DEFORMATION AND INSTABILITY OF THREE-DIMENSIONAL NATURE FIBRE / EPOXY HONEYCOMBS UNDER COMPRESSION PERFORMANCE

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DECLARATION

I declare that this this report entitled "Deformation And Instability Of Three-Dimensional Nature Fibre / Epoxy Honeycombs Under Compression Performance" is the result of my own research except as cited in the references. The Deformation And Instability Of Three-Dimensional Nature Fibre / Epoxy Honeycombs Under Compression Performance has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Air Conditioning and Refrigeration) with Honours. The member of the supervisory is as follow:

Signature :

Supervisor Name : DR. MUHAMMAD ZULKARNAIN

Date : 15 JANUARY 2022

DEDICATION

This thesis is dedicated to my father, Hanafi Bin Hassan who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, Gayah Binti Daud who taught me that even the largest task can be accomplished if it is done one step at a time. Both of them have encouraged me all the way and whose encouragement has made sure that I give it all it takes to finish that which I have started.

ABSTRACT

A numerical methodology for the investigation of a three-point bending test (TPBT) on Nature Fibre Sandwich Aluminum honeycomb panels with Aluminum core is presented. A more efficient alternative honeycomb production method must be pursued in light of the rising costs of electricity and raw materials. The ultimate goal of the cooperative development is to produce sandwich panels that meet technical criteria, are lighter in weight, and are more cost-effective when compared to currently available composite or metal alternatives, among other things. A dedicated focus on numerical models is presented. Using data obtained from experimental tests, a highly detailed Finite Element model will be built. Particular attention will be paid to verify the accurate modelling of the crushing behaviour of the core during the last part of TPBT.

ABSTRAK

Metodologi berangka untuk penyiasatan ujian lentur tiga mata (TPBT) pada panel sarang lebah Sandwich Aluminium Nature Fiber dengan teras Aluminium dibentangkan. Kaedah pengeluaran sarang lebah alternatif yang lebih cekap mesti diteruskan memandangkan peningkatan kos elektrik dan bahan mentah. Matlamat utama pembangunan koperasi adalah untuk menghasilkan panel sandwic yang memenuhi kriteria teknikal, lebih ringan dalam berat, dan lebih kos efektif jika dibandingkan dengan alternatif komposit atau logam yang tersedia pada masa ini, antara lain. Tumpuan khusus pada model berangka dibentangkan. Menggunakan data yang diperoleh daripada ujian eksperimen, model Elemen Terperinci yang sangat terperinci akan dibina. Perhatian khusus akan diberikan untuk mengesahkan pemodelan tepat kelakuan penghancuran teras semasa bahagian terakhir TPBT.

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Hopefully this report will guide further researcher in order to improve the outcome of this research. I also hope this report would be beneficial to the people out there in terms of knowledge.

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LIST OF SYMBOLS AND ABBREVIATIONS

SiC	-	Silicon Carbide Fibre
ksi	-	Kilopound force per square inch
°	-	degree
pcf	-	Pound per cubic foot

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CHAPTER 1

INTRODUCTION

1.1 Background

Honeycomb is a magical natural product that takes its name from honey. Scientists discovered that the hexagonal structure, which closely resembles a bee's honeycomb, performs superb behaviour with the maximum usable space, demonstrating a huge mechanical potential.(Wang, 2019) The honeycomb sandwich structure has high flexural rigidity and bending strength while being light in weight. Sandwich construction is becoming more common in the industry, and sandwich structural designing is one approach for creating sandwich structures. Human used paper to create the first artificial honeycomb construction 2000 years ago in China. Modern honeycomb goods were most likely invented in the late 1930s. The first all-aluminum sandwich panel was not produced until 1945. Since then, numerous materials have been used to create cellular honeycomb structures, including aluminum alloys, stainless steel, titanium, and non-metallic materials (e.g. glass-fibre, Nomex, Kraft paper).

The use of honeycomb sandwich structures continues to increase rapidly for applications ranging from satellites, aircraft, ships, automobiles, rail cars, wind energy systems, and bridge construction. These panels are made of skins and core. The core is usually made of a more flexible material than the skins, but the entire panel is characterized by a large force and low total weight. The honeycomb sandwich structures have been extensively used in manufacturing aeronautical structures due to their high specific bending stiffness of light and charges in a distributed resistance in addition to their good capacity for energy absorption.

