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THE PERFORMANCE USE WASTE GLASS IN CONCRETE TILE

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ABSTRACT

Most of glass bottles are not recycled and it's have dumped at landfill. This can cause problem to the environment. The recycling of waste glass as a source of aggregate for the production of concrete product such a tile has attracted the construction industry due its mechanical characteristics and interesting colour. From this consideration, concrete tiles with recycled glass are produced and evaluated through compressive strength and water absorption test. In this study, crushed glass has been mixed with non-resin mineral namely silica sand and white cement by replaced it with sand by 65%, 70% and 85% of glass waste. Mortar cubes with dimension 50 mm x 50 mm x 50 mm were prepared in laboratory in order to evaluate the properties of hardened concrete at difference ages which has been specific at 7, 28, and 90 days age of curing. All the cement mortar mixtures were used water – cement ratio of 0.50. The test results have shown gradual reduction in compressive strength when the content of waste glass is increased. Concrete tile made with 65% aggregate replacement with fine waste glass has better strength and lower water absorption compare other mixes. The study indicates concrete tile containing waste glass can be developed and it has fullfill the minimum requirement of construction material. As conclusion, glass bottles waste can be used as a new raw material in high concrete tiles grade and it can reduce the consumption of landfill cost which is good the environment.

ABSTRAK

Kebanyakan botol kaca tidak dikitar semula dan telah dibuang di tapak pelupusan. Ini boleh menyebabkan masalah kepada alam sekitar. Kitar semula kaca buangan sebagai sumber agregat bagi pengeluaran produk konkrit seperti jubin telah menarik industri pembinaan disebabkan oleh ciri-ciri mekanikal dan warna yang menarik. Dari pertimbangan ini, jubin konkrit dengan kaca yang dikitar semula dihasilkan dan dinilai melalui kekuatan mampatan dan ujian penyerapan air. Dalam kajian ini, kaca telah dihancur dicampur dengan galian bukan resin seperti pasir silika dan simen putih dengan digantikan dengan pasir dengan nisbah 65%, 70% dan 85% sisa kaca. Kiub mortar dengan dimensi 50 mm x 50 mm x 50 mm telah disediakan di dalam makmal untuk menilai kekuatan konkrit pada usia yang berbeza iaitu pada 7, 28, dan 90 hari umur pengawetan. Semua campuran mortar simen telah menggunakan nisbah air simen sebanyak 0.50. Keputusan ujian telah menunjukkan pengurangan secara beransur-ansur dalam kekuatan mampatan apabila kandungan kaca sisa bertambah. Jubin konkrit dibuat dengan 65% penggantian agregat dengan kaca sisa halus mempunyai kekuatan yang lebih baik dan penyerapan air yang lebih rendah berbanding campuran lain. Kajian ini menunjukkan jubin konkrit yang mengandungi kaca buangan boleh dibangunkan dan ia mempunyai keperluan minimum bahan pembinaan. Kesimpulannya, kaca botol boleh digunakan sebagai bahan mentah baru dalam jubin konkrit dengan gred yang bagus dan seterusnya boleh mengurangkan kawasan pelupusan sampah.

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A	Surface area in contact with the platens (mm^2)
Md	Mass weighed after oven 24 hour (dry)
Mw	Mass weighed after immersing (wet)
P	Ultimate compressive load of cube mortar (kN)

LIST OF ABBREVIATIONS

AM	Architectural mortar
ASR	Alkali silica reaction
ASTM	American Society for Testing and Materials
BS	British Standard Institution
CTMA	Concrete Tile Manufacturers Association
FWG	Fine waste glass
MPK	Majlis Perbandaran Kuantan
RG	Recycle glass
RWG	Recycle waste glass
SP	Super plasticizer
WB	Water to- binder
WC	White Cement
WG	Waste glass

CHAPTER 1

INTRODUCTION

1.1 GENERAL

In developing countries such as Malaysia, where the projects for industrialization of conjunction with rapid urbanization are vigorously embarked upon to improve the standard of living. The major problem is environmental pollution by the increasing generation of domestic and industrial waste. Disposal of wastes has become a major problem in metropolitan areas in Malaysia especially the disposal of waste glass. The collection and disposal of waste glass are a significant problem in Malaysia and although large quantities are collected in bottle banks throughout the country, much is deposited in landfill. The quantities of waste glass have been increasing significantly without being recycled increased the risk to public health due to the scarcity of land area (Park et al., 2004).

