# LOW VELOCITY IMPACT BEHAVIOUR OF ADVANCED COMPOSITE MATERIALS

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This report is proposed to fulfilled some of the requirement to be honor with Bachelor of Mechanical Engineering (Structure & Material)

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‘I admint that have read this work and to me this work was adequate form the aspect scope and quality to be honor with Bachelor of Mechanical Engineering (Structural and Material)’

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| Signature | :………………………… |
| Name 1st supervisor | : ………….......................... |
| Date | :…………………………. |

"I verify that this report is my own work except for the citation and quotation that the source has been clarify for each one of them"

Signature: ……………………………….

Name of writer: …………………………

Date: …………………………………….

To my beloved family and friends

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ABSTRACT

The focus of this research is to study the effect of low velocity impact on composite sandwich panel that is commonly used in aerospace industries. This research investigates the effect of damage on the sandwich panel at low velocity. The specimen used in this project is carbon fiber sandwich panel and three type of testing will be carry out including Quasi-static compression test, Drop weight impact test and surface analysis using SEM. In this study, Quasi-static compression test are carried out at different velocity ranging from 2mm/min to 5mm/min. Drop weight impact test are carried out at velocity 2, 2.4,2. 97 and 3.5m/s.From the result the velocity at 3mm/min for compression test had the biggest load that is 1.95 KN. The biggest load for drop weight test at 3.5m/s is 1.26 KN. The biggest energy also at velocity 3mm/min for compression test and the value is 3.506 J. The biggest energy for drop weight test at 3.5m/s is 19 KN. From the result load and energy are directly proportional. The load increase and the energy become more increase. Several type of damages were observed under both impact test and this include upper skin failure,skin core debonding and core crushing.

# ABSTRAK

Fokus penyelidikan ini adalah untuk mengkaji kesan halaju rendah kesan ke atas komposit “sandwich panel” iaitu biasanya digunakan dalam industri aeroangkasa. Penyelidikan ini akan menyiasat kesan kerosakan di “sandwich panel” pada halaju rendah. Spesimen yang akan digunakan dalam projek ini adalah gentian karbon “sandwich panel” dan tiga jenis ujian akan dijalankan termasuk ujian mampatan Quasi-static, ujian hentaman dan permukaan analisis menggunakan SEM. Dalam kajian ini, ujian mampatan Quasi-static akan dijalankan pada halaju berbeza meliputi 2mm / min hingga 5mm / min. Untuk ujian hentaman dijalankan pada halaju 2, 2.4,2. 97 dan 3.5m / s.Daripada hasil halaju pada 3mm / min untuk ujian mampatan, mempunyai nilai daya terbesar iaitu 1.95 KN. Nilai daya terbesar untuk ujian hentaman pada 3.5m / s adalah 1.26 KN. Tenaga terbesar juga pada halaju 3mm / min untuk ujian mampatan dan nilainya adalah 3.506 J Tenaga terbesar untuk ujian hentaman pada 3.5m / s adalah 19 KN. Daripada keputusan itu,daya berkadar langsung dengan tenaga.Lebih banyak daya maka tenaga juga bertambah.Beberapa jenis kerosakan diperhatikan dibawah ujian mampatan termasuk kerosakan “skin’ atas,teras bercantum dan kerosakan teras.

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# CHAPTER I

# INTRODUCTION

## 1.1 General

Sandwich panels are widely used in lightweight construction especially in aerospace industries because of their high specific strengths and stiffnesses. In the service life of a sandwich panel, impacts are expected to arise from a variety of causes. Debris may be propelled at high velocities from the runway during aircraft takeoffs and landings. Other examples include tools dropping on the structure during maintenance or even collisions by birds. Visual inspection may reveal little damage on the sandwich panel, but significant damage may occur between the impacted face sheet and the core. Reduction of structural stiffness and strength can occur, and consequently, propagate under further loading. Thus, their behaviour under impact had received increasing attention.

