DAMAGE INITIATION AND PROPAGATION OF SANDWICH COMPOSITES PANEL UNDER COMPRESSIVE LOADING

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Laporan ini dikemukakan sebagai
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"Saya akui laporan ini adalah hasil kerja saya sendiri kecuali ringkasan dan petikan yang tiap-tiap satunya saya telah jelaskan sumbernya"

Tandatangan :..................................

Nama penulis : ISKANDAR BIN MERAN

Tarikh : 12 MEI 2009

DEDICATION

I would like to dedicate this research to my beloved mother, who always support and keep praying for my success.

ACKNOWLEDGEMENT

Greatest thank to Allah Almighty God for giving me a strength, ability, and idea to finish this project, which hopefully will and can contribute in further research.

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ABSTRAK

Sasaran utama dalam menjalankan penyelidikan ini adalah untuk mencari jawapan kepada isu-isu permasaalahan permulaan kerosakan dan perambatan keatas panel apit kesan dari beban mampatan. Bahan yang telah terlibat dalam penyelidikan ini adalah Serat karbon yang diperteguh Plastik (CFRP), sarang lebah teras aluminium dan nomex teras sarang lebah. Untuk menganalisis permulaan kerosakan dan penyebaran panel apit di bawah beban mampatan, ujian lentur empat mata telah dipilih dan ujian ini akan dijalankan mengikut piawaian ASTM D5467 (Ujian Bahan Selaras Amerika).

CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST OF SYMBOL

ε	=	Strain
Δ	=	amount of Stretch
L	=	Origin Length
σ	=	Stress
E	=	Modulus of Elasticity

LIST OF APPENDIX

CHAPTER I

INTRODUCTION

1.1 Background of project

There have been far fewer studies for composites sandwich panel for the compressive failure than there have been of tensile failure. This is because it is extremely difficult to produce perfect reproducible specimens and compressive strength is very sensitive to variation in composites make up. In this research it will focus on finding the damage initiation and propagation of sandwich composites panel under compression load.

Although the plane shear method is preferred for obtaining actual honeycomb shear strength and modulus result, the beam-flexure test is often used to evaluate overall sandwich panel performance. Experience indicates that since these values are very much dependent on the facing thickness, facing material, loading conditions and also the lay-up process (manufacturing process), the calculated honeycomb properties may vary considerably from one test series to the next. Many type of beam-flexure test have been used but the two most common techniques are four point bending and three point bending.

The stabilized compressive strength (also called flatwise compressive strength) represents the ultimate compressive strength of the honeycomb in Newton per square meter when loaded in the T direction. Normally for this test, facings are adhesively bonded to the honeycomb material (stabilized compressive). The stabilized compressive modulus, also expressed in Newton per square meter, is determined from the slope of the initial straight-line portion of the stress-strain curve. Some honeycomb materials exhibit a linear initial stress-strain relationship, while other honeycomb materials exhibit a nonlinear curved initial stress-strain relationship.

In the study of failure initiation and propagation of composites sandwich panel, many things have to be consider such as manufacturing process, type of load, material it self, environment and etc. main purpose to study about the failure initiation and propagation is to determine the type of failure with variation of load, and to predict the composites material failure stage. It is useful to predict the failure initiation in everyday life and it all about safety.

1.2 Problem statement

The purpose of this research is to study and analyze the damage initiation and propagation on advance laminate sandwich composite panel under compressive load. The mechanical properties parameter observes are four points bending as per ASTM D5467. It emphasize the study on damage initiation characteristic of carbon fiber reinforced plastic

1.3 Objective

The aim of this research is to investigate on the damage initiation and propagation of sandwich panel under compressive loading via four-point bending test.

1.4 Scope

This research comprises of the following activities:-

i) Literature study on composites material.
ii) To carry out mechanical testing by four points bending.

CHAPTER II

LITERATURE REVIEW

2.1 Composites

In the continuing quest for improved performance, which may be specified by various criteria including less weight, high strength and lower cost, currently used material scientists, engineers and scientists are always striving to produce either improved traditional material or completely new material. Composites are an example of the latter category.

A composite is a combination of two or more material that can be arranged to be reinforcement or matrix. The combination forms a useful material to increase the properties of materials. The chemical reaction between reinforcement and matrix form an interface and interphase that separating them insoluble in each other. Figure 2.1 shows the formation of component in composite material. Composite have three categories which is polymer matrix composite, ceramic matrix composite, metal matrix composite. For the example, bricks made from mud reinforced with straw, which were used in ancient civilization, as composites. Some more recent examples, but before engineered material became prominent, are carbon black in rubber, steel rod in concrete cement or asphalt mixed with sand, fiberglass in resin etc. In nature, examples about a coconut palm leaf, cellulose fibers in a lignin matrix (wood), collagen fiber in an apatite matrix (bone) etc. For one material to be called composites it has to satisfy these three criteria. First, both constituents have to be present in reasonable proportion, say greater than 5%. Secondly, it is only when the constituent phases have different properties, and hence the composite properties are noticeably different from the properties of the constituents, that we have come to recognize these material as composites. Lastly, a man made composite is usually produced by intimately mixing and combining the constituents by various means.

