UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND FABRICATION OF COMPOSITE WATER TANK ADDED WITH FLY ASH FOR RESIDENTIAL UNIT

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours

by

SATHYA SRI S/O KRISHNA MOORTHY

B071610918

950621-07-5427

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TAJUK: **DESIGN AND FABRICATION OF COMPOSITE WATER TANK ADDED WITH FLY ASH FOR RESIDENTIAL UNITS**

SESI PENGAJIAN: **2019/2020 SEMESTER 1**

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SATHYA SRI A/L KRISHNA MOORTHY

Ts. KHAIRIL AMRI BIN KAMARUZZAMAN

Alamat tetap:
NO 24, LRG MACHANG BUBUK 28
TMN MACHANG BUBUK, 14020,
BUKIT MERTAJAM,
PULAU PINANG

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I hereby, declared this report entitled "Design and Fabrication of Composite Water Tank Added with Fly Ash for Residential Unit" is the result of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of UTeM as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical and Manufacturing Engineering Technology (Maintenance Technology) with Honours. The member of the supervisory is as follows:

……………………………………

(Ts. Khairil Amri Bin Kamaruzzaman)

ABSTRAK

Projek penyelidikan ini membincangkan reka bentuk dan fabrikasi tangki air komposit yang ditambah dengan abu terbang untuk unit kediaman. *Abu Terbang* adalah produk sampingan dari loji pembakaran arang batu yang disimpan di tapak pelupusan yang membahayakan alam sekitar. Kajian ini bertujuan untuk menambah abu terbang ke dalam gentian kaca untuk mengurangkan jumlah sampah. Untuk memenuhi objektif, kesan abu terbang pada gentian kaca diuji dan tangki air prototaip dicipta menggunakan acuan. Sampel dicipta menggunakan kaedah susun atur tangan untuk komposisi 0%, 5%, 10% dan 15% abu terbang dengan membuat lembaran panjang 550 mm dan lebar 340 mm. Spesimen dipotong menggunakan mesin pemotong laser CNC selepas mencipta reka bentuk sampel pada Penisian Solidworks. Sampel diuji untuk Ujian Tegangan, Ujian Lenturan dan Ujian Penyerapan Air. Hasil Uji Tegangan menunjukkan bahawa komposisi abu terbang 0% mempunyai tegangan tegangan tertinggi kira-kira 163.597 MPa berbanding 5%, 10% dan 15% abu terbang. Keputusan Ujian Lenturan menunjukkan bahawa komposisi 0% dan 5% abu terbang mempunyai tekanan lentur yang hampir sama 292.661 MPa dan 290.088 MPa manakala komposisi 10% dan 15% abu terbang mempunyai 267.923 MPa dan 266.056 MPa. Hasil uji penyerapan air menunjukkan bahawa komposisi abu terbang 10% mempunyai peratusan penyerapan air terendah. Hasil ujian dianalisis dan memilih mana yang terbaik peratusan abu terbang untuk dimasukkan ke dalam gentian kaca. Tangki prototaip dibuat dengan komposisi abu terbang 0% dan abu terbang 10% dan perbandingan dibuat pada kadar penyerapan air pada kedua-dua tangki.

ABSTRACT

This research project talks about the design and fabrication of composite water tank added with fly ash for residential unit. *Fly ash* is a by- product of a coal combustion power plant which deposited on landfills which harm for the environment. This research is intended to add fly ash into fiberglass to reduce the amount of the waste. In order to fulfil the objective, effect of the fly ash on fiberglass is tested and prototype water tank was created using a mould. The sample was created using a hand-layout method for a composition of 0%, 5%, 10% and 15% of fly ash by creating a sheet a length of 550 mm and a width of 340 mm. The specimen was cut using CNC laser cutting machine after creating the design of the samples on Solidworks Software. The sample is tested for Tensile Test, Flexural Test and Water Absorption Test. Result of the Tensile Test indicate that composition 0% fly ash has the highest tensile stress about 163.597 MPa compared 5%, 10% and 15% of fly ash. Result of Flexural Test shows that composition of 0% and 5% of fly ash has almost same flexural stress 292.661 MPa and 290.088 MPa while composition of 10% and 15% of fly ash has 267.923 MPa and 266.056 MPa. Result of water absorption test shows that composition of 10% fly ash has the lowest water absorption percentage. The result of the test is analysed and choose which is the best percentage of fly ash to add into fiberglass. A prototype tank was fabricated with composition of 0% fly ash and 10% fly ash and a comparison was made on water absorption rate on both tanks.