Honeycomb research has focused on basic mechanical behaviours like compression, buckling, and fatigue over the last two decades—also thermal, acoustic performance and applications in the physical field. Numerous studies focused on mechanical performance under various loading circumstances, including in-plane and out-of-plane compression loading, quasi-static, low-speed and high-velocity impact, bending, and shear. Honeycomb structures, in particular, were validated as a solid choice of energy absorber in the crashworthiness assessment.

Some concerns about the inclined condition were raised, and these studies proved that the inclined load had a significant impact on crushing behaviour. A new era of wealth has begun. With the advancement of engineering science, numerous requirements for lightweight, cost savings, crashworthiness, easy-packing, and noise reduction were added, especially for those utilised in extreme dynamic scenarios like blast protection, re-entry landing, and high-speed train crashes. However, the energy absorption capabilities of a single honeycomb block are insufficient to meet the criteria under the conditions mentioned earlier. As is generally known, honeycomb products are primarily made using the five primary methods of adhesive bonding, resistance welding, diffusion bonding, brazing, and thermal fusion. Expansion and corrugation procedures are the most popular methods among all the processes. In general, no matter what kinds of procedures are used, the single blocks' abilities are insufficient to match the criteria.

1.2 Problem Statement

The bending behaviours of fibre random distribution sandwich, including bending stiffness, strength and failure mechanism, are a challenge that needs to investigate, with providing the mechanical performance characteristics that need to study. The involving fibres distribution technique need to well introduce during construct 3D composite panel as coupling the honeycomb core. The stress and strain distributions have strong influences on the bending behaviours of the sandwich beams that need to explore.

1.3 Research Objective

Specifically, the objectives are as follows:

(a) To develop 3D sandwich model of thin-walled honeycomb with nature fibre composite panel using fibre random distribution method.

(b) To analysis three-point bending performance by varied fibre nature component content.

(c) Used random distribution method of fibre with 50 and 100 fibres number.

1.4 Scope of Research

The scope will conduct in the 3D simulation of Finite Element Analysis where the fibres distribute randomly in the longitudinal direction. Fibre distribution will develop by using MATLAB coding and the content is varied. All-composite sandwich thin-walled honeycomb with hexagon cores and coupled by nature fibre panel. The mechanical performance of the sandwich under three-point bending (TPB) load are studied by a three-dimensional (3D) failure mechanism.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is about information research and summarized that have been gathered from various resources like journals, articles, books and etc. It consists of studies that were done by past researchers regarding the epoxy honeycomb, natural fibre, three-point bending test (TPBT), deformation and instability, Finite Element, and the methods that have been used to obtain the results. These findings provide all the knowledge needed to guide the completion of the project.

2.2 Composites

Humans have been learning and employing natural rules and phenomena for their innovations since the dawn of civilization. By closely investigating the natural wonders of bones, composites have been constructed. Bone is a biological material that is light in weight but intense, thanks to the combination of collagen and appetite. Composites are made up of many materials that are combined to provide desired features such as thermal resistance, heat resistance, high strength, low thermal expansion coefficient, electrical, acoustical, and optical qualities. Composites are made up of two or more materials that differ in composition and have various chemical and physical properties, yet the resulting new mixture has a distinct appearance and properties than the separate components.(Islam et al., 2018)

Four generations of composites are recognized as pivotal moments in composites' history. They're displayed in Table 2.1.(Islam et al., 2018) At first, attempts were made to build automobile parts out of glass fibres, but there were significant restrictions of micro-cracks on the surface, brittleness, and fracture, among other things, sensitive portions of cars constructed from these fibres were causing a problem. This restriction enhanced the concept of high pressure, but it also harmed it. Fibres were immersed in a lightweight, low-strength matrix to tackle this challenge. The initial constraint was a lack of understanding of "how to add fibres to the matrix to ensure even dispersion." This challenge was remedied in 1940 when Pittsburgh plate glass fibres were first used in the marine industry was developed and used to replace wooden or metallic boats 1940. Meanwhile, in 1942, the US Navy replaced all of the electric boards with glass fibres. As a result, the most widely used commercial composites were glass fibre reinforced composites, which accounted for 90% of all applications worldwide.

Table 2.1: Four Generation of Composites

Years	Generation	Composites
1940’s	1^{st}	Glass fibres reinforced polymers (GFRP’S)
1960’s	2^{nd}	High performance composites
1970’s and 1980’s	3^{rd}	Synergy of properties of materials
1990’s	4^{th}	Hybrid and Nano composites