'I admit that I have read
this dissertation and in my opinion this dissertation
is satisfactory in the aspect of scope and quality for the bestowal of
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Signature : ....

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QUASI-STATIC INDENTATION FORCE ON COMPOSITE MATERIAL

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"I verify that this report is my own word except summary and extract that every one of it I have clarify the resource"

Signature	: ……………………
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Date	: 2 MAY 2008

DEDICATION

To My Beloved Family,

To My Respectful Supervisor,

To My Honorable Lecturers,

To My Fellow Friends.

ACKNOWLEDGEMENT

Greatest thanks to ALLAH Almighty for giving me the guidance to do the research on this topic, give ideas on solving the problems that occur, and helping me in the ability for me to complete this project that was given to me. I hope with this knowledge that I get, it will help the next generation to know more information about this topic.

For my respectful supervisor which is also my lecturer, Mr. Ahmad Rivai, who has given his full support in giving guidance on how to do this project, ideas and also advice for the mistake that I have done in order to improve myself, I would like to express my highest appreciation for guiding me in this project.

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Thanks.

ABSTRAK

Kajian ini telah dijalankan untuk mengkaji kesan ujian daya pelekuk quasi-statik ke atas bahagian dalaman antara lapisan komposit karbon bertenunan yang berketebalan 3 mm serta berorientasikan lapisan [$\pm45_2$]s. Kajian ini menekankan tentang bahan komposit, ujian daya pelekuk quasi-statik, pemilihan ujian tanpa musnah untuk mengkaji kewujudan rekahan dalam bahan komposit dan analisis keputusan ujian. Kajian ini lebih tertumpu pada ujian daya pelekuk quasi-statik di mana ujian ini mengenakan daya yang tetap dengan kelajuan tertentu kepada panel komposit yang akan mengakibatkan kerosakan dan rekahan pada bahagian dalaman bahan tersebut. Satu lagi ujian yang akan diaplikasikan ialah ujian tanpa musnah untuk mengesan kerosakan dan rekahan yg wujud pada bahan komposit tersebut. Keputusan daripada ujian daya pelekuk quasi-statik akan menunjukan jumlah minimum tenaga yang diperlukan untuk memulakan rekahan pada bahan tersebut dan melalui ujian tanpa musnah pula, pembuktian kewujudan rekahan di dalam bahan tersebut akan diperolehi.

ABSTRACT

The effects on the 3 mm Epoxy Resin Impregnated Carbon Fiber Woven Fabric 5 Shaft satin Weave with lay-ups $[\pm45_2]_s$ under Quasi-Static Indentation Force Test were studied. This study will highlight about the material composite, the Quasi-Static Indentation Force Test, selection of Non-Destructive Test method to define the crack existence in the material, and result analysis. The study will be focused on the Quasi-Static Indentation Force Test which is the experiment that provides a constant force with a certain speed to the composite panel that will cause a delamination and crack on the material. Another test that will be used is the Non-Destructive Test which is to determine the damage and crack growth in the composite materials. The results that will be obtained using the Quasi-Static Indentation Force Test are the minimum value of energy for the material to start the crack initiation and from the Non-Destructive Test, the results will prove that the crack have occurred in the structure of the material.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

MHz	=	frequency, MegaHertz
d	=	compressive extension, mm
F	=	minimum load, kN
F_{max}	=	maximum force, kN
δ	=	indenter displacement, mm
K.E.	=	Kinetic Energy, Joule
v	=	Velocity, mm/min
U	=	Energy, Joule
NDT	=	Non-Destructive Testing
UT	=	Ultrasonic testing
UTM	=	Universal Testing Machine
ASTM	=	American Standards for Testing and Machinery
UTeM	=	Universiti Teknikal Malaysia Melaka

LIST OF APPENDIX

CHAPTER I

INTRODUCTION

1.1 Background of Study

In recent years, advanced fiber reinforced composites have gradually emerged as a new class of engineering materials and have been gaining increasing acceptance in the engineering design of structural components. The desirable properties of high strength to weight and stiffness to weight ratios, together with the good fatigue resistance of composites to cyclic loading, have made strong candidate materials for many structural applications including aircraft, spacecraft and automobiles. The resulting demand for new design and methodology have prompted an increasing interest for better understanding of the response of the material under various kinds of loading and service conditions.

1.2 Objectives

This thesis is done to study the minimum energy required to start the crack initiation and to check whether the crack have occur in the impacted plate of composite materials using quasi-static indentation force test and non-destructive test method.

1.3 Scope

A test of quasi-static indentation force on composite material will be design. An experiment will be conducted using quasi-static indentation method base on the ASTM to determine the effect of the indentation force on the composite materials. A Non-Destructive Test (NDT) will be carried out to study the cracks that occur due to the quasi-static indentation force test.

