FLEXURAL BEHAVIOR OF SANDWICH COMPOSITE

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A thesis submitted in fulfilment of the
requirements for the award of the degree of
Master of Engineering (Mechanical)

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

JUNE 2013

To my mother for her enormous financial and emotional support throughout my study.

ACKNOWLEDGEMENT

Foremost, I would like to express my sincere gratitude to my supervisor Dr. Mohd. Yazid Bin Yahya for the continuous support of my study and research, for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped me in all the time of research and writing of this thesis. I could not have imagined having a better advisor and mentor for my Master study.

Besides, I would also like to thank my mother and younger brother. They were always supporting me and encouraging me with their best wishes.

Finally, I would like to thank my all friends for all their supports and encouragement throughout my study in Malaysia.

ABSTRACT

Composite sandwich structures are commonly used in aerospace application, ship building, bridge, etc. due to their low weight and excellent strength to weight ratio. In the last decades, light-weight core materials such as honeycomb, wood, foam core have been used in manufacture sandwich structures based on required. In this case, sandwich structure with poly-propylene honeycomb core and FGRP face sheet was modeled, produced, fabricated and tested. The composite sandwich structures were manufactured using hand lay-up and vacuum bagging manufacturing process. The behaviors of these structures under three point bending and four point bending were investigated. Flexural behavior of these structures has been experimentally and finite element investigated. Design sandwich composite structure with different thickness, manufacturing process and glass fiber skins. The main aim of the study is to analyze effect of material, loading span length, thickness and manufactured process on flexural behavior of the sandwich panel in load rate $1mm/min$. The experimental and finite element results were discussed and general conclusions were drawn. The result showed that flexural behavior of the sandwich composite beam with vacuum bagging technique was better than with hand lay-up. The result however indicated that increasing the number of layers decreased the amount of extension, but vacuum bagging method made the value of extension higher, and also in four point bending test, the span length has a significant role in the flexural properties of sandwich composite. By increasing the distance of load span, the number of maximum load obviously went up, but by reducing the span length, the value of flexural extension and maximum stress also had upward trends. The error of maximum stress value in the three-point bending test between the FEM analysis and experimental results declined as it was added to the number of layer and vacuum bagging method process.

ABSTRAK

Struktur sandwich Komposit biasanya digunakan dalam aplikasi aeroangkasa, pembinaan kapal, jambatan, dan lain-lain disebabkan oleh berat yang rendah dan kekuatan yang sangat baik kepada nisbah berat. Dalam dekad ini bahan-bahan teras ringan lepas seperti sarang lebah, kayu, teras foam telah digunakan dalam struktur sandwich pembuatan berdasarkan keperluon. Dalam kes ini, struktur sandwich dengan poli-propilena sarang lebah teras dan lembaran muka FGRP telah dimodelkan, dikeluarkan, direka dan diuji. Struktur sandwich komposit dihasilkan menggunakan kaedah hand lay-up dan vacuum bagging pembuatan. Tingkah laku struktur ini di bawah tiga titik lenturan dan empat titik lenturan telah disiasat. Kelakuan lenturan struktur ini telah uji kaji dan unsur terhingga disiasat. Kabentuk sandwich struktur gabungan dengan ketebalan yang berbeza, proses pembuatan dan kulit gentian kaca. Tujuan utama kajian ini adalah untuk menganalisis kesan material, muatan panjang rentang, tebal dan proses pembuatan ke atas tingkah laku lenturan panel sandwic kadar beban 1mm/min. Hasil dari eksperimen telah dibincang dan kesimpulan umum telah disediakan. Hasilnya menunjukkan bahawa kelakuan lenturan rasuk komposit sandwich dengan teknik vacuum bagging adalah lebih baik berbanding dengan tangan hand lay-up. Hasilnya bagaimanapun menunjukkan bahawa peningkatan bilangan lapisan mengurangkan jumlah lanjutan, tetapi kaedah vacuum bagging membuat nilai lanjutan yang lebih tinggi, dan juga dalam empat titik ujian lentur, panjang rentang mempunyai peranan penting dalam sifat-sifat lenturan komposit sandwic. Dengan meningkatkan jarak span beban, jumlah beban maksimum yang jelas telah naik, tetapi dengan mengurangkan panjang rentang, nilai lanjutan lenturan dan tegasan maksimum juga mempunyai trend menaik. Kesilapan nilai tegasan maksimum dalam ujian lentur tiga mata antara analisis FEM dan keputusan eksperimen menurun kerana ia ditambah kepada bilangan lapisan dan vacuum bagging proses kaedah.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

