UNIVERSITI TEKNIKAL MALAYSIA MELAKA

MECHANICAL AND PHYSICAL PROPERTIES OF GLASS WASTE MIXTURE IN CONCRETE

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (BMMV) WITH HONOURS

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Faculty of Mechanical and Manufacturing Engineering Technology

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DECLARATION

I declare that this Choose an item. entitled “Mechanical And Physical Properties of Glass Waste Mixture in Concrete” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : Fatin

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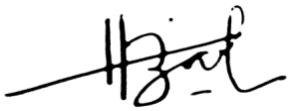
APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (BMMV) with Honours.

Signature : 

Supervisor Name : Dr Mohd Haizal Bin Mohd Husin

Date : 20 January 2023

DEDICATION

I devote my dissertation work to my family and many friends. A special feeling of gratitude to my loving parents, Encik Ahmad Daud and Puan Puzaiah Bt Husian whose words of encouragement and push for tenacity ring in my ears. My siblings, Hazzem and Balqis have never left my side and are very special.

I also dedicate this dissertation to my classmates and lecturers who have supported me throughout the process from the beginning. I will always appreciate all they have done.

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ABSTRACT

Solid waste management is define as one of the most pressing environmental issues in the world. Sadly, post-consumer glass is a significant of solid waste component, and finding markets that would receive glass collected for recycling is difficult. The existence and accumulation of this trash posed a threat to the ecosystem. As a result, employing discarded glass as an aggregate replacement in concrete is a promising option for reducing waste disposal costs while also conserving natural resources. To address these issues, this study utilized fundamental experimental research to evaluate the feasibility of employing crushed waste glass as an aggregate replacement in concrete. Glass waste samples were collected and mashed into 2 sizes which are fine and coarse before being mixed into the concrete mix. The size of the aggregates was determined by sieving. Fine aggregates were available in powder form up to 4mm in size, while coarse aggregates were available in 5mm to 20mm in size. After performing compressive strength tests on five different ratios, the ratio for cement and sand used in this research was 1:2. There were 39 samples of concrete mixes made with 0%, 5%, 10%, 20%, 30%, 40%, and 50% waste glass substitution by weight. Compressive strength, dry density, water absorption and moisture content were studied under experimental investigation. After several tests were conducted, concrete with fine glass aggregates was determined to be the best concrete, with 21.19% strain, 6.32% water absorption, 1.72% density, and 4.1% moisture content. Using glass dust waste in concrete is an intriguing possibility for waste disposal sites and natural resource conservation.

ABSTRAK

Pengurusan sisa pepejal ditakrifkan sebagai salah satu isu alam sekitar yang paling mendesak di dunia. Malangnya, kaca pasca pengguna adalah komponen sisa pepejal yang penting, dan mencari pasaran yang akan menerima kaca yang dikumpul untuk dikitar semula adalah sukar. Kewujudan dan pengumpulan sampah ini menimbulkan ancaman kepada ekosistem. Akibatnya, menggunakan kaca terbuang sebagai pengganti agregat dalam konkrit adalah pilihan yang menjanjikan untuk mengurangkan kos pelupusan sisa sambil juga memulihara sumber semula jadi. Untuk menangani isu-isu ini, kajian ini menggunakan penyelidikan eksperimen asas untuk menilai kebolehlaksanaan menggunakan kaca sisa hancur sebagai penggantian agregat dalam konkrit. Sampel sisa kaca dikumpul dan dilenyek kepada 2 saiz iaitu halus dan kasar sebelum dicampurkan ke dalam adunan konkrit. Saiz agregat ditentukan dengan penyaringan. Agregat halus boleh didapati dalam bentuk serbuk sehingga saiz 4mm, manakala agregat kasar tersedia dalam saiz 5mm hingga 20mm. Selepas melakukan ujian kekuatan mampatan pada lima nisbah yang berbeza, nisbah bagi simen dan pasir yang digunakan dalam penyelidikan ini ialah 1:2. Terdapat 39 sampel bancuhan konkrit yang dibuat dengan 0%, 5%, 10%, 20%, 30%, 40%, dan 50% penggantian kaca sisa mengikut berat. Kekuatan mampatan, ketumpatan kering, penyerapan air dan kandungan lembapan telah dikaji di bawah penyiasatan eksperimen. Selepas beberapa ujian dijalankan, konkrit dengan agregat kaca halus telah ditentukan sebagai konkrit terbaik, dengan 21.19% terikan, 6.32% penyerapan air, 1.72% ketumpatan, dan 4.1% kandungan lembapan. Menggunakan sisa habuk kaca dalam konkrit adalah kemungkinan yang menarik untuk tapak pelupusan sisa dan pemuliharaan sumber semula jadi.

