BUCKLING BEHAVIOR OF LAMINATES COMPOSITE UNDER COMPRESSIVE LOADING

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APPROVAL

'I / We admit that have read this composition and from my / our opinion this composition is enough from scope and quality for purpose of bestowal Bachelor of Mechanical Engineering (Structure & Material)'

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DECLARATION

"I hereby, declared that all part of this thesis is the results of my own work except for a few section which extracted and quoted from other resources that as been mentioned"

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We are very lucky as final year student to be given an opportunity to do this challenging and profitable project. This research is about a study of buckling behavior of laminate composites panels subjected to compressive loading. It focuses on the investigation about the buckling behavior of laminate composite structures that has not been clearly investigated until now. So, from this task, I've got an opportunity to doing my research and investigation based on this topic.

Last but not least, my warmest gratitude to anyone who gives their continuing encouragement, support, and advice to me to finish this report contents.

ABSTRACT

This research is dedicated to the study of buckling behavior of composite panels subjected to compressive loading. It focuses on the investigation buckling behavior of composite structures. Fabrication of test specimen which includes two types of materials that are CFRP and GFRP are made prior to compression test as per ASTM D695, with dimension of 75 mm x 10 mm x 2 mm. The effect of loading rate is also considered in this study, with the range of 1.3 mm/min to 1.5 mm/min. Under compressive loading, for CFRP laminates, woven possessed higher stiffness and compressive strength. At loading rate of 1.3 mm/min, the stiffness and compressive strength are low. For the GFRP laminate, the specimens showed highest stiffness at loading rate of 1.5 mm/min. Comparison between CFRP (woven) and GFRP (woven) showed that CFRP (woven) is higher in terms of stiffness as well as compressive strength. At microscopic level, from SEM micrograph, it is observed that for CFRP laminates, fracture surface is relatively smooth and consists of a network of blocky outcrops of fibres and resin at different level. The transverse strength of laminae is poor compared to the longitudinal tensile strength. The fracture surfaces show the failure of single fibres, kink band, and microbuckling for each specimen. For GFRP laminates, the fracture surface consists of bundle of fibres and overlapping platelet topography in the resin, termed hackles or lacerations. In the compressive fracture region, striation can be seen on both the fibres and the epoxy. It is observed that there are some similarities between two types of materials that is formation of kinking band and microbuckling failure surface. Both of materials have a longitudinal fracture bundle of fibre and the other fibre fracture in different direction (longitudinal). From the numerical simulation via Nastran/Patran, at preliminary stage, it is found that the CFRP laminates showed the buckling behavior with stiffness higher than GFRP when load is applied at 1.3 mm/min, while the critical load of GFRP is lower than CFRP.

ABSTRAK

Penyelidikan ini mengkaji tentang kelakuan lengkokan bahan komposit di bawah beban mampatan. Ia menjurus kepada kajian kelakuan lengkokan struktur bahan komposit. Fabrikasi untuk bahan ujian yang terdiri daripada dua jenis bahan iaitu CFRP dan GFRP akan disiasat melalui ujian mampatan seperti ASTM D695-96 dengan ukuran 75 mm x 10 mm x 2 mm. Kesan daripada halaju juga dipertimbangkan, dengan purata halaju dari 1.3 mm/min hingga 1.5 mm/min melalui ujian mampatan. Untuk bahan CFRP lamina, woven menunjukkan ketegaran dan kekuatan mampatan yang lebih tinggi. Pada halaju 1.3 mm/min, ketegaran dan kekuatan mampatan adalah rendah. Untuk GFRP lamina, specimen menunjukkan ketegaran yang paling tinggi pada halaju 1.5 mm/min. Perbezaan antara CFRP(woven) and GFRP(woven) menunjukkan CFRP(woven) lebih tinggi dari sudut ciri-ciri kekerasan dan kekuatan mampatan. Pada imej mikroskop, daripada mikrograf SEM, dapat diperhatikan bahawa untuk CFRP lamina, permukaan retakan adalah halus dan terdiri daripada seberkas susunan gentian yang menjulur dan pada arah yang berlainan. Kekuatan lamina yang melintang adalah lemah jika dibandingkan kepada kekuatan membujur dalam ujian tarikan kekuatan. Ianya boleh dilihat melalui permukaan retakan morfologi gentian karbon yang menunjukkan permukaan gentian bersih dan kerapuhan permukaan matriks. Retakan permukaan gentian menunjukkan kegagalan setiap permukaan gentian, jalur punding, lengkokan yang kecil untuk setiap specimen. Bagi GFRP lamina, permukaan retakan pada resin itu terdiri daripada seberkas susunan gentian dan bertindih pada permukaan resin. Dalam bahagian retakan, pelecetan boleh dilihat pada kedua-dua fiber dan epoksi. Persamaan antara dua jenis bahan ini boleh dilihat dengan pembentukkan jalur punding dan lengkokan kecil pada permukaan. Daripada simulasi dengan menggunakan perisian Nastran/Patran didapati bahawa CFRP lamina menunjukkan kelakuan lengkokan dengan kekerasan yang tinggi berbanding GFRP lamina apabila beban dikenakan pada halaju 1.3 mm/min. Beban genting untuk GFRP adalah lebih rendah berbanding CFRP.