Most of waste glass bottles are not being recycled but rather abandoned, so this may occurred of that serious problem such as the waste of natural resources and environmental pollution. When such mineral admixtures come from industrial by products, it's reuse contributes to reduce CO_2 and other greenhouse gas emissions due to production and also contributing to the reduction of the potential environmental impacts caused by landfill deposit. In additionally, the mechanical and durability related properties of cement mortar and concrete can be enhanced by incorporation of mineral admixture. Nowadays, the civil construction industry is searching for an alternative to satisfy the increasing needs for cement and concrete production. The uses of recycled glass are currently limited and the development of new uses, like the one developed by concrete tiles, provides another effective route for sizeable quantities of waste glass of

any colour to be recycled. However, only negligible proportions of the total used bottles are actually currently being recycled. Glass in general is a highly transparent material formed by melting a mixture of materials such as silica, soda ash, and $CaCO_3$ at high temperatures followed by cooling during which solidification occurs without crystallization.

Tiles are often used for coverings floor and wall, showers and other objects such as a tabletop or countertop. It is a simple design like a square tiles to complex mosaic. Concrete tiles are increasing day by day and are becoming interested in developing lucrative tiles with high strength for household uses as well as for decorating purposes. Concrete tiles have various characteristics and it can be used in many different places because of surface hardness. But in this research, concrete tiles have used with new materials such as recycled mix glass, white Portland cement, silica sand and some mix with water have been produced. As demand for green buildings, concrete tiles manufacturers have stepped up to the plate to supply builders with new product. Therefore, it has sought to evaluate the recycle ability of domestic waste glass as a fine aggregate for concrete and other secondary processed construction materials.

1.2 PROBLEM STATEMENT

Quantities of waste glass have been on the rise in recent years due to an increase in industrialization and the rapid improvement in the standard of living. Unfortunately, the majority of waste glass bottles is not being recycled but rather abandoned, therefore for cause of certain serious problems such as the waste of natural resources and environmental pollution (Zainab and Enas, 2009)

For these reasons, this study has been conducted with mechanical properties to analyze the possibilities of recycling waste glasses as fine aggregate for concrete tiles to slab installation. Using recycled glass as an alternative to natural aggregates can make a significant contribution to reducing businesses operating costs as well as reducing environmental impacts, so concrete tiles produced by the waste glass can be demand for market.

1.3 RESEARCH OBJECTIVES

This research is conducted to accomplish some predefined objectives. The main objectives of this research are:

i. To investigate the effect of waste glass in concrete tiletowardsit's compressive strength.
ii. To investigate the effect of waste glass in concrete tile towards it's water absorption.
iii. To determine the suitability of waste glass in concrete tile for glaze surface.

1.4 SCOPE OF WORK

Basic of testing characteristics such as compressive strength, glazed surface and water absorption are the main focuses in this research. Strength is one of the most important in produced to make a concrete tile. In this research use glass aggregate as a silica sand replacement have been produced by following percentages in the mortars. The mix materials of concrete tiles such as crushed mixed colour glass bottles, white Portland cement and silica sand.

This research focussed on waste material like as glass, mainly on green building material. So to produce these researches have been conducted using mechanical properties in the laboratory. All the strength tests are limited to the ages of 7, 28, and 90 days after production of the specimens. Besides that, the physical and chemical properties of the waste material are also studied in this research. By the way, this product testing with comes three mix proportions by following of 65%, 70% and 85% by replacing silica sand.

1.5 SIGNIFICANT OF STUDY

The unique properties of waste glass in concrete make this research is very popular nowadays. This proves that this research is a very important and has the

potential for future needs such as in this project to produce concrete tile use waste glass bottles.

A Glass bottle is a material that is easy to get. There a many glass wastes that can be used in concrete. The use of glass bottle waste in concrete not only makes it economical, but also helps in reducing disposal problem. One such waste is glass, which could be used in various applications such as flooring, countertop, tile, and ground cover, tabletop and others. The development of new construction materials using recycled glass is important to both the construction and the glass recycling industries.