Execute of the quasi-static indentation force test and the non-destructive test. The data that will be collected from the quasi-static indentation force test are the loads value that will be applied, the delamination value and the crack growth initiation on the composite plate. The data that would be get from the NDT is the existence of cracks.

Analysis will be carried out on the experimental results. All the results data will be compared and summarized to make a conclusion for this study.

1.4 Problem Statement

The inspection and maintenance of the composite materials that has been widely used by the transportation industry is a major challenge for the manufacturers. All the components that are being used will surely suffer a consecutive impact from many aspects. It has become essential for these composite structures to perform well under various types of impact loading. For example, in the aerospace industry, the residual compressive strength of an impact-damaged composite structure has become the design-limiting factor.

In this project, the most suitable experiment has to be conducted due to the topic that's being proposed. A new design of experiment for the material that will be tested has to be design. The materials to be tested also need to be specified. All the equipments have to be validated, and can be prepared by the university. The way of the experiment that should be executed must be prepared and referred to the American Society for Testing and Materials (ASTM) for the safety reason and to obtain the right data from the test that will be conducted.

CHAPTER II

LITERATURE REVIEW

2.1 Composite Materials

A structural composite is a material system consisting of two or more phases on a macroscopic scale, whose mechanical performance and properties are designed to be superior to those of the consistent materials acting independently. One of those phase is usually discontinuities, stiffer, and stronger and is called reinforcement, whereas the less stiff and weaker phase is continuous and is called matrix. Sometimes, because of chemical interactions or other processing effects, an additional phase, called interphase, exists between the reinforcement and the matrix. The properties of a composite material depend on the properties of the constituents, geometry, and distribution of the phases. One of the most important parameters is the volume fraction of reinforcement, or fiber volume ratio. The distribution of the reinforcement determines the homogeneity or uniformity of the material system. The more the non-uniform is the reinforcement distribution, the more heterogeneous is the material and the higher is the probability of failure in weakest areas. The geometry and orientation of the reinforcement affect the anisotropy of the system.

The phases of composite system have different roles that depend on the type and application of the composite material. In the case of low to medium performance composite materials, the reinforcement, usually in the form of short fibers particles, provides some stiffening but only local strengthening of the material. The matrix, on the other hand, is the main load-bearing constituent governing the mechanical properties of the material. In the case of high performances structural composites, the usually continuous-fiber reinforcement is the backbone of the material that determines its stiffness and strength in the direction of fibers. The matrix phase provides protection and support for the sensitive fibers and local stress transfer from one fiber to another. The interphase, although small in size, can play an important role in controlling the failure mechanisms, fracture toughness, and overall stress-strain behavior of the material.

2.1.1 Lamina and Laminate

A plane layer of unidirectional fibers or woven fabric in a matrix is called lamina. It is also referred to as unidirectional lamina in the case of unidirectional fibers. The lamina is an orthotropic material with principal material axes in the direction of fibers (longitudinal), normal to the fibers in the plane of the lamina (in-plane transverse), and normal to the plane of the lamina (Figure 2.1). In the case of a woven fabric composite, the warp and the fill directions are the in-plane principal directions.

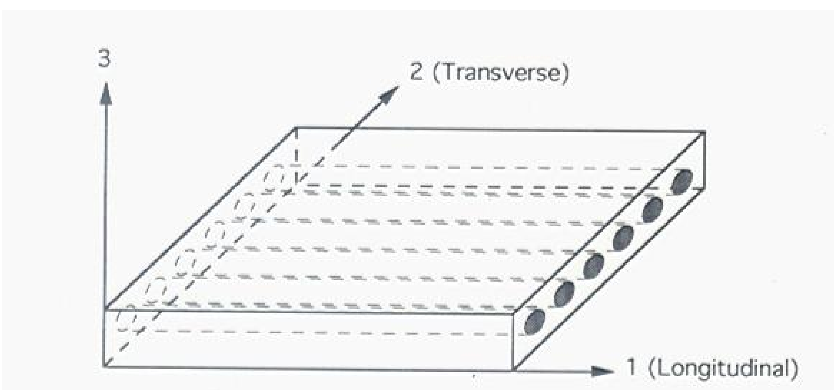

Figure 2.1 Unidirectional lamina and principal coordinates axes. (Source: Daniel, (1994))

A laminate is made up of two or more unidirectional laminate or plies stacked together at various orientations (Figure 2.2). The laminate (or plies, or layers) can be of various thicknesses and consist of different materials. Since the principal material axes differ from the ply to ply, it is more convenient to analyze laminates using a common fixed system of coordinates (x,y,z) as shown. The orientation of a given ply is given by the angle between the reference x-axis and the major principal material axis (fiber orientation) of the ply, measured in a counterclockwise direction on the x-y plane.

