A COMPARISON STUDY OF STANDARD TEST METHOD FOR THE DETERMINATION OF FLEXURAL PROPERTY OF GLASS FIBER POLYESTER LAMINATES

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DECLARATION

I hereby declare that this project report entitled

A COMPARISON STUDY OF STANDARD TEST METHOD FOR THE DETERMINATION OF FLEXURAL PROPERTY OF GLASS FIBER POLYESTER LAMINATES

is written by me and is my own effort and that no part has been plagiarized without citations.

Signature	: ……………………....
Writer Name	: ……………………....
Date	: ………………………

DEDICATION

To my beloved mother and father,
Johari bin Dailam and Saniah binti Sulaiman.
Who inspired me with their love and kindness.

To all my sisters,
For giving me endless strength and support.

To all my friends,
For giving me support and idea.

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ABSTRACT

Glass reinforced plastic is a composite material made of a plastic reinforced by fine glass fibers. Like graphite reinforced plastic, the composite material is commonly referred to by the name of its reinforcing fibers. Whereas the plastic resins are strong in compressive loading and relatively weak in tensile strength, the glass fibers are very strong in tension but have no strength against compression. By combining the two materials, glass reinforced plastic becomes a material that resists both compressive and tensile forces well. The two materials may be used uniformly or the glass may be specifically placed in those portions of the structure that will experience tensile loads. There are lot types of mechanical property for glass reinforced plastic such as flexural strength. Flexural strength is maximum fiber stress developed in a specimen just before it cracks or breaks. Flexural properties of composite are obtained by placing a specimen on two supports span. In determining the flexural property of composite material, it has two similar standard test methods in collecting the flexural data. The two nearly similar standards have developed by two established standard organization body, American Society for Testing Material (ASTM) and British Standard Organization (BSI). Even though these two methods nearly similar, but it is not technically equivalent between them. This study will performed this two methods and comparative study will be done to identify the differences. The composite specimen will be tested according to ASTM 790, which was developed by ASTM and also based on BS ISO 178 that was developed by BSI. Three point bending test method will be used as it is the similar method that was used in ASTM 790 and BS ISO 178 which is used to determine flexural properties in plastic or composite material.

ABSTRAK

Plastik bertetulang kaca adalah satu bahan komposit dibuat sekeping plastik yang diperkuatkan oleh gentian kaca . Seperti Grafit bertetulang plastik, bahan komposit adalah biasanya dirujuk kepada bahan tetulangnya. Manakala damar plastik adalah kukuh dalam beban mampatan dan agak lemah dalam kekuatan tegangan, gentian kaca adalah amat bertenaga dalam ketegangan tetapi tidak mempunyai kekuatan mampatan. Dengan menggabungkan dua bahan, plastik bertetulang kaca menjadi satu bahan yang menolak kedua-dua kuasa mampatan dan kuasa tegangan.Dua bahan boleh digunakan sama rata atau mungkin khususnya dalam bahagian-bahagian struktur yang akan mengalami beban tegangan. Terdapat beberapa jenis sifat mekanik untuk kaca plastik bertetulang iaitu sepeti lenturan kekuatan. Lenturan kekuatan adalah tekanan maksimum dang dihasilkan dalam satu bahan ujikaji sejurus sebelum ia retak atau pecah. Ciri-ciri lenturan bahan komposit diperolehi dengan meletakkan satu bahan ujikaji di antara dua bahan penyokong. Dalam memastikan sifat lenturan bahan komposit, ia mempunyai dua kaedah ujian yang hampir serupa dalam pengumpulan data lenturan bahan tersebut.. Dua piawai yang hampir serupa tersebut telah dibangunkan oleh dua organisasi piawaian yang terkenal iaitu American Society for Testing Material (ASTM) dan British Standard Institution (BSI). Walaupun dua kaedah ini hampir sama, tetapi dari segi teknikal ia tetap bebeza. Kajian ini akan melaksanakan dua kaedah tersebut dan kajian perbandingan akan dilakukan untuk mengenalpasti perbezaan –perbezaan antara kedua-dua kaedah tersebut. Jadi, bahan ujikaji akan diuji berdasarkan piawai ASTM 790, yang diterbitkan oleh ASTM dan juga berdasarkan piawai BS ISO 178 yang dibangunkan oleh BSI. Kaedah ujian lenturan tiga titik akan digunakan kerana ia adalah kaedah serupa yang telah digunakan dalam piawai ASTM 790 dan BS ISO 178 untuk menentukan ciri-ciri lenturan dalam plastik atau bahan komposit