It is very important for to keep continuing this research because our country is having so much source of glass waste. This research can give benefits not only in the construction industry, but also other industry that related. However, focusing with green building material, this research makes waste glass can apply as new raw materials. The characteristic of compressive strength, glazed and water absorption for tile have been produced as required. With the outcome of this study, determined the concrete tiles have been produced better properties of tile that capable to be market demand for green building materials to rise.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Concrete tile is more popular in anywhere, because concrete tiles have a unique rustic look. Concrete tile is a natural material that with varied over time and from piece to piece. Concrete tile can be used about anywhere like as indoors or out, floors, walls, shower enclosures, countertops, and building facades. Concrete tile is made of Portland cement, sand and water in varying proportions. The material is mixed and extruded on molds under high pressure. The exposed surface of the tile may be finished with cementation material colored with synthetic oxide additives.

Concrete tiles are also referred to as cementations tiles and cement bodied tiles, which indicate they are manufactured from a mixture of cement and aggregate. Concrete is also a very versatile material that can create its own or duplicate any texture, shape, colour and size of other natural or man-made materials. Their surfaces can be left natural, polished like stone, coloured and textured like tiles. Available sizes run through the spectrum from panelized 4″ x 4″ units up to 30″ x 30″ units. Concrete tile does not need to be fired like ceramic tile does. The tile is cured via extending the hydration period to react the required strength. The use of additives and covering the tile during with plastic holds the moisture in and aids in the hydration process.

2.1.1 Materials Used in Concrete Tiles

The materials and product performance of concrete tiles have been shown in table below. All of this summary from the handbook concrete tile manufacturers association.

Table 2.1: Material Used in Concrete Tiles

Materials	Specifications	Standards
Cement	Portland Cement	ASTM C150
	Blended Cement	ASTM C595
Aggregates	Concrete Aggregate	ASTM C33
	Lightweight Aggregate for Structural Concrete	ASTM C330
Admixture	Chemical Admixture for Concrete	ASTM C494
	Chemical Admixture for Use in Producing Flowing Concrete	ASTM C1017
	Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete	ASTM C618
	Pigments for Integrally Colored Concrete	ASTM C979
	Fiber-Reinforced Concrete and Shotcrete	ASTM C1116
	Silica Fume for Use as a Mineral Admixture in Hydraulic-Cement Concrete Mortar and Grout	ASTM C1240
Sealers	Liquid Membrane-Forming Compounds having Special Properties for Curing and Sealing Concrete	ASTM C 1315

Source: CTMA handbook (1998)

Table 2.2: Product Performance

Properties	Result	Standard
Compression Strength	4000 psi	ASTM C-39
Absorption	12%	ASTM C-67
Moisture Content	7%	ASTM C-67
Density	140 lbs cubic/ft	ASTM C-642
Length Change (+/-)	0.1% max	ASTM C-157
Bond Strength (shear)	50 psi	ASTM C-482
Abrasion Resistance	20 wear index	ASTM C-1353

Source: CTMA handbook (1998)

2.1.2 Types of Installation Concrete Tiles

Concrete flooring has many types which give a decorative look and costs less. For installing different types of concrete flooring which are as follows:

2.1.2.1 Polished

Concrete floors can be tarnished to a gleaming shine which will give a waxed look. Heavy machines grind down on concrete floor gives a smooth and shiny surface. Almost all the concrete floors can be polished except older, flawed or porous floors.

2.1.2.2 Sealed

Concrete flooring can be protected from stains, abrasion and water by applying a concrete sealer over them. These seals have been coming in coloured seals to make your flooring coloured and more vibrant. A sealed concrete surface will become slip resistant and makes a floor easy to clean.

2.1.2.3 Scored

Circular saws make shallow cuts in existing concrete which makes the design look like tile grouts or creating geometric designs and patterns.

2.1.2.4 Stampede

The fresh concrete floor is stampeded with a pattern which gives the floor textured appearance of materials like brick, stone, slate, tile, wood planks or other types of flooring.

2.1.3 Classes of Tile

Types of tile should be used in different areas, and tile comes with different rating. Five classes exist that rate the scratch resistance and durability of the tile. The table 2.3 below has showed the types of class tiles.

Table 2.3: Types of Class Tiles

Classes	Specification
1	Areas that have no foot traffic.
2	Light traffic areas.
3	Ideal for bathroom walls and kitchens, floors and most other residential applications.
4	Ceramic tile is used in areas with moderate to heavy traffic such as offices, shopping malls, showrooms and restaurants.
5	Heavy to extra-heavy traffic areas like airports, subways, supermarkets and other commercial and industrial buildings.