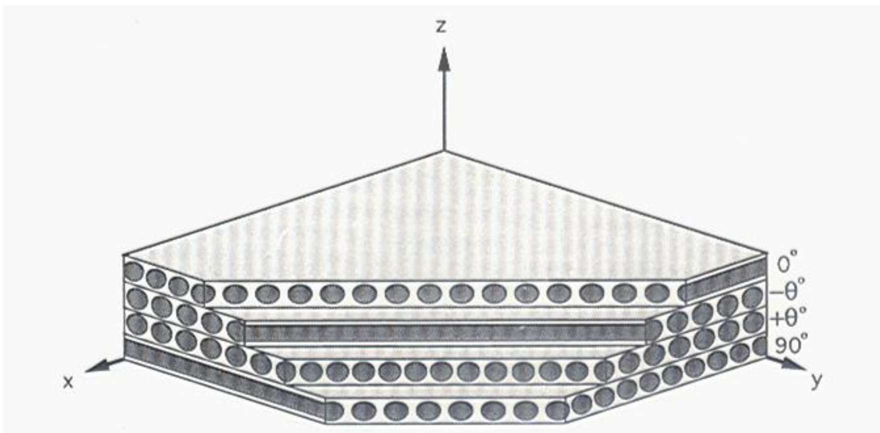

Figure 2.2 Multidirectional laminate and reference coordinate system.
(Source: Daniel, (1994)

Composite laminate structure containing plies of two or more different type of materials are called **hybrid composites** and, more specifically, **interplay hybrid composites**. For example, a composite laminate may be made up of unidirectional glass/epoxy, carbon/epoxy and aramid/epoxy layers stacked together in a specified sequence. In some cases it may be advantageous to intermingle different types of fibers, such as glass and carbon or aramid and carbon, within the same unidirectional ply. Such composites are called **intraply hybrid composites**. Of course, one could combine intraply hybrid layers with other layers to form an intraply-interply composite.

Composite laminates are designated in a manner indicating the number, type, orientation, and stacking sequence of the plies. The configuration of the laminate indicating its ply composition is called lay-up. The configuration indicating, in addition to the ply composition, the exact location or sequence of the various plies is called the **stacking sequence**.

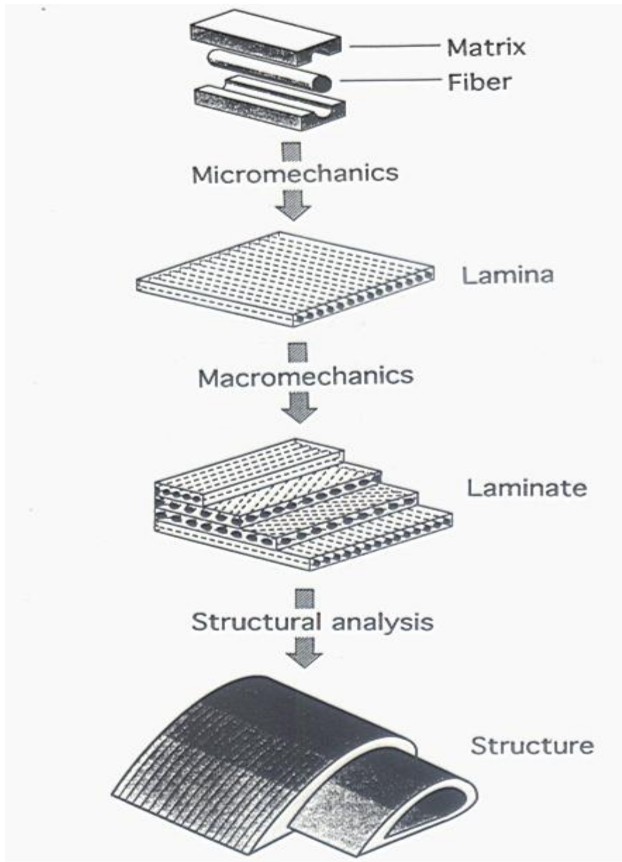

Figure 2.3 Levels of observation and types of analysis for composite materials
(Source: Daniel, (1994))

