare the strength to weight ratios of Normal Aluminum rod (panel) and Aluminum Honey Comb Panel.

### B. The Use of Honeycomb Sandwich Panels in The Engineering Applications

D N CROSS Composite or Honeycomb sandwich panels are used mostly as beams or plates. For the purposes of this paper, let us consider the simple beam case. We are all familiar with the use of beams i.e. Bridges, Aircraft. On analysis of the beam, we see that the outer most point from the neutral axis attracts most of the load. As can be seen, the neutral axis or centre of the beam carries no tensile or compression load at all. There is however a very high shear loads on the neutral axis. From the above analysis we obtain shapes which have been tailored for efficiency.

### C. A Study of Hypervelocity Impact on Honeycomb Structure

Pranav Mahamuni, Pratik Bhansali, Sachin Salunke ,Yash Parikh

The near Earth space environment is mostly covered with man-made debris and naturally occurred meteoroids. This space debris poses a threat to satellite structure because of their high velocity. It can easily damage the internal structure of satellite hence now-a-days Honeycomb Structure have been widely used in aerospace structures due to their high strength, lightweight and good energy absorbing capacity as well as it protects the internal parts of satellite from hypervelocity impact of space debris. This paper studies the effect of hypervelocity impact on honeycomb structure.

### D. Bending Behavior of Aluminum Honey Comb Sandwich Panels

K. Kantha Rao, K. Jayathirtha Rao, A.G. Sarwade, B. Madhava Varma

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skins. Several core shapes and material may be utilized in the construction of sandwich among them, it has been known that the aluminum honeycomb core has excellent properties with regard to weight savings and fabrication costs. This paper is theoretically calculate bending behavior, of sandwich panels and to compare the strength to weight ratios of Normal Aluminium rod(panel) and Aluminium Honey Comb Panel.

#### *E. Aluminum Face and Paper Honeycomb Core Sandwich Material Tested in Shear*

FRED WERRE

If plates of sandwich construction are designed so that their facings are elastically stable under the intended loads, the only important stresses to which the cores are subjected are shear stresses. The consideration of the effect of repeated shear stresses on the material of the cores and on the bonds between the cores and facings is, therefore, important. It was the purpose of the experiments conducted for this report to determine the shear fatigue characteristics of a typical assembled sandwich panel. The facing material employed was 0.020-inch 24ST aluminum, the core material was 1/2-inch B-flute resin-impregnated paper honeycomb, and facing 3 and core were bonded together with a high-temperature-setting phenol resin. The paper honeycomb material used as the core material, in these specimens were made at the Forest Products Laboratory. The material was produced by impregnating 4.5 mil kraft paper of 12-inch width with about 10 percent phenol resin, and putting the dried paper through a B-flute corrugating machine. Node-to-node length and height of corrugations were approximately 0.230 and 0.097 inch, respectively (fig. 1). The corrugated paper was cut into sheets 40 inches long, and the individual sheets impregnated with a hot setting polyester resin, B. The sheets were then laid node to node to form a block about 2-5/8 inches thick. Thus the final dimensions of the block were approximately 2-5/8 by 12 by 40 inches with the flutes parallel to the 12-inch direction. The cured block had an over-all density of 5.90 pounds per cubic foot, and a resin content of approximately 55 percent.

#### *F. Design of Honeycombs for Modulus and Yield Strain in Shear*

Jaehyung Ju, Joshua D. Summers<sup>1</sup>, John Ziegert, George Fadel

Two dimensional prismatic cellular materials of periodic mesostructures are called honeycombs. The hexagonal versions of such meso-structures are cellular materials commonly employed in various applications used in the design of lightweight structures. For example, the in-plane moduli of hexagonal honeycombs have been successfully investigated with the cell wall bending model, which is called cellular material theory (CMT) summarized by Gibson and Ashby. In this paper, we explore a flexible structural application of honeycombs in shear. While pursuing a hexagonal honeycomb structure with in-plane shear properties similar to an elastomer, we investigate the effect of various geometric parameters on the in-plane effective elastic properties (Young's and shear moduli) of conventional and auxetic hexagonal honeycombs with mildsteel (MS) and polycarbonate (PC). Effective shear yield strains,  $(cpl^*)_{12}$  of hexagonal honeycombs are also investigated. Under a given volume, the effects of cell

heights and wall thickness with five cell configurations on effective properties and  $(cpl^*)_{12}$  are discussed with the two core materials.