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LIST OF SYMBOLS AND ABBREVIATIONS

WG	-	Waste glass
CaMg(CO3)2	-	Dolomite
CaCO3	-	Calcium carbonate limestone
MSW	-	Municipal Solid Waste
CO2	-	Carbon Dioxide
CaO	-	Calcium oxide
RCC	-	Reinforced Cement Concrete
SCC	-	Self-Compacting Concrete
RGA	-	Recycled Glass Aggregate
ASR	-	Alkali-silica reaction
GA	-	Glass Aggregate
GG	-	Ground Glass
W0	-	Weight of the dry sample
W1	-	Weight of the saturated sample in water
w^b	-	Weight of sample before ventilated in furnace
w^a	-	Weight of sample after ventilated in furnace
ASTM	-	American Society for Testing and Materials

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CHAPTER 1

INTRODUCTION

1.1 Background

Every country, including Malaysia, makes extensive use of glass. Glass containers in the form of bottles and jars for beverages, window panes and other commodity goods from used glass has been reused as a construction material due to its chemical compositions and physical qualities. Glass is made by vanishing a mixture of silica, specifically silicon oxide, dolomite (CaMg(CO3)2), sodium carbonate, and limestone (CaCO3) at high temperatures up to 1600 degrees Celsius. To prevent crystallization and solidification, the mixture was chilled. Glass is an amorphous solid material because of its nonliquid and nonsolid state. Glasses are colored and have specific properties thanks to special additives.

Glass is the least recycled material in several nations, according to Poutos et al. (2008). Meanwhile, only around 3% of glass is recycled out of total production each year, with the remainder going to the landfill according to Malaysian Standard Waste Management figures. This is the last disposal technique for glass products that have zero recycling value and are not used to manufacture new materials by industries. The massive volume of glass garbage should be disposed of properly, to avoid significant pollution problems.

In order to reduce environmental consequences and disposal costs, many studies have been undertaken to include waste into concrete. These items take up a significant amount of landfill area, producing considerable environmental damage (air, water and soil pollutions)

due to the nonbiodegradable nature of glass. In addition, the shortage of room for new landfills is a concern in many countries' densely populated cities. Reusing this glass waste is the best method for reducing their environmental impact. The current affair of dumping it to landfills failed to provide for an environmentally beneficial glass waste management due to the nonbiodegradable nature of waste glass. On the other hand, the pozzolanic properties and chemical composition of waste glass, imply that it could be used in cement and concrete.

1.2 Problem Statement

Glass is rapidly becoming an impurities in single-stream recycling systems. Other recyclables, such as cardboard and paper, might be spoiled by broken glass, reducing their value. Glasses that broken is dangerous for employees, but it can also cause damage to recycling machines. As a result, glass processing costs are rising. Most manufacturers needs recyclable glass to be separated by color, leading to produce high-quality glass bottles and jars. When glass is fractured, it is hard to sort, and if it is broken down too finely, it can be difficult to reprocess. They send it all to the trash when recycling companies realizes it too expensive or difficult to separate glass from the rest of the stream . "More than 28 billion glass bottles and jars wind up in landfills every year," cited from Recycle Across America, "equal to filling up two Empire State Buildings every three weeks." For these reasons, study on the physical and mechanical properties of glass waste mixture in concrete is needed to substitute waste glass as a fine aggregate in concrete. The main reason of this study is to probe the features of concrete accomodate with crushed glass and to obtain the suitable ratio of crushed glass which improves the properties of concrete.

1.3 Research Objective

The main aim of this research is to construct a concrete by a recycled a glass waste. Specifically, the objectives are as follows:

a) To produce samples of glass waste mixtures in concrete with different composition.

b) To explain the effect of the influence of glass waste mixture in concrete based on the composition of glass waste mixture and preparation method in physical and mechanical properties in terms of compressive strength, water absorption, density and moisture content.

