



**A STUDY ON THE IMPACT OF GLASS WASTE
ON PROPERTIES OF CONCRETE**

BY

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requirement for the degree of Master of Science
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ABSTRACT

According to the Global Environment Centre (GEC), solid waste is one of the three major environmental problems in Malaysia, where, over 23,000 tons of waste produced per day in Malaysia. The problem is predicted to become worse as this amount is expected to rise to 30,000 tons by the year 2020. Thus, 'recycling' is the best way to reduce the amount of waste and reduce the problem of shortage of landfill area, and promote environmental sustainability. The laboratory experiment was conducted to study the properties of concrete (workability and compressive strength) by using recycle clear container glass as fine aggregates. The mix ratio was designed as 1:2:4. A proportion of fine aggregate was replaced by glass waste with particle sizes range of 50 μ m – 4.75mm and 2.38FM a ratio of 20%, 40% and 60%. The samples were investigated in terms of strength and workability. The characteristics and physical properties of glass waste are also studied. The result of the experiment from the research suggested that glass waste aggregate has the potential to be used as fine aggregate in concrete applications. However, in order to market "glass waste concrete", further research has to be carried out in terms of others concrete properties, chemical reaction, design and service life.

خلاصة البحث

وفقا لمركز البيئة العالمي (التغيرات البيئية العالمية) ، النفايات الصلبة هي واحدة من ثلاث مشاكل بيئية رئيسية في ماليزيا ، حيث تنتج ماليزيا أكثر من 23000 طن من النفايات يوميا. ومن المتوقع ان تصبح المشكلة أسوأ اذ انه من المتوقع ان يصل هذا المقدار إلى 30000 طن بحلول عام 2020. وبالتالي ، إعادة التصنيع هي أفضل وسيلة للحد من كمية النفايات والحد من مشكلة النقص في منطقة طمر النفايات ، وتعزيز الاستدامة البيئية. وقد أجريت تجربة في المختبر لدراسة خصائص الخرسانة (قابلية العمل وقوة الضغط) باستخدام نفايات الحاويات الزجاجية الشفافة لركام ناعم. وقد صممت نسبة المزيج 01:02:04. تم استبدال نسبة من الركام الناعم بنفايات الزجاج بأحجام جسيمات قياس 50 μm -- 4.75mm و FM2.38 بنسبة 20 % ، 40 % و 60 % . وقد تم فحص العينات من حيث قابلية العمل والقوة. ودرست أيضا الخصائص الفيزيائية لنفايات الزجاج. واقترح نتيجة لهذه التجربة ان نفايات الزجاج لديه القدرة على أن تستخدم كالركام الناعم في الخرسانة. ومع ذلك ، من أجل تسويق " خرسانة نفايات الزجاج " ، يجب إجراء مزيد من البحوث عن الخرسانة من حيث الخصائص ، والتفاعل الكيميائي ، والتصميم ومدة الخدمة.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science Building Services Engineering.

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Atikah Binti Razali

Signature.....

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made with FWG, CWG and FCWG

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LIST OF ABBREVIATIONS

AR	: Atikah Razali
ASR	: Alkali-Silica Reaction
ASTM	: American Society for Testing and Materials
BF	: Biodegradable Fraction
BS	: British Standard
BS EN	: British European Standard
CEM	: Cement
C&D	: Construction and Demolition
CIDB	: Construction Industry Development Board
CWG	: Coarse Waste Glass
EPA	: Environment Protection Agency
FCWG	: Fine and Coarse Waste Glass
FWG	: Fine Waste Glass
GDP	: Gross Domestic Product
GEC	: Global Environment Centre
GWA	: Glass Waste Aggregate
GWC	: Glass Waste Concrete
JKR	: Jabatan Kerja Raya
KAED	: Kulliyah of Architecture and Environmental Design
LCD	: Liquid Crystal Display
LCDGC	: Liquid Crystal Display Glass Concrete
MHLG	: Ministry of Housing and Local Government
MS	: Malaysian Standard

MSW	: Municipal Solid Waste
NA	: Not Available
OPC	: Ordinary Portland Cement
TCLP	: Toxicity Characteristics Leaching Procedure
VS	: Volatile Solid
W/C	: Water-cement ratio

CHAPTER ONE

INTRODUCTION

1.1 RESEARCH BACKGROUND

Concrete is a composite construction material, composed of cement, aggregates (coarse and fine) and admixtures. It is the major material used in the construction industry because of its versatility in applications. There are many applications and uses of concrete in the construction industry such as for buildings, dams, pavements, roads, bridges, ornamentals, etc. However, the growing concern of the performance of existing concrete applications, resource depletion and environmental sustainability has challenged the construction teams to seek and develop alternative materials in building construction and these include the use of waste materials.

In Malaysia, many researches have been carried out pertaining to the use of waste materials into the concrete mixes. Most of the researches used waste materials from the industrial processes such as Palm Oil Fuel Ash (POFA) (Budiea et al., 2010), Fly Ash (Mohd Mustafa Al Bakri et al., 2011) and Rice Husk Ash (RHA) (Kartini, 2008) into concrete mixes. These researches were done on cementitious materials, i.e., to replace certain percentage of cement with the alternative materials. However, there is one research that has been carried out on the use of construction waste which is recycled aggregates (Yong and Teo, 2009; Anuar, Ridzuan and Ismail, 2001) into concrete mixes. In addition to being inspired by the circumstances to provide alternative materials to the construction industry as well as to sustain the environment, the researches also enhanced the properties of concrete.