2.2 WASTE GLASS

In general, glass consists of 70% or above silica (SiO_2) and a small percentage of soda ash (Na_2CO_3) or potash (K_2CO_3) and lime (CaO). The occurrence and supplies of all these components are abundant, widespread and cheap throughout the world. Glass is chemically inert. It does take up some space when buried in landfills but remains stable and will not release any toxic substance into the environment.

The current waste management practice is still to landfill deposit most of the non-recyclable glass. Since glass is not biodegradable, deposit in landfills does not provide an environment-friendly solution. At the same time, in Portugal, the available pozzolanic materials for cement and concrete production will soon be insufficient to supply all the demands of the construction industry. In Portugal, disposed used glass bottles are only partially reutilized as new products. They are collected, sorted, and crushed to be used mostly as a raw material for new bottles. However it is estimated, that only 30% of the total disposed used bottles are actually currently being recycled (Sousa, 1995).

Theoretically that glass is a fully recyclable material. It can be recycled without any loss of quality. There are many examples of good recycling of waste glass, as a cullet in glass production, as a pozzolanic additive, as a raw material for the production of abrasives to produce fiberglass and others. Waste glass can also be produced from empty glass such as bottles and pots, and in come in several distinct colours containing common liquids and other substances. In its original form, glass comes as a balanced combination of the three main raw natural materials, like as sand, silica, and limestone (Shi and Zheng, 2007).

Waste glass cannot be used as aggregate without taking into account its alkali silica reaction (ASR) properties. As for cost analysis, it was determined as to lower the cost of concrete productions (Abdullah, 2007). Glass is one of the oldest man-made materials. Glass need to be reused or recycle to avoid the problems of environmental can be created, if will be sent to landfill. Theoretically, glass is a 100% recyclable material, so it can be recycled without changing its chemical properties (Sobolev et al.,

2006). Glass which is mostly considered for recycling in terms of environmental protection. The glass will be utilized in this research project will derive from post-consumer container glass end of life vehicle glass and architectural glass. It is considered in the varying recycling process to be a material will be used as a binder and also as a aggregate replacement in concrete tile.

2.2.1 Types of Glass

Glass is an organic mixture with high temperature and cooled without crystallization. Glass comes with six basic types. The table below shows the thermal properties of commonly used glass by (Wahab and Tanjung, 2011).

Table 2.4: Thermal properties of commonly used glass

Categories of Glass	Thermal Expansion	Heat Resistance
Soda-lime-silica	High	Low
Lead-alkali-silica	High	Low
Fused silica	Low	High
95% silica	Low	High
Borosilicate (Pyrex)	Medium	Medium
Aluminosilicate	Medium	Medium

2.2.2 Properties of Glass

Glass in unique material that could be recycled many times without changing its chemical properties. It is important to be discussing of these products are similar to a given type of glass, and typical chemical compositions of the various coloured glass have presented in Table 2.5.

Table 2.5: Chemical composition of various colored glas

Composition	Clear glass	Brown glass	Green glass
SiO_2	72.42	72.21	72.38
Al_2O_3	1.44	1.37	1.49
TiO_2	0.035	0.041	0.04
Cr_2O_3	0.002	0.026	0.130
Fe_2O_3	0.07	0.26	0.29
CaO	11.50	11.57	11.26
MgO	0.32	0.46	0.54
Na_2O	13.64	13.75	13.52
K_2O	0.35	0.20	0.27
SO_3	0.21	0.10	0.07

2.3 ENVIRONMENT ISSUE PROBLEMS

Today, most people in Malaysia are becoming aware of the need to enhanced sustainability in the way we consume our resources. In recent years, the authorities as well as private organizations, community groups and individuals have carried out numerous initiatives to reduce the amount of waste produced or to ensure the materials are recycled after used. Majlis Perbandaran Kuantan (MPK) has realized the need to continuously improve recycling and waste minimization. One important waste which the MPK has decided about increase recycling uses glass. In most places in Malaysia, recycling of glass is very limited as recycling is hardly economically viable. Recycling of glass is very important not only to save resources but also because making new bottles and containers from recycled glass requires much less energy than making them from primary raw materials.