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CHAPTER I

INTRODUCTION

This project is dedicated to the study on the buckling behavior of composite materials under compressive loading. The investigation about the buckling behavior of composite structures has not been clearly investigated until now. In this research, the buckling behavior in laminate composite are investigated experimentally.

Buckling may be demonstrated by pressing the opposite edges of a material such as a flat sheet of cardboard towards one another. For small loads the process is elastic since buckling displacements disappear when the load is removed. Buckling refers to the loss of stability of a structure and in its simplest form, is independent of material strength where it is assumed that this loss of stability occurs within the elastic range of the material. It is primarily characterized by a loss of structural stiffness and cannot be modelled using basic linear finite element analysis [5].

Laminate composite structures under compressive loading are susceptible to buckling. Buckling may also be stable or unstable and different geometries lead to different forms of buckling stability. A distinction is also made between classical buckling and other forms of structural instability. Without resorting to formal definitions and distinctions at this stage, one physical manifestation of these differences is that classical buckling results in the structure deforming primarily in a direction orthogonal to that of the applied loading causing this instability. Another form of structural instability, termed snap buckling, is where the deformation is primarily in the direction of the applied loading. Material failure and buckling may both occur in sequence leading to structural collapse. A laminate structure may initially buckle elastically but the resulting high deformations may cause localised material failure. A laminate composite structure under high compressive loading may exhibit localised inelastic behaviour, such as plasticity, which lowers the stiffness leading to buckling.[6]

Structural materials can be divided into four basic categories such as metal, polymers, ceramics and composites. In this paper, the investigation is about the buckling behavior of composite material. Composites which consist of two or more separate materials combined in a macroscopic structural unit are made from various combinations of the other three materials. Each materials are bonded together and must exist more than 5%. It is can be present either in interphase or interface condition. Composite can be produced by various processing techniques for example hands lay-up and spray molding method. Composite materials are usually classified according to the type of reinforcement used. Two broad classes of composites are fibrous and particulate. Each has unique properties and application potential, and can be subdivided into specific categories.[3]

Lamina is a flat (or sometimes curved) arrangement unidirectional (or woven) fibers suspended in matrix material. A laminate is a stack of lamina, oriented in a specific manner to achieve a desired result. Individual lamina is bonded together by a curing procedure that depends on the material system used. The mechanical response of a laminate is different from that of the individual lamina that form it. The laminate's response depends on the properties of each lamina, as well as the order in which the lamina are stacked.[1]

Most of the efforts associated with buckling of composites have centered around plate and shells. Buckling failures associated with lamina have not been investigated to the same extent as those associated with laminates. The problem encountered in buckling is that it is generally results from the geometric instability rather than a material failure due to overstressing. A failure theory based on stress (or strain) is not applicable for buckling analysis.

1.1 OBJECTIVES

The objective of this research is to study and discuss the buckling behavior of composite materials under compressive loading.

1.2 Scope of the Project

The main scope of doing this project are:

i. To do literature study on composite material particularly under compressive loading.
ii. To carry out compressive test for different type of composite materials.
iii. To carry out surface analysis after compression via SEM.
iv. To compare the data using Finite Element Analysis.

1.3 Problem of Statement

A large amount of research has been dedicated to solve structural problems of composite materials. However, buckling behavior of composite structures has not been clearly investigated until now. Buckling is a type of damage to coil compression springs in which the spring is permanently deformed after reaching solid compression due to operating under a heavier load than it can withstand. Buckling appears as a bowing or side-ways deflection. But, for this case, the laminar composite will be used in the investigation [5]. Delamination is one of the most common failure modes in composite materials. It is developed as a result of imperfections in the production technology or due to the effects of certain factors during the operational life of the laminate, such as impact by foreign objects [4]. In this research, it will be more focused to investigate the failure of composite material under compressive loading and the buckling behavior of laminate composite under compressive loading.

1.4 Planning and Execution

Below is the planning and execution for PSM I (Table 1)

Table 1 Table and Execution for PSM I.

No	Task	July				Aug				Sept				Oct	
		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1.0	Select Topic/ Proposal														
2.0	Literature Review														
3.0	Research Methodology														
3.1	Research Flow														
3.2	Design of Experiment														
3.3	Material														
3.4	Testing and Analysis														
4.0	Report Submission														
5.0	Preparing for PSM Seminar 1														