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CHAPTER 1

INTRODUCTION

This chapter is to provide the reader with an introduction to the research conducted for this comparison study. This chapter discussed on the objective, problem statement, scope of study and outline for each chapter of this study.

1.1 Background

Fiberglass is material made from extremely fine fibers of glass. It is used as a reinforcing agent for many polymer products, the resulting composite material, usually known as fiber-reinforced polymer (FRP) or glass-reinforced plastic (GRP), is called "fiberglass" in popular usage.

A fiber-reinforced plastic is a composite material comprising a polymer matrix reinforced with fibers. The fibers are usually fiberglass, carbon, or aramid, while the polymer is usually an epoxy, vinylester or polyester thermosetting plastic. Fiber-reinforced plastic are commonly used in the aerospace, automotive, marine, and construction industries (Miracle, 2001)

Glass reinforced plastic (GRP), is a composite material or fiber reinforced plastic made of a plastic reinforced by fine fibers made of glass. Like graphite-reinforced plastic, the composite material is commonly referred to by the name of its reinforcing fibers (fiberglass). The plastic is most often polyester or vinylester, but other plastics, like epoxy (GRE), are also sometimes used. The glass is mostly in the form of chopped strand mat (CSM), but woven fabrics are also used. (Miracle, 2001)

1.2 Objective

The objective of this comparison study is to identify and compare the differences of standard test method that are used in two standard institutes for determination of flexural property of glass fiber polyester laminates

1.3 Problem Statement

Traditionally, there is a lot of test method that was used to determine the flexural property of glass fiber polyester laminates. American Society of Testing and Materials (ASTM) and British Standard Institution (BSI) are the institutes that have their own standard in determining the flexural property of composite material. Even though the recommendation standards of these two institutes are commonly similar, but it has a lot of substantial difference between them.

1.4 Scope

Scopes of this study include:

a) Explanation about property and production process of glass fiber reinforced plastic.

b) Study on the standard test methods that are use in determining the flexural property of glass fiber polyester laminates.
c) Fabrication and preparation the specimen based on the standard test method.
d) Study of differences of test method that was developed by ASTM and BSI.

1.5 Report Outline

Chapter 2 is discuss on the literature search on definition and composition of fiber reinforced polymer, background for American Society of Testing and Material (ASTM), and the British Standard Institution (BSI), as well as the test method in determining the flexural property that were developed by these two well known standards organization.

Chapter 3 is based on the experimental work and technique that will be conduct during this study in obtaining the data. The process of this study starts with researching the relevant literature review, the fabrication of the specimen and the laboratory works. The laboratory works that will be used is the flexural test by using three point bending test.

Chapter 4 is mainly about the result and how the data will be analyzed after the test has been completed.

Chapter 5 is the discussion on the result and interpretation of the results that have been found through this study. Besides that, this chapter will discuss on the limitation. Then, the different between ASTM D790 and BS ISO 178 also will be emphasizing in this chapter.

Chapter 6 is the conclusion for this project. This chapter will conclude based on the overall results, analysis and the comparison between the test method that was produced by ASTM and BSI.

CHAPTER 2

LITERATURE REVIEW

Chapter two will discuss on literature review of fiber reinforced plastic composite and its main composition, standard organization. Some information about mechanical properties especially on flexural properties, flexural test and the standard method that was used by international standard organization for this composite will be mention in this chapter.