1.4 Scope of Research

The scope of this research are as follows:

- Preparation of glass waste mixture samples in concrete with various compositions of 0%, 5%, 10%, 20%, 30%, 40%, and 50% by using mixing methods.
- Samples of glass waste mixture in the concrete that has been produced will be tested for mechanical and physical properties such compressive strength as well as water absorption capacity, density profile and moisture content.
- Samples of glass mixes in the concrete that have been produced will be compared with reference mix in terms of mechanical and physical properties.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The single-use nature of usages glass such as window pane, which is one of its original uses, is a major issue. In 2016, rejected glass was predicted to make up 5% of global municipal solid trash, with recycling rates ranging across regions and internationally (Harrison et al., 2020). Glass waste is nonbiodegradable, filling up valuable landfill space endlessly.

The number of waste glass has risen in recent years, due to an ever-increasing use of glass items. The majority of used glasses was disposed of in landfills. Glasses waste should not be thrown away because they are non-biodegradable, making them less environmental friendly. The transfer of glass debris to landfills enlarge reliance on natural base resources, depleting sources such as beaches in order to make additional glass items (Harrison et al., 2020) due to poor recycling processes. Landfill taxes are likely to rise to encourage greater recycling behaviors, as the request for increasing landfill space. Exploring new method to reuse discarded glass can reduce disposal costs while also extending the life of landfills and natural resources. Glass is an exceptional recycling material. The usage of recycled glass in brand new containers reduces energy consumption. It is beneficial in the production of ceramics and bricks. It saves raw materials and energy in the manufacturing process, usage, as well as the amount of trash disposed of in landfills.

When waste glasses are utilized in the production of concrete goods, the price of concrete production will be reduced. Glass concrete-based products are split into two types

which are value-added and commodity. To recycle as many waste glass as possible are the basic goal for simple commodity products. This study aimed to determine the best composition of glass dust waste for use as a fine aggregate replacement material in concrete, as well as to investigate the concrete's compressive strength.

2.2 Glass Recycling

Containers, and all other uses, according to Kirk Othmer, Glass Recycling (2005). While glass container makers could theoretically employ all of the colour-sorted cullet gathered to produce new containers, there are considerable obstacles for many communities: Transportation costs, the difficulty of commercial mixed colours, and, others currently, having them processed using electromechanical glass sorting equipment are all factors to consider. Cullet is post-consumer, commercial glass that has been used and recovered, as well as off-specification glass that can be remelted.

The glass recycling rate of 22 percent shows the containers percentage that are actually recycled into commercial items by manufacturers, not merely the volume composed (Title of Reseach Report: Design and Develop New Glass Bottle Recycling System in Kuantan Community Universiti Malaysia Pahang, 2012). This figure is referred on the overall number of bottles and jars sold, not simply a particular portion of the container market. Recycled glass, known as cullet, is utilized in secondary markets such as glasphalt and fibreglass, which is paving asphalt that uses crushed cullet as a grog element instead of aggregated stone. When there were enough commercial glass to explain the establishment of a processing configuration, it can be recycled. There are numerous classification and separation concerns to be resolved. (Title of Reseach Report: Design and Develop New Glass Bottle Recycling System in Kuantan Community Universiti Malaysia Pahang, 2012).

Window, vehicle glass and glass containers, electronic glasses, such as, fluorescent tubes and light bulbs, and TV tubes; fibreglass, including textile types and insulating wool; and home cookware all have chemical variances. Only post-consumer containers and flat glass are often recycled commercially. Glass container recycling accounted for a large share of previous cullet recycling.

Other industries are increasing their usage of post-consumer cullet, such as insulating fibre glass. 12.6 million tonnes of glass containers (41 billion containers) are produced each year in the United States of America.Moreover, the United States imports an assessed 800,000 tonnes of glass containers every year (Title of Reseach Report: Design and Develop New Glass Bottle Recycling System in Kuantan Community Universiti Malaysia Pahang, 2012). Glass containers are usually the first runner up donator to recycling programmes in terms of weight, trailing only newspapers. In 2003, 8,875 curbside municipal solid waste [MSW] recycling programmes were available, down from 9,700 in 2001 (Title of Reseach Report: Design and Develop New Glass Bottle Recycling System in Kuantan Community Universiti Malaysia Pahang, 2012). One of the four main elements of container glass is cullet. Using cullet for non-manufacturing purposes saves landfill area for non-recyclable materials disposal.