DEDICATION

To my beloved parents, sibling and family

ACKNOWLEDGEMENT

I would like to thanks UTeM for accepting me as one of your student in Faculty of Mechanical and Manufacturing Engineering Technology. To my supervisor, Ts. Khairil Amri Bin Kamaruzzaman thank you for always guiding me throughout the project. Also, to all my lecturers that had teach me since in the first year of degree until this final year. Special thanks to my beloved parent Mr Krishna Moorthy A/L Krishna Moorthy and Mrs Jayasree A/P Subramaniam, all my friend for all the spirit word, love and helping me during all this study journey that give me the strength to finish my study. Lastly, thank you to those who had been involved in this project. Thank you everyone.

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LIST OF ABBREVIATIONS

μm – Micron

B.C – Before Century

A.D – Anno Domini

U.S – United States

3-D – Three Dimensional

ASTM – American Society for Testing and Materials

Etc – Etcetera

ISO – International Organization for Standardization

mm – Millimetre

MPa – Megapascal

N – Newton

CHAPTER 1

INTRODUCTION

1.1 Project Background

The coal combustion companies produce waste-product called fly ash. It is considered as one of the deposits created from coal in the electric power plant in the burning chamber and contains the fine particles which rise with the flue gases. Malaysia's coal resources are in Perak, Perlis, Sabah, Sarawak, and Selangor, but mining and exploration were undertaken only in Sabah, Sarawak, and Selangor. According to (National Minerals Information Center, 2017), the complete coal reserve in Malaysia was 1.9 billion metric tonnes (Gt) of which 281 Mt was measured, 378 Mt was stated, and 1.3 Gt was inferred.

Fly ash is a spherical fine glass powder with an estimated particle size of betwe en 0.5 and 100 μm. Fly ash is a pozzolan, a substance that forms cement in the presence of water, containing aluminum and siliceous material. Fly ash forms a compound like Portland cement when blended with lime and water. This makes fly ash, among other construction products, appropriate as a primary material in mixed cement, mosaic tiles, and hollow blocks. Used in concrete mixtures, fly ash enhances concrete strength and segregation and makes pumping simpler. Fly ash mostly is been disposed in landfills and pond with less commercial usage. This is a major impact on environment.

The main objective of this project is to produce a 2 Litres water storage tank using fiberglass with fly ash. Furthermore, this project is to test the materials and investigate the physical properties after being combined. FVW-501 is a cylindrical type Frontier water tank which is currently in the market. The tank has a diameter, D of 925 mm, a height, H of 940 mm which has a capacity of 500 Litres. The construction of cisterns can be made from reinforced concrete, fiberglass, polyethylene, concrete and steel. As these materials are waterproof and do not rust, the use of polyethylene (PE) plastic and fiberglass increases.

1.2 Problem Statement

Out of sixty-three power stations in Malaysia, there are seven coal fired electric power stations in service. These power stations usually can produce a high amount of electric power of more than 8400 Megawatts (MW). In Peninsular Malaysia, there are four coal fired electric power stations which are Jimah Power Station in Negeri Sembilan, Manjung Power Station in Perak, Sultan Salahuddin Abdul Aziz Shah Power Station in Selangor and Tanjung Bin Power Station in Johor Bahru that produced at least 8070 MW of electric power (Malaysian Energy Statistics, 2017). Fly ash is a waste resultant from electrical power plants using coal as their source of fuel. Previously, by burying it in landfills or returning it to strip mines, a coal-based power plant disposed of the waste amounts from their equipment. Growth in power plants using coal as the fuel source has produced hundreds of millions of tons of ash each year in various countries as shown in Figure 1.1.

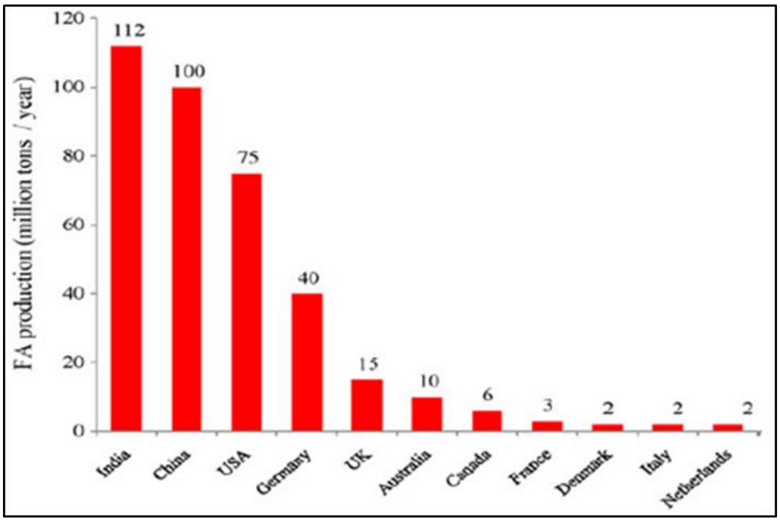

Figure 1.1: Fly ash production (million tonnes/year) in different countries

(Source: http://www.tifac.org.in)