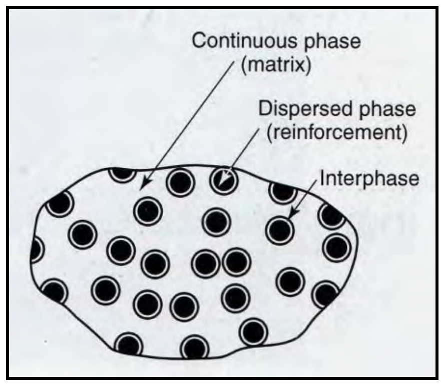

Figure 2.1: Formation in composite material. [Source: Helsel & Liu (2001)]

The essence of the concept of composites is the bulk phase accept the load over a large surface area, and transfer it to the reinforcement, which being stiffer, increase the strength of the composites. The significant here lies in there are numerous matrix material and as many fiber types, which can be combined in countless ways to produce just the desired properties. One of the unique things about composites is anisotropy, which is being directionally dependant, as opposed to isotropy where homogeneity in all direction. It can be defined as a different in physical property such as absorbance and reflective index for some material when measured along different axes.

2.2 Matrix

Matrix is one part of composite that used to surround the reinforcement material. The matrix can be polymer, metal and ceramic. It acts as a medium to support and protect the reinforcement. The matrix protects the individual fibers from the surface damage because of mechanical abrasion or chemical reaction with the environment. It avoids brittle cracks from fiber to fiber and serves as a barrier to crack propagation (Callister, 2003). Usually matrix have a lower density, stiffness, and strength compared to reinforcement material but when the matrix combine with reinforcement material it produces high strength, and stiffness and still low in density.

2.2.1 Metal Matrix Composites

Metal matrix composite (MMC) commonly used a ductile and light metal as a matrix such materials include aluminium, magnesium and titanium. For high temperature applications, cobalt and cobalt-nickel alloy widely used.

When matrix embedded the reinforcement, reinforcement may improve the specific strength, specific stiffness, abrasion resistance, creep resistance, thermal conductivity and dimensional stability. MMC can be operate also in higher temperature, non-flammability and greater degradation by organic fluids compared to PMC, but the MMC is much more expensive than PMC. Compared to unreinforced material, MMC have greater strength but they have much lower ductility and toughness. MMC with fiber reinforced are excellent conductors of heat and electricity because the heat or electrical current is transmitted from fiber to fiber efficiently.

The reinforcement for MMC can be particulates, continuous, discontinuous and whiskers. Commonly used of Continuous fiber materials include carbon, silicon carbide, boron, alumina, and the refractory metals. The concentrations of reinforcement normally range between 10% and 60%. Discontinuous reinforcements consist primarily of silicon carbide whiskers, chopped fibers of alumina and carbon, and particulates of silicon carbide and alumina.

Although MMC improve the material properties but the cost of MMC restricted the use of MMC. MMC application widely used in military, automotive and aerospace, in automotive industry MMC used to produce automotive disc brakes especially for high performance cars such as Lotus and Porsche. Honda also applied MMC in their cars, aluminium MMC used to produces the H22A, H23A, F20C, F22C, and C32B engines. Toyota, Lotus, Porsche, and Yamaha also used MMC in their engines. MMC also used to produce engines driveshafts to increase rotational speeds and reduced vibration noise levels. Extruded stabilizer bars, forged suspension and transmission components also used MMC in automotive application. In aerospace application the F-16 Fighting Falcon uses monofilament silicon carbide fibers in a titanium matrix for a structural component of the jet's landing gear and Space Shuttle Orbiter used boron fiber reinforced aluminium alloy matrix as structure. In military application, some tank armors made from metal matrix composites, probably boron nitride reinforced steel matrix. Boron nitride is a good reinforcement for steel because it is very stiff and it does not dissolve in molten steel. Jacobs & Kilduff, (2001).

2.2.2 Polymer Matrix Composites

Polymer matrix composites (PMC) are a type of composite that uses polymer such as a matrix to surround the reinforcement. Polymer matrix has the largest applications and large quantity because of its light properties in ambient temperature, ease of fabrication and cost.

Polymer resin can be thermoset or thermoplastics but thermoset is the most common polymer resins for commercial used because of its properties that resistance to heat and chemical reaction (Helsel & Liu, 2001). Besides that they have greater dimensional stability than thermoplastics. Thermoset matrices that widely applied in PMC is Polyester, bismaleimides, and Vinyl ester that used with glass fiber reinforcement. Epoxies used for aerospace components because they have better mechanical properties and resistance to moisture compared to Polyester and Vinyl Ester but the Epoxies application needs high cost. For high temperature applications, the Polyimide is used because of its upper temperature limit reach to 450 ºC (230ºC). For the future aerospace application the matrix will be using are Polyetheretherketone (PEEK), Polyphenylene Sulfide (PPS), and Polyetherimide (PEI) which are the high temperature thermoplastic resins. Glass, carbon, and aramids are the most common fiber reinforcement that combined with polymer matrix. Boron, Silicon Carbide, and Aluminium Oxide also used as reinforcement but it has low degrees. (Callister, 2003)

The PMC applications have been used in military aircraft components, helicopter blades, and some sporting equipments by using Boron fiber reinforced polymer composites. Silicon carbide and alumina fibers are utilized in tennis rackets circuit boards, and rocket nose cones. Table 2.2 shows the general characteristics of thermoset and thermoplastic matrices.