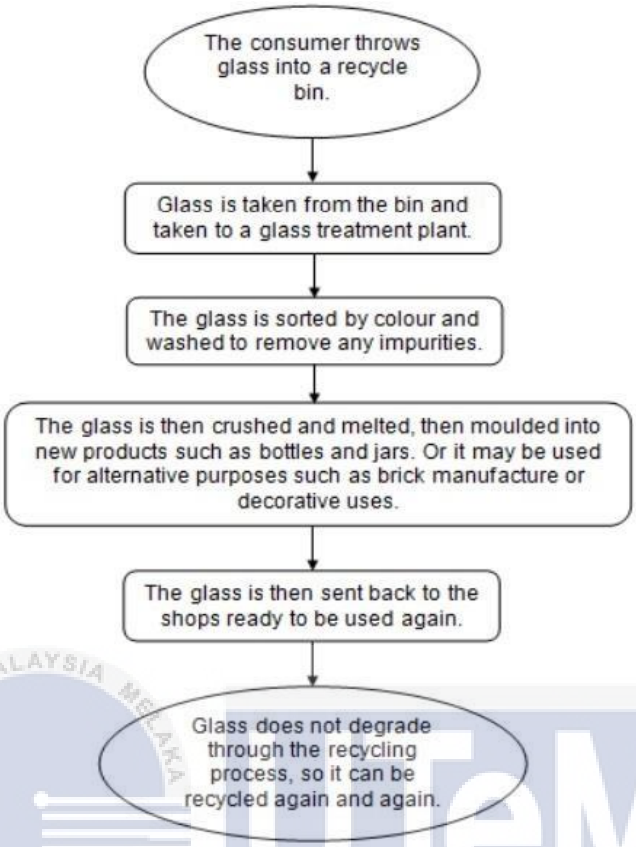

Figure 2.1 Process Involve in Bottle Glass Recycling

(Title of Reseach Report: Design and Develop New Glass Bottle Recycling System in Kuantan Community Universiti Malaysia Pahang, 2012)

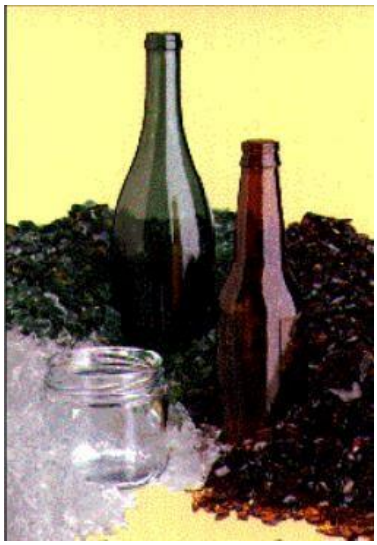

Figure 2.2 Glass Cullet Based on Color

(Title of Reseach Report: Design and Develop New Glass Bottle Recycling System in Kuantan Community Universiti Malaysia Pahang, 2012)

2.3 Benefits of Glass Recycling

Glass recycling counts (2008) found that glass recycling has numerous benefits, including emissions and less pollution, lower energy use, and more manageable raw resources, all of which benefit everyone. Glass recycling reduces CO2 discharges, the primary greenhouse gas linked to global warming, by 56%. Every year, glass recycling helps the environment by saving hundreds of thousands of tonnes of main raw materials.

This conserves the environment by conserving resources and reducing the need for quarrying. Glass recycling also saves the environment by extending the life of our gradually rare waste sites and conserving the British countryside. Glass recycling reduces waste disposal expenses; glass makes up around 8% of the residential garbage collected by local governments. Nearly 1.4 million tonnes of glass were composed in 2003, at a cost of £35 per tonne, and shipped to landfill at a cost of £30 per tonne, for a total cost of over £93 million (Title of Reseach Report: Design and Develop New Glass Bottle Recycling System in