## 1.2 Problem statement

There are many types of impact damage such as face/core bonding, hyper velocity, drop weight, and etc. These sandwich panels may encounter low-velocity impacts, such as tool-drop, runway stones, and tire blow out debris. Even though a visual examination of the impacted surface may reveal very little damage, significant damage might exist between the face sheet and the core. This type of damage leads to substantial reduction of the compressive and bending strengths of the sandwich construction. Will have to analyze the impact damage because to know the factors of safety especially for the aerospace industries which have widely used the sandwich panels. That is the first and important reason to study and analyze about the damage.

## 1.3 Objectives of Research

In this research, experimental investigation will be carried out to gain a better understanding of the effects of low-velocity impact on composite sandwich constructions.The objective of this study are:

i. To study the effect of low velocity impact on composite sandwich panel.
ii. To study the behaviour of composite sandwich panel under Quasi-static Compression Testing.
iii. To study the effect on composite sandwich panel after impact under Drop Weight Testing Machine.
iv. To study the type of impact damage on the surface of composite sandwich panel using scanning Electron Microscope(SEM).

## 1.4 Significant of research

From this research, the result of the low velocity of impact via quasi-static compression test, the effect on composite sandwich panel after impact under drop weight testing machine, and the type of impact damage on the surface are investigated.

## 1.5 Research scopes

The research activities include the following:

i. Sample preparation on composite sandwich panel.
ii. Low velocity impact testing via Quasi-static Compression Test.
iii. Drop weight impact testing.
iv. Surface defect analysis using Scanning Electron Microscope(SEM)

## 1.6 Planning and execution

| PLANNING AND EXECUTION FOR PSM I | JANUARY | | | | FEBRUARY | | | | MARCH | | | | APR | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RESEARCH ACTIVITY/TIME** | **W1** | **W2** | **W3** | **W4** | **W5** | **W6** | **W7** | **W8** | **W9** | **W10** | **W11** | **W12** | **W13** | **W14** |
| **Literature review** | | | | | | | | | | | | | | |
| **Research Methodology** | | | | | | | | | | | | | | |
| -Design of experiment | | | | | | | | | | | | | | |
| - Design of test specimen | | | | | | | | | | | | | | |
| **Report writing for PSM I** | | | | | | | | | | | | | | |
| **Preparation for PSM Seminar I** | | | | | | | | | | | | | | |
| **Submission of report & log book** | | | | | | | | | | | | | | |

**PLANNING AND EXECUTION FOR PSM II 2008**

| RESEARCH ACTIVITY/TIME | JULY | | | | AUGUST | | | | SEPTEMBER | | | | OCT | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | W1 | W2 | W3 | W4 | W5 | W6 | W7 | W8 | W9 | W10 | W11 | W12 | W13 | W14 |
| **Literature review** | | | | | | | | | | | | | | |
| **Experimental activities:-** | | | | | | | | | | | | | | |
| - Sample preparation | | | | | | | | | | | | | | |
| - Mechanical Testing | | | | | | | | | | | | | | |
| Quasi-Static Compression Test | | | | | | | | | | | | | | |
| Surface Analysis using SEM | | | | | | | | | | | | | | |
| **Data collection** | | | | | | | | | | | | | | |
| **Results and analysis** | | | | | | | | | | | | | | |
| **Report writing for PSM II** | | | | | | | | | | | | | | |
| **Preparation for PSM Seminar II** | | | | | | | | | | | | | | |
| **Submission of report & log book** | | | | | | | | | | | | | | |

# CHAPTER II

# LITERATURE REVIEW

## 2.1 Composite materials

Composite materials (or composites for short) are engineered materials made from two or more constituent materials with significantly different physical or chemical properties and which remain separate and distinct on a macroscopic level within the finished structure. Composite materials have gained popularity (despite their generally high cost) in high-performance products that need to be lightweight, yet strong enough to take harsh loading conditions such as aerospace components (tails, wings, fuselages, propellers), boat and scull hulls, bicycle frames and racing car bodies. Other uses include fishing rods and storage tanks. The new Boeing 787 Dreamliner structure including the wings and fuselage is composed of over 50 percent composites.Carbon composite is a key material in today's launch vehicles and spacecrafts. It is widely used in solar panel substrates, antenna reflectors and yokes of spacecrafts. It is also used in payload adapters, inter-stage structures and heat shields of launch vehicles.