With the improvement of technology and economic crisis in Malaysia, the development of infrastructure has been promoted in the use of new structural materials, but with unsatisfactory overall cost savings. However, using waste industrial waste such as fly ash as a source to replace the existing cost-effective building materials can solve this problem. The main aspect of waste management is to prevent waste production by minimizing waste generated and by recycling the reuse of waste materials (Nordin et al., 2016).

Storage tanks are a prime environment for residue build-up and development of bacteria, which can lead to discolored and possibly unsafe water. Tanks can develop cooler layers of "heavier water" and warmer "light water," which can create barriers to mixing in the water level. If water is not properly mixed, it can result in an extended water age in the tank as older water stays in the tank continuously while the newer water is distributed (Whitford & Hawkins, 2009). As the time passes the gel coat on the tank will begin to break down and gets thinner when ultraviolet light degrades the resin that holds the glass in place. Another issue is the outer wall of the tank will show a spider web crack pattern when something hit or bump the tank.

1.3 Objective

The purpose of this study is to merge fly ash and composite material together and reducing fly ash being deposited on landfills. The objectives of the project are:

- To study the effect of fly ash on the mechanical properties of composite material.
- To design and fabricate composite water tank using fly ash.

1.4 Work Scope

The scope of this project is consist of designing and fabricating water tank for double storey residential building at Taman Bukit Beruang, Malacca. The design specification is only for prototype water tank. Next, is to observe the mechanical properties of fiberglass by adding fly ash. Finally, is to test the mechanical properties of fiberglass with fly ash through various test.

CHAPTER 2

LITERATURE REVIEW

2.1 Fundamental of Composite

Composite research and development has significantly added mixtures to the collection of material property. According to (Callister & Rethwisch, 2012), composite is ordered to be any multi-phase material that slows down the production of a significant property. Based on the principle of combined action, the property of the material is improved by careful combination of more than one distinct material.

The term composites do not have a fixed meaning in the field of material development of composites where the term differs from one source and another. According to (Soboyejo, 2003) "It is possible to improve the strength of a system (material) by strengthening with a second stage that has a better strength than the natural limit of the host material generally known as matrix." The following system is known as a composite material created by combining two or more phases. Besides that, composites are defined by “A composite material is a material system made up of properly organized mixture or combination of two or more micro or macro elements with a separating interface that differ in form and chemical composition and are insoluble”. Figure 2.1 shows the combination of the composite material definition in the first source.

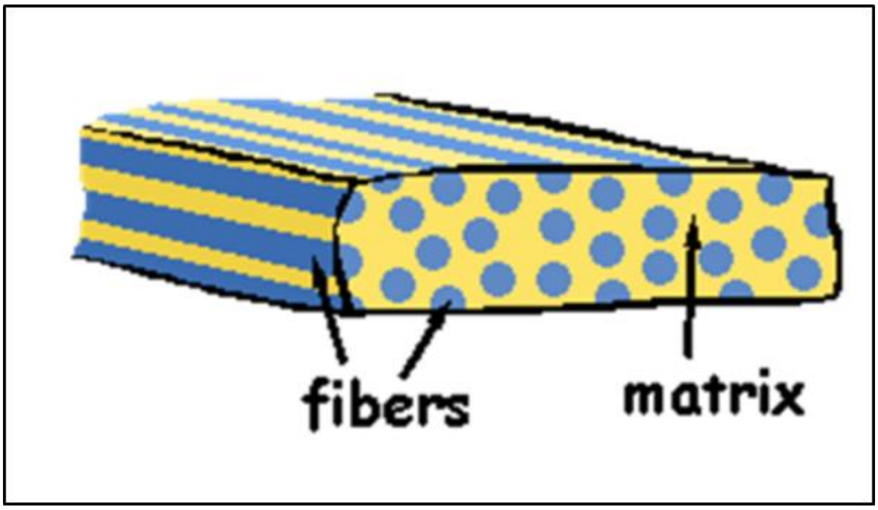

Figure 2.1: Combination of material in composite

(Source: https://slideplayer.com/slide/11545465/)

Composite materials are developed from two or multiple materials where the properties of the material could not be harvested from the single material alone. One of the material acts as matrix and the other acts as reinforcement in the composite (Dragan Aleksendric, 2015). The essential functions of the matrix is to guard the reinforcement, disperse stress to the reinforcement and provide final shape to the composite structure. The reinforcement job is to give strong mechanical properties and strengthen the matrix in desired orientation. Composites properties rely on the type of reinforcement and matrix used, profile of reinforcement (particles, short fibers and long fibers) and the composition reinforcement and matrix content (Lopresto et al., 2016).