Glass constitutes a significant part of solid waste produced in the society. Glass is primarily used for bottles or other containers for storing consumables and for drinking glass or windows. Compared to many other types of waste, glass is unique because it can be 100% recycled. Yet, glass recycling in Malaysia is still in its infancy. Less than 30% of new bottles is made from recycled glass compared to 80% in Thailand and 60-70% in Europe. A vast majority of glass still ends up in landfills.

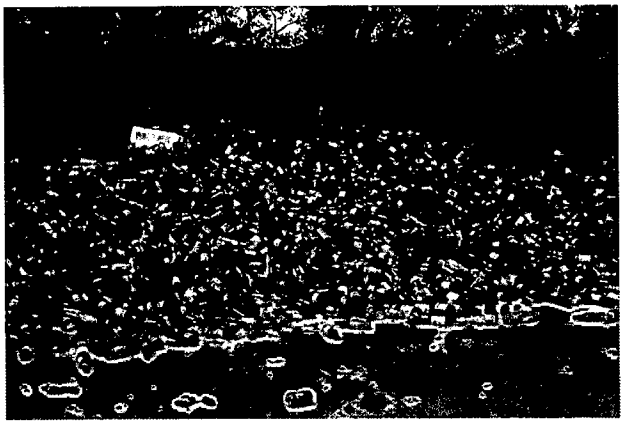

Figure 2.1: Waste glass bottles

Solid waste about 20 million tons, that is 7% made up of glass, and for Germany about 3 million tons of waste glass being recycled. Using waste glass in concrete is an environmentally friendly for nature to eliminate. The Glass is being used in daily life of humans and in many fields such as bottle glass, flat glass and others (Topcu and Canbaz, 2004). Waste glass is collected and stored, and prevent to be problematic for the environment, they are recycled and used In the construction industry, especially cement and concrete, has started to develop new usage of industrial wastes. So this way, help to reduce waste (Shayan and Xu, 2004).

2.4 MIX PROPORTION

2.4.1 Crushed Glass

The use of waste glass in a concrete mix is also studied to reduce landfill problem and to reduce greenhouse gas emission without negative impact on the economy. For this purpose effect of the use of fine waste glass as additive in concrete tile mix with recycled glass at ambient and elevated temperatures will be studied. Percentages of replacement from 65–86% of fine waste glass in concrete tile. Mechanical properties of concretes containing waste glass aggregate such as testing of compressive, tensile, and flexural strengths of concretes containing the waste glass aggregate that decreasing along with an increase in the mixing ratio of the waste glass aggregates (Park et al.,2004).

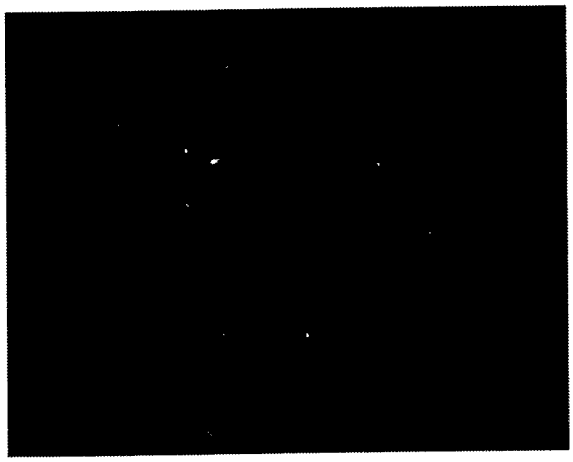

Figure 2.2: Recycled mixed color glass aggregate

The recycled waste glass (RWG) is an essential raw material due to its good resistance to abrasion, durability and also in consideration of its easy shaping into different forms. Glass is chemically inert and not biodegradable and so it will remain indefinitely in the environment. As recycling operations can reduce the demand for new raw material considerably (Petrella et al., 2007).

2.4.2 Water

Water is part of important in producing concrete. To get the quality of concrete, the amount of water must be limited depend the required for a job. Water in excessive for hydration acts between coarse and fine aggregates to produce concrete with workable and economical. Water is also used for curing and has containing impurities and leading to stains is objectionable. For the compressive strength with 7 day and 28 day for cube or cylinder specimens prepared impure water should not differ by 10 per cent with pure water (Duggal, 2003). Water should be clear and free from sulfates, acid, alkalis and humus. Potable water from wells usually acceptable (Wahab and Tanjung, 2011).