Table 2.1: General Characteristics of Thermoset and Thermoplastic Matrices.
[Source: Helsel & Liu (2001)]

General Characteristics of Thermoset And Thermoplastic Matrices					
Resin type	Process Temperature	Process Time	Use Temperature	Solvent Resistance	Toughness
Thermoset	Low	High	High	High	Low
Toughened Thermoset	↕	↕	↕	↕	↕
Lightly Cross-linked Thermoplastic	↕	↕	↕	↕	↕
Thermoplastic	High	Low	Low	Low	High

2.2.3 Ceramic Matrix Composites

Matrix of ceramic matrix composite (CMC) commonly made from glass. The most popular ceramic matrix are lithiumaluminasilicate (Li_2O-Al_2O_3-SiO), BMAS (BaO-MgO-Al_2O_3-SiO) and magnesia-alumina-silicate (MgO-Al_2O_3-SiO) and commonly reinforced with fiber, whiskers, or particulates of silicon carbide (SiC), Silicon nitride (Si_3N4), Zirconium Oxide (ZrO_2), Aluminium Oxide (Al_2O_3) or other engineered ceramics. Helsel and Liu (2001).

Ceramic matrix composites are used to improve the fracture toughness of ceramic itself, because the fracture toughness of ceramic materials is low which is between 1 and 5 Mpa √m (14 to > 140 ksi √in.). The reinforcement materials in ceramic matrix composites increase the fracture toughness to 6 and 20 Mpa √m (5.5 and 18 ksi √in.). (Callister, 2003) Ceramic matrix also have a high strength at high temperature, low thermal conductivity and very hard.

The ceramic matrix composite widely applications are cutting tools, bearings, seals, heat engines, diesel engine component, gun barrel liners, and aircraft gas turbine engine.

2.3 Reinforcement

The reinforcement is the phase of the composite that is primarily responsible for the structural properties of composite. Reinforcement is phase provides structural properties including strength and stiffness. The reinforcement is generally in the shape of fiber, whisker, or particulate.

2.3.1 Fiber Reinforcement

Fiber can be characterized by its geometries which is length greater than its cross sectional. By using fiber as a reinforcement the strength and stiffness will be increased. Fiber reinforcement has two classifications; it is characterized from fiber length which is discontinuous fiber (short fiber) and continuous fiber (long fiber).

The fiber length is one of factor that influenced the mechanical properties of composites because the fiber is important to transmit the load by the matrix phase. So the interface between fiber-matrix is important because the fiber length influenced the contact area between fiber and matrix. Besides that, the fiber length also can be use to characterize the continuous and discontinuous fiber. Under an applied stress, this fiber-matrix bond ceases at the fiber ends, yielding a matrix deformation pattern. (Callister 2003). Figure 2.2 shows the deformation patent in the matrix surrounding a fiber that is subjected to end applied tensile load.

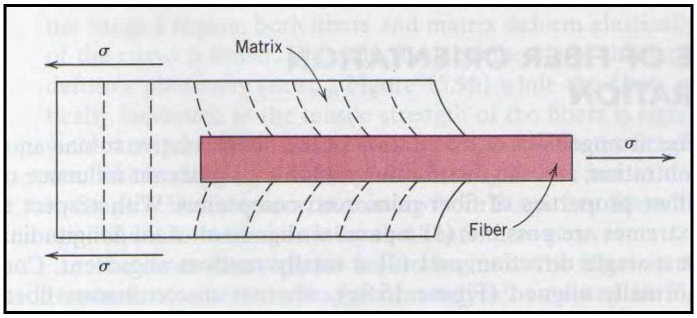

Figure 2.2: The deformation patent in the matrix surrounding a fiber that is subjected to end applied tensile load [Source: Callister (2003)]

2.3.2 Particulate Reinforcement

The particulate reinforcement has similar dimension in all direction. Particulate have variety of geometries such as platelet, spherical, cubic, or any geometries. Particulate reinforcement has two classification, large particle and dispersion strengthened.

Large particulate reinforcement is harder and stiffer than matrix. The matrix-particulate interactions can not be treated on the molecular level. This reinforcement phase used to restrain movement of the matrix phase. The large particle reinforcement bears the fraction of load from matrix that had applied stress. This reinforcement improve the mechanical properties depends on matrix-particulate interface.

Dispersion strengthened particulate the diameter of particles smaller than large particle between 10nm and 100 nm. The strengthening of material lead by the interaction of matrix-particulate interactions on the molecular level. It is similar to precipitation hardening of an alloy. This particle improves the plastic deformation, tensile strength and hardness because the small dispersed particles impede the dislocations motion when load bears the major portion of applied load.