2.1 Definition of FRP

In general, Fiber Reinforced Polymer (FRP) can be classified as composite materials that combine a polymer matrix with reinforcing agents. The polymer matrix can be either thermoset or thermoplastic resin such as polyester, isopolyester, vinyl ester, epoxy and phenolic that reinforced with fibers such as glass, carbon, aramid or other reinforcing materials. FRP may also contain fillers, additives and core materials added to modify and enhance the final product for structural application.

This type of composite is similar with reinforced concrete where the beam is embedded in an isotropic matrix called concrete. The combination of these two materials in a sufficient ratio allows an incredible range of strength and physical properties to be achieved. For these reasons, FRP can be developed specifically to meet the required performance versus the traditional materials such as timber, steel and ceramic. (Tan Sim Thye, 2003)

Many terms can be used to define the FRP composites. Basically, they are identified by a specific fiber such as Glass Fiber Reinforced Polymer (GFRP), Carbon Fiber Reinforced Polymer (CFRP) and Aramid Fiber Reinforced Polymer (AFRP). Another familiar term being used is the Fiber Reinforced Plastics. All these refer to the same meaning of the FRP composites.

2.2 Composition of Fiber Reinforced Plastic

Basically, the FRP is a composition of resin, reinforcement, filler and additive. Each constituent plays an important role in the processing and final products. The constituents retain their identities in the composites and can be physically identified.

Polymer or resin acts as the glue that holds the composite together and influence the properties of the end product. The reinforcement or fiber provides the mechanical strength while fillers and additives are added as performance aids to the special properties of the end product. (Tan Sim Thye, 2003)Figure 2.1 shows the composition of FRP that commonly used.

It is important to study the composition of FRP and their characteristics. The type, quality, quantity and proportion of materials used to fabricate the FRP products are directly influence their mechanical properties and performance. Among the criteria to be considered during the design stage includes:

