THE USE OF SCRAP TYRE AS FINE AND COARSE AGGREGATE IN CONCRETE

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This project report is dedicated to: My beloved parents Alhaji Adamu Musa and Halima Adamu Musa

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ABSTRACT

This study investigates the possibility of using scrap tire in concrete. Grade 30 concrete with slump between 30- 60 mm was made using DoE mix design. 0 %, 5%, 10% and 15% replacements of both the fine and coarse aggregates were replaced with tire particles of size 1-4 mm and 5-8 mm respectively. The properties of both the fresh and hardened concrete such as slump, compressive strength, splitting tensile strength, flexural strength, drying shrinkage, and water absorption of concrete were measured based on short-term investigation according to ASTM, BS, and BS EN standard in civil engineering laboratory. Laboratory results revealed that the workability of 5% and 10% replacement were higher than the control mix, while 15% replacement showed a significant decrease in workability. Also were decreases in compressive strength, splitting tensile strength and flexural strength, water absorption and drying shrinkage, as the percentage replacement increases. The compressive strength of 5% fine and coarse aggregate replacement was found to be approximately the same as the control mix of 30 MPa. However, drying shrinkage of 5% replacement at the later ages was found to be lower than the control mix.

Keyword: Scrap tire, flexural strength, splitting tensile strength, compressive strength, drying shrinkage and concrete.

ABSTRAK

Kajian ini menyiasat kemungkinan menggunakan tayar sekerap dalam konkrit. Konkrit Gred 30 dengan penurunan (slump) di antara 30 - 60 mm dibuat menggunakan campuran reka bentuk DOE. 0 %, 5 %, 10 % dan 15 % penggantian bagi kedua-dua agregat kasar dan halus telah digantikan dengan zarah tayar masing-masing saiz 1 - 4 mm dan 5 - 8 mm. Sifat konkrit basah dan keras seperti penurunan kemerosotan, kekuatan mampatan, kekuatan tegangan tak langsung kekuatan lenturan, pengecutan kering dan penyerapan air konkrit diukur berdasarkan penyiasatan jangka pendek mengikut standard ASTM, BS, dan BS EN dalam makmal kejuruteraan awam. Keputusan makmal menunjukan bahawa keboleh karjaan untuk 5% kebolehkerjaan dan 10% penggantian lebih tinggi daripada campuran kawalan, manakala 15% penggantian menunjukkan penurunan ketara dalam kebolehkerjaan. Terdapat pengurangan dalam kekuatan, mampatan, kekuatan tegangan tak langsung dan kekuatan lenturan, penyerapan air dan pengecutan kering, dengen kengikan peratusan penggantian. Kekuatan mampatan untuk 5% penggantian agregat kasar dan halus didapati lebih kurang sama seperti kekuatan reka bentuk 30 MPa, manakala pengecutan kering 5% penggantian pada usia kemudiannya didapati lebih rendah daripada campuran kawalan.

Kata kunci: Tayar sekerap, kekuatan lenturan tak langsung, kekuatan tegangan, kekuatan mampatan, pengecutan kering dan konkrit.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND SYMBOLS

AACP	Autoclaved Aerated Concrete Panel
ACI	American Concrete Institute
ASTM	American Standard of Measurement
BS	British Standard
BS N	British European Standard
CA	Coarse Aggregate
CR	Crumb rubber
CRC	Crumb rubber concrete
CTA	Concrete with Tire Aggregate
F	Fahrenheit
FA	Fine Aggregate
GR	Ground Rubber
HPC	High Performance Concrete
HPC	High Performance Concrete
HSC	High Strength Concrete
IS	International Standard
ISO	International Standard Organization
ISSN	International Standard Serial Number
K	Thermal Conductivity
MIN	Minutes
MPA	Mega Pascal
NA	Natural Aggregate
No	Number
NSC	Normal Strength concrete
^{o}C	Degree Celsius