### 2.1.1 Processing of composites

In general, the reinforcing and matrix materials are combined, compacted and processed to undergo a melding event. After the molding event, the part shape is essentially set, although it can deform under certain process conditions. For a thermoset polymeric matrix material, the melding event is a curing reaction that is initiated by the application of additional heat or chemical reactivity such as organic peroxide. For a thermoplastic polymeric matrix material, the melding event is solidification from the melted state. For a metal matrix material such as titanium foil, the melding event is a fusing at high pressure and a temperature near the melt point. [9]

For many molding methods, it is convenient to refer to one mold piece as a "lower" mold and another mold piece as an "upper" mold. Lower and upper refer to the different faces of the molded panel, not the mold's configuration in space. In this convention, there is always a lower mold, and sometimes an upper mold. Part construction begins by applying materials to the lower mold. Lower mold and upper mold are more generalized descriptors than more common and specific terms such as male side, female side, a-side, b-side, tool side, bowl, hat, mandrel, etc. Continuous manufacturing processes use a different nomenclature. The molded product is often referred to as a panel. For certain geometries and material combinations, it can be referred to as a casting. For certain continuous processes, it can be referred to as a profile. [9]

Autoclave method process using a two-sided mold set that forms both surfaces of the panel. One the lower side is a rigid mold and on the upper side is a flexible membrane made from silicone or an extruded polymer film such as nylon. Reinforcement materials can be placed manually or robotically. They include continuous fiber forms fashioned into textile constructions. Most often, they are pre-impregnated with the resin in the form of prepreg fabrics or unidirectional tapes. In some instances, a resin film is placed upon the lower mold and dry reinforcement is placed above. The upper mold is installed and vacuum is applied to the mold cavity. The assembly is placed into an autoclave pressure vessel.This process is generally performed at both elevated pressure and elevated temperature. The use of elevated pressure facilitates a high fiber volume fraction and low void content for maximum structural efficiency. [9]

### 2.1.2 Mechanical properties of composite materials

Composite materials have gained popularity (despite their generally high cost) in high-performance products such as aerospace components (tails, wings, fuselages, propellers), boat and scull hulls, bicycle frames and racing car bodies. More mundane uses include fishing rods and storage tanks. [10]

Carbon composite is a key material in today's launch vehicles and spacecrafts. It is widely used in solar panel substrates, antenna reflectors and yokes of spacecrafts. It is also used in payload adapters, inter-stage structures and heat shields of launch vehicles. [10]

Table 2.1: Mechanical properties of composite materials [10]

| Material | Strength, MPa | Elastic Modulus, GPa | Density, kg/m$^3$ | Specific strength, m$^2$/s$^2$ |
|---|---|---|---|---|
| Polyethylene | 6.9 | 3 | 830 | 8313 |
| Pure Al. | 44.9 | | 2730 | 16 440 |
| Pure copper | 207 | | 8910 | 23 330 |
| 2024 Al. alloy | 480 | 73.1 | 2780 | 173 000 |
| Steel – high s. | 1650 | 200 | 7800 | 212 000 |
| Kevlar-epoxy | 448 | | 1390 | 322 300 |
| Carbon-epoxy[1] | 2100 | 150 | 1600 | 1 310 000 |
| Titanium alloy | 1170 | 110 | 4460 | 262 330 |
| Epoxy | 103 | | 1390 | 74 100 |
| Alumina | 207 | | 3175 | 65 200 |
| SiC | 480 | 410 | 3100 | 154 000 |

I. Glass Fibers

Glass fibers have been used for many years to produce fabrics and reinforcement materials for composites. They are gotten through warm spinning method of glasses made in a suitable way (usually, alumino- borate –silicate) according to the use and the environment where it will be used. The kinds of glass commonly used for fibers are kind E and kind S, with a density of about 2,6 g/cm$^3$, with elastic modules of about 80 and 90 GPa and break resistance of respectively 3,5 and 4,5 GPa. [9].

To obtain composites with good characteristics under stress, the break stretching of the fiber (3 and 6% in many composites) must be less and the rigidity must be more