- Type of reinforcement or fiber
- Percentage of fiber volume by weight

- Orientation of fiber
- Type of resin
- Service conditions

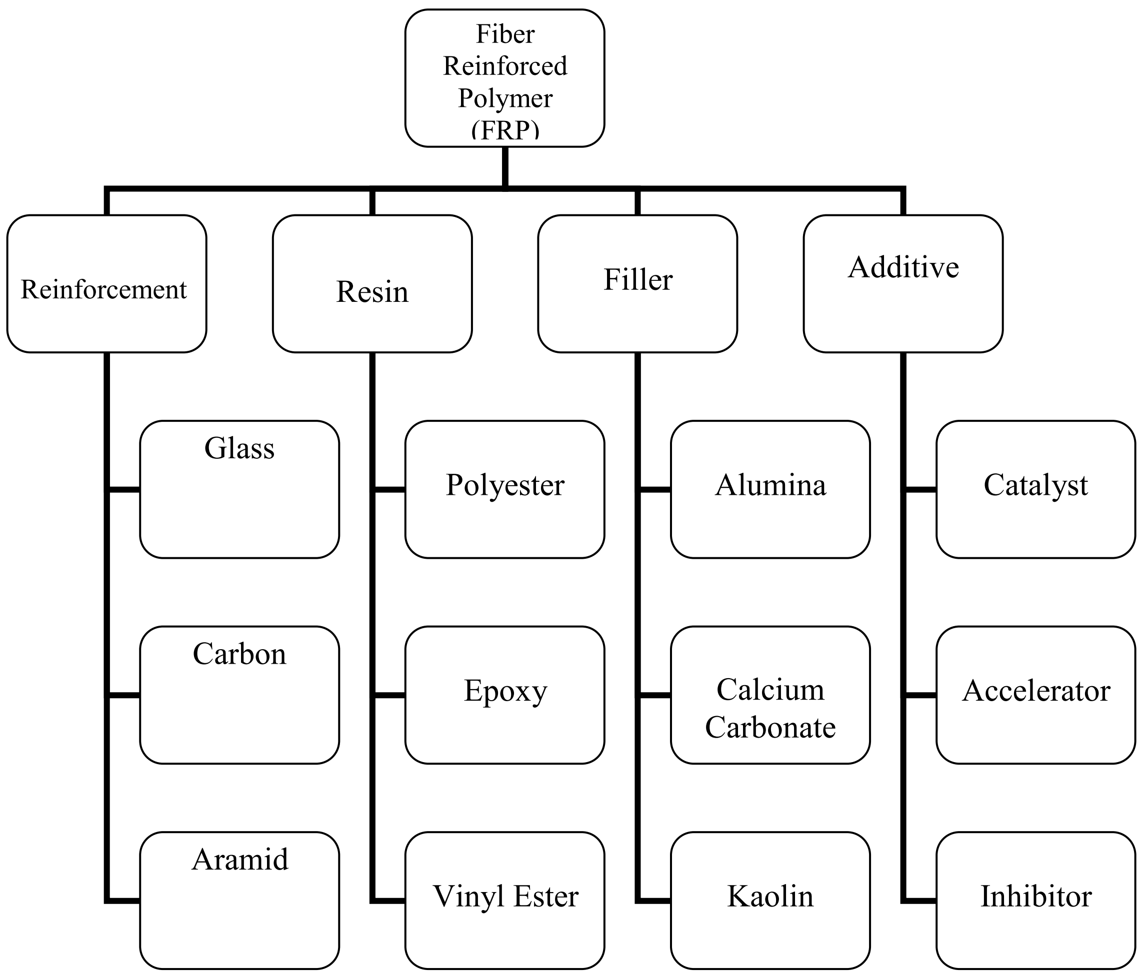

Figure 2.1: Composition of FRP (Tan Sim Thye, 2003)

2.2.1 Reinforcement

Reinforcing agents can be either natural or man-made. The primary function of the reinforcement is to sustain load along the length of the reinforcement in order to improve the structural characteristics. In addition, they can be continuous in the form of fibers, filaments or tapes, or discontinuous in form of whiskers, flakes, spheres, powders, platelets or particulates. Reinforcements are permanently combined with the polymer matrix on a microscopic scale. (Composites Basic Material, 2004) By adding such reinforcements, a lot of improvements can be achieved by:

- Improve formability
- Increase strength to density and stiffness to density ratio
- Increase resistance to corrosion,fatigue, creeps and stress rupture
- Reduce coefficient of thermal expansion
- Produce higher temperature performance

Fiber is commonly used as the reinforcement. They can be inorganic and organic with diameter ranging from about one micrometer to over hundred micrometers. However, glass fiber is more commercialize either in its quantity consumed or product sales. Other types of fiber that have been used include carbon, aramid, boron, steel and aluminum. Properties of these fibers are summarized in Table 2.1.

Table 2.1 Properties of high performance fibers in reinforced polymers
(Composites Basic Material, 2004)

Reinforcement	Specific Gravity	Ultimate Tensile Strength, (GPa)	Tensile Modulus (GPa)	Specific Tensile Strength (GPa)	Specific Modulus (GPa)
E- Glass	2.56	3.60	76	1.40	29
S- Glass	2.49	4.50	86	1.80	34
Carbon	1.82	2.30	200	1.26	110
Aramid	1.45	2.94	130	2.03	90
Steel	7.80	1.00	200	0.13	26
Aluminum	2.80	0.50	75	0.18	27
Boron	2.62	3.40	344	1.30	130

2.2.2 Glass fiber

Glass is an amorphous material obtained by super cooling of molten glass. They are produced by the combination of metallic oxide with silica in a chemical reaction. E-glass which is based on alumina-lime-borosilicate composition is extensively used since they are more economic, good chemical resistance, high insulating properties and well-performed in mechanical properties. Another commercial type of glass fiber is S-glass which has higher strength, heat resistance and modulus. S-glass normally being applied in the aerospace industry, which has about one-third stronger than E-glass and composed of 65 % silicon dioxide, 25 % aluminum oxide and 10 %magnesium oxide.(Composites Basic Material, 2004)

In comparison, glass is generally good in the impact resistance, but higher in weight compare to carbon and aramid. It has an equal or better than the steel in certain forms of characteristics. However, the lower modulus made it need a special design in order to perform well in its applications.