PET	Polyethylene terephthalene
PRC	Plain rubberized concrete
PRC	Plain Rubberized Concrete
TA	Tire Aggregate
TR	Tire Rubber
W/C	Water/Cement
W/mk	Watts per metre Kelvin
Eqn	Equation
K	Kelvin
V	Volts

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Over the years, the need for continuous use of locally available building materials has increased. The cost of the conventional building materials keeps sky-rocketing, which at present time is beyond the reach of even the rich. This situation, coupled with the call by the concerned bodies to develop indigenous technology has necessitated the need to research into the engineering properties of locally available and recycled materials in order to find the probable ways of reducing the cost of building. This can be done by substituting or partially substituting the expensive materials with cheaper and more commonly available ones.

Concrete is a construction material composed of cement and other cementitious materials such as fly ash and slag cement aggregate (generally coarse aggregate made of gravels or crush rocks such as limestone or granite, plus a fine aggregate such as sand), Water and chemicals admixtures. Concrete solidifies and hardens after mixing with water and placement due to chemical process of hydration. The water react with the cement which bonds the other component together eventually creating a stone like material.

Due to the escalating environmental problems faced today almost everywhere around the world including countries like Malaysia which are fast growing in terms of industries, there is need for the proper recycling and utilization of waste materials and by-products, which if not properly dispose, recycled and reuse can cause a environmental pollution now and potential future environmental problems. Sometimes accumulation, burning and landfill of solid waste disposal could be expensive and undesirable. Recycling and reuse of such waste materials in different areas such as the construction industry can reduce the danger of such environmental problems, reduce the environmental effects and at the same time reduces the overall cost of construction and reduces the shortage of construction materials which are likely to be less available due to the rapid expansion of construction activities, housing and buildings.

A tyre is a composite of complex elastomer formulations, fibers and steel/fiber cord. Tyres are made of plies of reinforcing cords extending transversely from bead to bead, on top of which a belt is located below the thread. Over the years, disposal of tyres has become one of the serious problems in environments. Land filling is becoming unacceptable because of the rapid depletion of available sites for waste disposal. For example France, which produces over 10 million scrap-tyres per year, will have a dwindling supply of landfills starting from July 2002, due to a new law that forbids any new landfill in the country. Used tyres are required to be shredded before land filling. (Siddique & Naik, 2004). Siddique. & Naik. (2004) also reported that innovative solutions to meet the challenge of tyre disposal problem have long been in development. The promising options are: use of tyre rubber in asphaltic concrete mixtures; incineration of tyres for the production of steam and reuse of ground tyre rubber in a number of plastic and rubber products.

Waste tyres need a larger storage space than other waste due to their large volume and fixed shape. They are unlikely to be decomposed, as burying the waste tyres would shorten the service life of the burial ground and have low economic benefit. In addition, long-term buried waste tyres often emerge from the burial ground surface or destroy the anti-leakage cover of the burial ground, and the

exposed waste tyres accumulate water that may breed bacteria, molds, insects or mice. In the case of fire, waste tyres generate toxic gases, such as dioxin, that could result in severe pollution problems .Therefore, effectively recovering and reusing waste tyres is an urgent and important issue. Landfill disposal, which is the most common method, will be drastically reduced in the near future due to the recent introduction of European Union directives that include significant restrictions on this practice in favor of alternatives oriented toward material and energy recovery. Furthermore, the disposal of used tyres in landfills, stockpiles or illegal dumping grounds increases the risk of accidental fires with uncontrolled emissions of potentially harmful compounds. In order to properly dispose of these millions of tyres, the use of innovative techniques to recycle them is important. Rubber tyre can be used in a variety of civil and non-civil engineering applications such as in road construction. (Yung, et.al, 2013).

Modification of concrete properties by the addition of appropriate materials is a popular field of concrete research. The brittle nature of concrete and its low loading toughness compared to other materials, has prompted the use of waste particles as a concrete aggregate to possibly remedy or reduce these negative attributes. Elastic and deformable tyre-rubber particles could improve concrete properties (Khaloo, et.al, 2008).