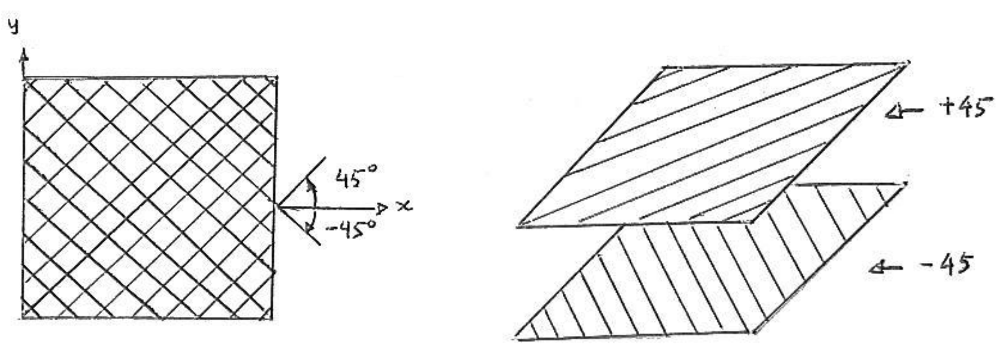

Figure 2.4 [±45]ns angle-ply laminate

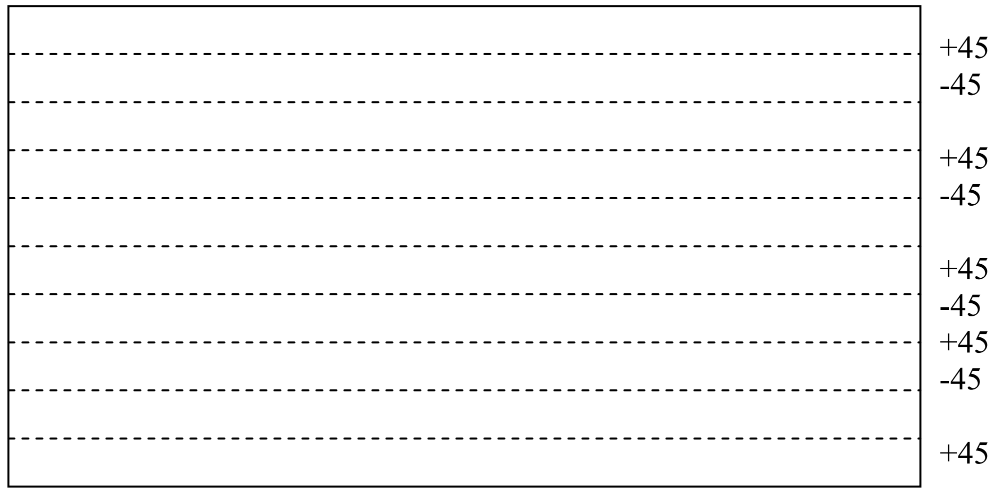

Figure 2.5 Layer Orientation of the Specimen

2.2 Quasi-Static Indentation Force Test

A quasi-static process is a process that happens infinitely slowly. In practice, such processes can be approximated by performing them "very slowly". A quasi-static process often ensures that the system will go through a sequence of states that are infinitesimally close to equilibrium, in which case the process is typically reversible.

There were three reasons of conducting quasi-static indentation force tests. Firstly, it was easier to develop some preliminary understanding of damaged characteristics by executing a quasi-static test in a much better controlled manner. This knowledge of what to expect allowed the impact tests to be carried out more effectively. Secondly, the quasi-static results could be treated as very low velocity impacts when examining the effect of impact velocity on damage at a later stage. Thirdly, it made it possible to examine the interaction of local indentation and global plate deflection and its effect on the onset of damage, which was significant in these thick laminates.

2.3 Non-Destructive Testing

Non-Destructive Testing (NDT) is the use of special equipment and methods to learn something about an object without harming the object. NDT also is a test methods used to examine an object, material or system without impairing its future usefulness. NDT method can detect and assess the inhomogeneities and harmful defects without impairing the usefulness of materials/components/systems (test object). There are six basic of NDT method which are Visual Inspection, Penetrant Testing, Magnetic Particle Inspection, Eddy Current Testing, Ultrasonic Testing and Radiography.

2.3.1 Ultrasonic Techniques

Ultrasonic measurements are commonly used to detect damage in composite structures. The basic principles of all these techniques is that ultrasonic pulse (usually in the frequency range from 1 to 20 MHz) are generated and transmitted through the material to a transducer or are reflected back to the input transducer by defects or materials inhomogeneities (reflection or pulse-echo mode) (McIntire P, 1991) [6]. In both techniques, a piezoelectric transducer is placed on one surface of the specimen to introduce sound waves in the ultrasonic frequency range. In general, a frequency of 10 MHz or higher is used for thin laminates while the frequency can be as slow as 2 MHz for thick laminates. As the sound waves propagate through the material, some of them are interrupted by the presence of defects or materials inhomogeneities, and the energy levels are attenuated. Some of these attenuated waves propagate though the specimen, while other waves are reflected back to the surface. The amplitude, frequency dependence and arrival times of detected pulse are used for defect analysis. Careful examination of the dependence of ultrasonic attenuation on frequency allows materials properties to be assessed or damaged to be monitored.