2.1.1 History of Composite

It is not of recent origin to consider merging several components to produce a new material with new properties that cannot be achieved with single components. For thousands of years, humans have invented composite materials to build tougher and lighter objects. The use of composite material was appeared 3400 B.C. by Mesopotamian who glued wood strips at different angles to create plywood. Besides that, the Egyptians used Cartonnage and layers of linen or papyrus soaked in plaster to make laminated writing material between 3400 B.C. and 2055 B.C. as shown in Figure 2.2.

Figure 2.2: Laminated writing material from papyrus plant

(Source : http://knowledgebase.lookseek.com/Egyptian-Papyrus-Cyperus-Papyrus.html)

During 1500 B.C, worldwide civilizations have used basic elements of their surrounds in the manufacture of dwellings, which includes mud, straw, wood and clay by early Egyptian and Mesopotamian settlers. Straw offers continuous reinforcement of old composite products including pottery and boats. "Bricks," as shown in Figure 2.3, were and still are made of mud and straw.

Figure 2.3: Brick which made from mud and straw

(Source: https://www.123rf.com/photo_3862153_mud-bricks-are-mode-of-clay.html)

Mongols developed the first composite bow in 1200 A.D. using an aggregate of wood, bone and animal glue pressed and wrapped using birch bark. These bows were extraordinarily powerful and accurate, providing army dominance to Genghis Khan because this weapon became the world's most powerful weapon by using the composite era until gunpowder was discovered.

Moreover, the history of recent composites probably began in 1937 when salesmen from the fiberglass company Owens Corning began selling fiberglass to stakeholders around the U.S., although composite materials were known in countless forms throughout human history. In 1930, when an engineer became interested in a fiber formed during the process of applying lettering to a glass milk bottle when fiberglass was made almost by accident. Boats, trucks, sports cars, storage tanks, pipes, ducts and many other products have been built using composites as it has grown rapidly since 1950 (Herakovich, 2012). In 1953, the Chevrolet Corvette rolled off the assembly line with the first generation of fiberglass body panels. In addition, production methods such as vacuum bag moulding, pultrusion and winding of large filaments were developed in the early 1950s. In the 1960s and beyond, filament winding became the basis for the large-scale rocket engines that propelled space exploration. Composites were first used in several infrastructure applications in Europe and Asia during the late 1970s and early 1980s, including the world's first highway bridge using composite tendon reinforcement and the first all-composite bridge deck to be built in McKinleyville, West Virginia (Nagavally, 2017).

In the early 2000s, Nanotechnology started to be used in commercial products, making composites an important part of carbon nanotubes. To enhance the thermal, mechanical and electrical properties of the bulk product, a bulk carbon nanotube was used as composite fibers in polymers. Nanomaterials used in new composites are included in advanced fibers and resins.

In the 2010s, the rise in 3-D printing brought production to homes and small businesses. The usage of CAD program allows users to produce any item they might dream of. In addition, 3-D printing items with reinforced fibers are jumping into the field by composites companies as discontinuous carbon fiber strands. They are most commonly used in 3-D printing processes to strengthen plastics across all market sectors, including aerospace, automotive, tooling, infrastructure and medicine. These enhancements bring in less time composites strength with less material and can be designed and prototyped from a single desktop.

The composite industry is making new advancement on composite which are less expensive, less energy- intensive to manufacture and making easier to recycles. Besides that, the industry is developing new fibers and resin to create more application for composite. They are also creating environmentally friendly resin which combine recycled plastic and bio-based polymers as composite to make it strong, lighter and environmentally friendly.

2.1.2 Mechanical Properties of Composite

A physical property that a material displays its so-called mechanical properties upon application of forces. These are a few examples of mechanical characteristics that are elasticity modules, tensile strength, elongation, limits on hardness fatigue, and so on. When materials are in use, they are often subjected to forces. Mechanical engineers calculate these forces and how materials deform (extent, compress, twist) or break as a function of the load, time, temperature, and other conditions applied. By testing the products, the technicians learn about these mechanical characteristics and