Scrap tyre management and disposal is a major concern in developed countries and fast growing industrial countries like Malaysia, this is due to the high number of motor vehicles and high usage of these vehicles which results to the rapid generation of waste tyre. Stockpiling of waste tyre causes treats to environment because it presents fire hazards and provides shelter for various animals and insects such as snakes, rats and mosquitoes.

Scrap tyre management is continuously becoming a significant environmental, health, and aesthetic problem that need to be solved; but is very difficult to solve. The use of scrap tyre in concrete is a possible disposal solution.

(Ganjian, et.al, 2009) stated that scrap tyre is composed of ingredients that are non-degradable in nature at ambient condition, they usually produce environmental mal-effects; one of the methods of utilizing these materials is by using them in concrete and other building products.

1.2 Problem Statement

The increasing demand for concrete with use of new materials to modify one or more properties of the concrete, and the need for proper utilization of waste materials to avoid environmental pollution by reusing in the construction industry encourage this research to be conducted. Waste tyre is one of the materials which tend to cause danger of pollution of environment in developed and fast growing industrial countries like Malaysia need to be properly recycled, utilized or reused to prevent stockpiling of the waste material which can cause high risk of fire hazards, and provides shelter and playing ground for snakes, rats, and mosquitos' e.t.c.

Many countries around the world are facing the problems of shortage of construction materials like aggregate which is mostly gotten from natural sources. Moreover, aggregates constitute the highest proportion in concrete and mortar. Therefore the need to discover new materials which can be used as aggregates substitute both in fine and coarse. Hence, this research tends to look into the possibility of waste tyre as aggregate (light weight aggregate) both as fine form and in coarse form in concrete. Hopefully, this research can contribute to the other findings in developing concrete and can be applied in local construction industries in Malaysia and other countries around the world. This research work, if found effective will reduce the shortage of construction materials and will reduce the overall cost of construction.

1.3 Aims and Objectives of Study

The aim of this study is to investigate the potential use of scrap tyre to partially replace fine and coarse aggregate in concrete and its effects on the properties of the concrete. The following objectives are identified to satisfy this aim:

1) To determine the mechanical properties of scrap tyre concrete

2) To determine water absorption properties of scrap tyre concrete

3) To investigate the drying shrinkage of concrete containing scrap tyre rubber

1.4 Scope of the Research

This experiment investigation includes the determination of the effect of scrap tyres as fine and coarse aggregate in concrete on the application on some properties of concrete. The properties considered were workability, compressive strength, and flexural strength, splitting tensile strength, water absorption and drying shrinkage.

The research is limited to one concrete mix with target strength of 30 N/mm^2 with slump between 30- 60 mm. The concrete mix design was limited to the DOE method of concrete mix design, and tests were conducted on strength properties for 3, 7, 28, and 60 days. Scrap tyres of sizes ranging from 1 – 4 mm were used as fine aggregate replacement, and coarse aggregate of sizes ranging from 5 - 8 mm were used as coarse aggregate replacement in concrete. The properties considered for the research were limited to those mentioned in the scope.

1.5 Research Hypothesis

Scrap tyre can successfully be used as a partial replacement of fine and coarse aggregates in making a concrete with improved workability, reduced strength, reduced water absorption, increased splitting tensile strength, reduced drying shrinkage and increased flexural strength and toughness.

1.6 Significance of the Research

Aggregate being one of the most important constituent material almost all civil engineering construction, and which constitute the bulk of the concrete, and due to the shortage of aggregates experienced by many countries around the world, use of other materials as partial substitute or full substitute of fine or coarse aggregate in concrete will minimize this shortage of materials and reduce the cost of using aggregates. It will also provide cheap materials of construction and save a considerable quantity of natural aggregate. This will also reduce the environmental pollutions and effects caused by these waste materials and by-products. Thus, the use scrap tyre as partial replacement of fine and coarse aggregates in concrete will provide an economic use of by-product and consequently produce a cheaper concrete for low concrete construction.

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