Overseas, the use of waste materials in the construction industry has started since 1980 (Gut and Nixon, 1980). The waste materials used are pulverized fuel ash from coal burning power station and blastfurnace slags from ironmaking. Waste materials that are characterised as recyclable materials are plastic, metal, glass, paper, wood, rubber etc. Among these identified waste materials, the use of glass waste aggregates into concrete mixes in the construction industry was studied by few researchers. The researches were done on different types of glass waste such as discarded liquid crystal display (LCD) (Wang, 2009), multi-coloured container / bottle glass waste (Turgut and Yahlizade, 2009; Ahmad Shayan, 2002; Jasem M. Alhumoud, Nayef Z. Al Mutairi and Muhamad J. Terro, 2008; Meyer, Egosi and Andela, 2001), and glass ceramic (Yoon and Yun, 2005). However, such research has never been carried out in Malaysia. Therefore, the study of the glass waste as an alternative material in the construction industry is considered as a new research area in Malaysia.

Most of the glass waste in Malaysia is generated from the municipality and the majority is clear/flint container/bottle glass waste. Thus, this experimental research aims to develop the use of municipal glass waste as potential alternative aggregates into concrete mixes. This research does not only aspire at limiting the use of natural raw material, but also increases the interest in the use of alternative materials, or waste, coming from various activities, which, in this way, can gain a non-negligible economic, energetic and environmental value (Limbachiya and Roberts, 2004).

1.2 PROBLEM STATEMENT

This research is inspired by concrete issues regarding its performance as the universal construction material, limiting the raw materials to avoid shortage of resources and express concern on the environmental sustainability. The common issue of concrete is the concrete defects. The defects affect the performance of concrete in terms of strength, which may shorten the service life of concrete. Similar to human nature that is weaker with ageing, concrete will deteriorate and malfunction in a stipulated time. Therefore, to prolong the service life of concrete, concrete has to be maintained in the aspects of functions, surfaces, permeability and loads. There are many concrete material problems that have been discovered that may reduce the service life of concrete such as cracking, sulphate attack, fatigue, fissures, drying shrinkage, creep, brittle and spalling (Mindess, Young and Darwin 2003; Day, 1999; Dobrowolski, 1998; Levitt, 1997). Therefore, the findings of this research may enhance the performance of conventional concrete (properties) and provide alternative explanations to the current problems of the existing concrete in Malaysia.

In year 2005, the issue of sand shortage has caused the delay in construction projects (Nick Leong, 2005). Sand or natural fine aggregate is one of the ingredients in the concrete mix. The shortage of sand has caused impact on the production of the concrete to be reduced and it has resulted delay in construction. This is because most of the applications in buildings and infrastructures were used concrete. Instead of sand shortage, this research is also influenced by previous overseas researches done by Wang (2009), Turgut and Yahlizade (2009), Ahmad Shayan (2002), Jasem M. Alhumoud, Nayef Z. Al Mutairi and Muhamad J. Terro (2008), Meyer, Egosi and Andela (2001), and Yoon and Yun (2005). These researches used glass waste as an alternative material to replace sand in the concrete mixes and it can be applied to

concrete in Malaysia. Thus, this research may introduce new alternative materials that are beneficial to solve the lack of raw materials supply, avoid projects delay, as well as to improve the concrete properties.

Besides that, the researcher believes that this research also supports the incentive of waste reduction, recycling program, reducing the loads of landfills, protects human health and promotes environmental sustainability. Furthermore, this research is in line with the Ninth Malaysian Plan which is targeting to achieve 22% recycling rates in year 2020. By recycling glass wastes as an alternative material to be used in the construction industry, it reduces the amount of waste to be dumped at the landfill area. Glass waste is also chosen due to the lowest rates of recycling compared to others recycling items (Fischer, 2008). Moreover, glass waste is a hazardous material because broken glass is sharp and improper management of glass waste is hazardous to human. Uncollected glass waste also blocks drains, causes floods, creates insanitary conditions, and is an aesthetic nuisance. Therefore, the use of glass waste will reduce the amount of wastes as well as the impacts toward environmental sustainability and human health and enhances the comfortability and living standards of Malaysia citizens.

1.3 RESEARCH QUESTIONS

In order to achieve the aim and objectives of the study, there are three research questions developed. The research questions are:

- i. What are the characteristics and physical properties of glass waste aggregates?
- ii. How do glass waste aggregates perform in the concrete mix in terms of strength and workability?

- iii. Are glass waste concrete properties better as compared to conventional concrete properties?

1.4 AIMS AND OBJECTIVES OF THE STUDY

The aim of the research is to evaluate the possibility of using recycle glass waste into concrete mixes as alternative material to the construction industry and to promote recycling of waste materials.

To achieve the aim of this study, three main objectives are formulated. The objectives are:

- i. To identify and study the characteristics and properties of glass waste
- ii. To investigate the properties of glass concrete; workability and strength
- iii. To analyse and compare the strength of the glass waste concrete with conventional concrete

1.5 SCOPE AND LIMITATIONS OF THE STUDY

The scope of the study is to analyse the strength and workability of *glass waste concrete* compared to conventional concrete. *Glass waste concrete* is a concrete mix composed of cement, sand, glass waste aggregate and coarse aggregate. The designed mix is regulated and the procedures of conducting the experiment are in accordance with Malaysian Standard (MS). The concrete mix design is 1:2:4 and the cement water ratio is 0.55. No super plasticizers are used. The waste material used as aggregate is glass waste and the type is clear/flint containers only.

This experimental research is for concrete samples with the cube size of 150mm x 150mm x 150mm only. The experiment is designed to replace sand (natural fine aggregate) with glass waste aggregate. The fine material portion is replaced with