Glass Fiber Reinforced Polymer is widely used in the construction and automobile industries. For examples, highway sign and post, manhole cover, aesthetic building structures and commercial roofing. As proven, bridge columns that were wrapped with the GFRP were not shaken during earthquake. (Composites Basic Material, 2004)

2.2.2.1 Formation of glass fiber

Glass fiber is formed when thin strands of silica-based or other formulation glass is extruded into many fibers with small diameters suitable for textile processing. Glass is unlike other polymers in that, even as a fiber, it has little crystalline structure The properties of the structure of glass in its softened stage are very much like its properties when spun into fiber. One definition of glass is "an inorganic substance in a condition which is continuous with, and analogous to the liquid state of that substance, but which, as a result of a reversible change in viscosity during cooling, has attained so high a degree of viscosity as to be for all practical purposes rigid.

2.2.2.2 Properties

Glass fibers are useful because of their high ratio of surface area to weight. However, the increased surface makes them much more susceptible to chemical attack. By trapping air within them, blocks of glass fiber make good thermal insulation.

Glass strengths are usually tested and reported for "virgin" fibers which have just been manufactured. The freshest, thinnest fibers are the strongest and this is thought to be due to the fact that it is easier for thinner fibers to bend. The more the surface is scratched, the less the resulting tenacity is. Because glass has an amorphous structure, its properties are the same along the fiber and across the fiber. Humidity is an important factor in the tensile strength. Moisture is easily adsorbed, and can worsen microscopic cracks and surface defects, and lessen tenacity.( )

In contrast to carbon fiber, glass can undergo more elongation before it breaks. The viscosity of the molten glass is very important for manufacturing success. During drawing (pulling of the glass to reduce fiber circumference) the viscosity should be relatively low. If it is too high the fiber will break during drawing, however if it is too low the glass will form droplets rather than drawing out into fiber. (Dominick V. R., 1997)

2.2.3 Resin

Resin offers an adhesive property to the composition in FRP. It acts as a glue to hold the fibers together so that the stress can be transferred between the reinforcing fibers and protect them from mechanical damage and environmental attack. Basically, resin can be divided into two categories, known as thermoplastic and thermoset.

Thermoplastic resins soften repeatedly when heated and harden when cooled. They may be shaped or molded while in a heated semi-fluid state and become rigid when cooled. However, thermoplastic resins will melt at high temperature and become brittle at low temperature. Low heat distortion temperature makes them unsuitable for structural application. Below the Glass Transition Temperature, they behave like glass with strong, rigid but brittle properties. Examples of the thermoplastic resins include polypropylene, polystyrene, phenoxy, polyvinylchloride and nylon.

Thermoset resins are usually available in liquids monomer-polymer mixtures or partially polymerized compounds. They pass through one soft plastic stage and then harden irreversibly. Unlike the thermoplastic resins, once they are cured, they can not be reshaped or return to their original liquid form. With cross linking and inter-linking, thermoset resins are stiffer than the thermoplastic resins. These make them more suitable for the construction purposes. Their types include polyester, epoxy, melamine, urethane and silicon. (Dominick V. R., 1997)

2.2.3.1 Polyester Resin

Unsaturated polyester resin is a family of thermoplastic polyesters that being used as in the textile industry and represents about 75 % of the total resin used. For the manufacturing industry of FRP, thermosetting polyester is commonly used, varied for the small structures until very large construction. When reinforced with various fibers, particularly E-glass fiber, they develop outstanding mechanical properties in order to be applied for the structural applications. By adding fillers, finished surface can be improved. Besides, fillers are also added to reduce shrinkage and minimize crazing.

In chemistry the reaction of a base with an acid produces a salt. Similarly, in organic chemistry the reaction of an alcohol with an organic acid produces an ester and water. By using special alcohols, such as a glycol, in a reaction with di-basic acids, a polyester and water will be produced. This reaction, together with the addition of compounds such as saturated di-basic acids and cross-linking monomers, forms the basic