#### *G. Hyperelastic Constitutive Modeling of Hexagonal Honeycombs Subjected to In-Plane Shear Loading*

Jaehyung Ju, Joshua D. Summers

The in-plane flexible shear property of hexagonal honeycombs may be useful for the compliant structural applications. In this paper, hyperelastic strain energy functions are developed for a finite in-plane shear deformation of hexagonal honeycombs over a constituent material's elastic range. Effective shear stress-strain curves of hexagonal structures and local cell wall deformation are investigated using the finite element based homogenization method. The hyperelastic models, which are only related to the effective properties of a honeycomb, may not be good enough to capture the nonlinear behavior at a high macroscopic shear strain level. The primary microscopic cell wall deformation mode under macroscopic in-plane shear loading was identified to be the bending of the vertical cell wall  $h$ , which is perpendicular to the macroscopic loading direction. The re-entrant hexagonal structures having a negative Poisson's ratio shows a high macroscopic shear flexible property associated with the high  $h$  when the honeycombs are designed to have the same macroscopic shear modulus.

#### *H. Light Weight Actuator Structure with SMA Honeycomb Core and CFRP Skins*

Yoji Okabe, Hiroshi Sugiyama, Toru Inayoshi

In this paper, a sandwich structure that consists of a shape memory alloy (SMA) honeycomb core and carbon fiber reinforced plastic (CFRP) skins as a shapecontrollable structure. The proposed lightweight actuator structure can be bent by heating even though it has a moderate bending stiffness. First, unidirectional CFRP skins were bonded to the SMA honeycomb core made of thin SMA foils, and residual shear strain was applied to the SMA core. Then, the ends of the upper and lower skins were fixed to other cores. The length, thickness, and width of the sandwich beam specimen were 180 mm, 16 mm, and 13 mm, respectively, and its weight was 9.6 g. Hence, the effective density of the entire beam was only 0.26 g/cm<sup>3</sup>. When the specimen was heated, the beam either bent upward, taking the form of a sigmoid curve, or generated a moderate blocking force. When the specimen was cooled to room temperature, the beam regained its initial straight shape. Therefore, a two-way actuation is possible. This method has a better ability to bend skins with high in-plane stiffness because the recovery shear force has an out-of-plane stress component and is applied uniformly to all the skins from the inner core. In addition, the microscopic mechanism of this bending deformation can be clarified by a numerical simulation with a finite element method. Furthermore, the proposed actuator structure can possibly be used as a member that suppresses resonance since the natural frequency of the beam can be controlled by increasing the elastic moduli of SMA on heating.

### *I. Out-of-Autoclave Composite Fairing Design, Fabrication, and Test*

Steven A. Lane<sup>1</sup>, John Higgins, Adam Biskner, Greg Sanford, Chris Springer, Jerome Berg

Composite materials and structures offer benefits over metallic structures for launch vehicle payload fairings, particularly in regard to strength per weight. This translates into more available payload mass and lower cost to launch, which are driving factors for launch system selection. Often, the diameter of the fairing is a limiting criterion for the design of a payload and can be a key obstacle in designing and employing large aperture remote sensing payloads (e.g., a 6-m mirror will not fit in a 5-m fairing). This can necessitate more complex deployable systems (e.g., the deployable mirror used on the James Web Space Telescope). This work presents the structural performance and design issues of a prototype composite payload fairing that was manufactured using a combination of out-of-autoclave manufacturing technologies. First, this paper will summarize the fairing design and design parameters. This is followed by finite element model results and analysis. Next, fabrication and assembly of the fairing are summarized. Data from a laboratory test, conducted using flight qualification loads, are presented and compared to model predictions.

### *J. Novel Electrode-Supported Honeycomb Solid Oxide Fuel Cell: Design and Fabrication*

Toshiaki Yamaguchi<sup>1</sup>, Toshio Suzuki, Yoshinobu Fujishiro, Masanobu Awano

Recently, reduction in SOFC operation temperature has been intensively investigated for the cost reduction and lifetime extension in addition to the size-down and quick start-up/shut-down operations. One of the effective approaches for them is the hybridization of the miniaturization of the cell size and the integration of the miniaturized cells. Among various proposed cell designs, a honeycomb supported SOFC is considered to be one of the most suitable designs for simultaneous achievement of the miniaturized cell size and the integration of the miniaturized cells because of the structural advantages, such as the large capacity of multiple cells and the ease with which the cell size and configuration can be controlled. For the honeycomb supported SOFCs, however, there are only few reports on the electrolyte honeycomb supported type with millimeter-sized channels. The electrolyte-honeycomb supported type needs further improvement due to the large ohmic resistance of thick electrolyte and relatively low electrode area per unit volume, which leads to high operation temperature and low volumetric power density. The objective of this study is to design and fabricate the efficient electrode-supported SOFC with honeycomb structure. In this study, the effects of channel shape and wall thickness of the honeycomb as well as its material on the performance were investigated using numerical analysis.

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