$1LHC$	1 layer hand lay-up CSM
$1LHW$	1 layer hand lay-up woven
$1LBC$	1 layer vacuum bagging CSM
$1LBW$	1 layer vacuum bagging woven
G	Shear rigidity
σ	Stress
pp	Poly propylene

CHAPTER 1

INTRODUCTION

1.1 Introduction

Composite sandwich structure is a confirmed construction technique that combines two or more materials to create unique materials with low weight and high performance, thus making it ideal for wide range of applications such as aerospace, marine and transportation application. Thus, the understanding of flexural behavior of sandwich beam is a main parameter which had been considered by manufacturer. The flexural behavior of this construction is affective by the rate of the loading specimen, span length, thickness, skin sheet and manufacturing technique.

1.2 Background of the Study

A composite material is combination of reinforcement fibers, particle and fillers embedded in a cured resin also known as a matrix polymers. The matrix holds the reinforcement together to make the required shape while the reinforcement increases the general mechanical behavior of the matrix. When designed satisfy, the new combination of material shows improved strength behavior in comparison of each individual material. The application usage of each composite depends on their physical and mechanical performance. These performance can be point-out from standard ASTM procedures.

Fiber glass composite sandwich beam with foam and honeycomb core construction are suitable for building light-weight structures, especially for aerospace and marine industries. Sandwich structures are famous as good resistance to weight ratios compared to predictable materials.

This study has showed some experimentation and finite element to analyze four-point and three-point bending performance of sandwich structures composed of composite face sheets of woven glass fiber or CSM, and polypropylene honeycomb core.

1.3 Statement of the Problem

Sandwich composites are mainly subjected to failure, damage and crack. This damage and defect is not easy to find out in composite materials. This detect will cause delamination, core disbonds, and crash. The fault will reduce the stiffness of the structures and will reduce the fatigue life of the component.

1.4 Purpose of the Study

Manufacturing of the sandwich composite structures have widely used in aerospace, transportation and marine applications. The advantages of combination of sandwich composites in constructions of the industries are numerous. In comparison between metallic structural components and sandwich composites, composite sandwich structures have higher strength to weight ratio (which results in growth the number of payload, decrease fuel consumption), extended fatigue life, lower maintenance cost, as well as a range of integrated performance, such as thermal and sound isolation, good vibration behavior, fire safety, excellent energy absorption, directional behavior of the face sheets enabling optimized properly design and produce of complicate and smooth hydrodynamic surface. The purpose of the study in this study report was to analyses flexural performance of glass-fiber sandwich beam with polypropylene honeycomb core by bending tests.

1.5 Objective and Scopes of theStudy

1.5.1 Objectives

The objectives of this study are listed below:

- To investigate the effects of different thicknesses and materials, manufacturing processes and length of span.
- To compare the experimental results of three-point bending test with FEM simulation.

1.5.2 Scopes of the Study

- Determination of flexural behavior based on CSM and Woven fiber glass as face sheet, different thickness 1,2,3 layers, hand lay-up and vacuum bagging manufacturing process with different span length in four-bending and three-point tests.
- Validate the FEM simulation results with experimental results of three-point bending test.

1.6 Research Questions

What is the effect of thickness of the sandwich panel face sheet on bending behavior?

What are the effects of the number and type of face sheet layers on four point and three point bending behavior?

What are the effects of span length on four point bending test?

What are the effects of type of manufacturing process on flexural behavior?

1.7 Significance of the Study

Due to the importance applications of composite sandwich materials, understanding of flexural behavior and prediction of the maximum loadings, displacements and stresses are useful for manufacturer and researcher. Because of their constitutions, the flexural behavior of these materials can be investigated by using the various numbers and types for the face-sheet, acting on manufacturing process and span length, which the finding of this parameters are important to discovered the behavior of the beam or panel under four-point and three-point bending tests, and to investigate the problems and benefits of the structure. With the information at hand, standard measures could be exposed and more wide studies can be recommended for the future.

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