

MECHANICAL PROPERTIES OF CONCRETE
CUBES USING TYRE WASTE AS PARTIAL SAND
REPLACEMENT

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SUPERVISOR'S DECLARATION

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Sisa buangan tayar getah motokar mempunyai peningkatan yang mantap dalam penjanaannya setiap tahun di Malaysia. Bilangan tayar getah buangan tahunan yang dihasilkan di negara ini dianggarkan berjumlah 8.2 juta atau lebih kurang 57391 ton pada tahun 2006. Tambahan pula, 60% sisa buangan tayar getah dilupuskan melalui cara yang tidak diketahui. Sisa Buangan tayar getah di Malaysia tidak dikategorikan sebagai sisa pepejal ataupun sisa berbahaya. Pada masa kini, sisa tayar getah hanya diumukan sebagai sisa perdagangan. Oleh sebab ketiadaan undang-undang ataupun peraturan yang mengendalikan pengurusan tayar getah buangan, kami telah mengambil keputusan untuk menggunakan bahan ini dalam penyelidikan untuk menentukan sifat-sifat mekanikal konkrit selepas penggantian pasir. Tayar dibuat daripada getah yang memberikan sifat penyerap kejutan, oleh itu peratusan tertentu dalam konkrit akhirnya akan memberikan sifat baru dalam konkrit. Sisa tayar yang digunakan dalam penyelidikan ini dikisar menjadi bentuk serbuk dan kemudian digunakan sebahagiannya untuk menggantikan pasir dalam reka bentuk campuran konkrit untuk mendapatkan peratusan yang patut digunakan untuk meningkatkan kekuatan optimum. Kiub konkrit yang diuji dalam penyelidikan ini bersaiz (150mm x 150mm) masing-masing dan diuji pada peratusan penggantian pasir yang berbeza. Kiub-kiub dibahagikan kepada 0%(kiub terkawal), 5%, 10%, dan 15%. Setiap peratusan mempunyai 9 kiub yang sama digunakan untuk mendapatkan data purata yang telah diuji pada hari yang ke-7, ke-14 dan ke-28 sejak kiub-kiub tersebut digunakan. Ujian yang dijalankan pada kiub-kiub ini merupakan *Ultrasonic Pulse Velocity* (UPV) yang juga dikenali sebagai Ujian Pundit, Ujian Slump dan Ujian mampatan. Keputusan eksperimen dalam 28 hari menunjukkan bahawa pada ujian mampatan hari ke-7, kiub dengan penggantian pasir 10% mempunyai kekuatan konkrit tertinggi iaitu 723.1kN manakala bagi kiub dengan 10% pada hari ke-14 mempunyai kekuatan konkrit tertinggi juga iaitu 810.9kN diikuti hari ke-28 yang juga menunjukkan kiub dengan penggantian pasir 10% mempunyai kekuatan konkrit yang tertinggi.

ABSTRACT

Motorcar waste tyre has a steady increase in its generation annually in Malaysia. The number of motorcar waste tyres generated annually in the country was estimated to be 8.2 million or approximately 57,391 tonnes in the year 2006. In addition to this, 60% of the waste tyres are disposed via unknown routes. Waste tyres in Malaysia are neither categorized as solid waste or hazardous waste. Currently it is just generalized as trade waste. Since there isn't any law or regulation which governs waste tyre management, we have decided to use this material in our research to determine the mechanical properties of concrete after partial sand replacement. Tyre is made of rubber that gives it properties of absorbing shock and therefore having it at a certain percentage in the concrete will eventually give the concrete new properties. The tyre waste used in this research is grinded into powder form and then used partially to replace sand in a concrete mix design to find its suitable percentage to be used to gain the optimum strength. The concrete cubes tested in this research are sized at (150mm x 150mm) each and tested at different percentage of sand replacement. The cubes are casted at a 0% (controlled cube), 5%, 10% and 15%. Each percentage had 9 identical cubes casted to get an average data that was tested on the 7th, 14th and 28th day since it was casted. The tests carried out for these cubes are Ultrasonic Pulse Velocity (UPV) also known as the pundit test, slump test and the compression test. The results from the experiment as of the 28 days shows that at the 7th day compression testing, the cube with 10% sand replacement has the highest concrete strength of 723.1kN, whereas for the 14th day testing the cube with 10% has the highest concrete strength as well at 810.9kN followed by the 28th day that also shows that the cube with 10% sand replacement having the highest concrete strength.

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LIST OF SYMBOLS

σ Direct Stress

LIST OF ABBREVIATIONS

kN	Kilogram Newton
MPa	Megapascal
OPC	Ordinary Portland Cement
UMP	Universiti Malaysia Pahang
UPV	Ultrasonic Pulse Velocity

CHAPTER 1

INTRODUCTION

1.1 Introduction

The management of waste material is a problem worldwide. In the developing countries, waste management is becoming an acute problem and in Malaysia there are many waste materials being generated daily that demands immediate attention. This has to be taken into serious consideration by the authorities and management because Malaysia is categorized as an emerging industrialized country among countries like China and South Korea (Von Lina Lau, 2004). Tyre dealers face considerable pressure when the waste tyres produced accumulates at their premises, often causing improper place of disposal of the tyre waste. These tyre dealers usually don't have any assistance from their principals or authorities for proper management and disposal of waste tyres (Von Lina Lau, 2004).

In the past, tires were burned to avoid this accumulation in stockpiles. The tire fires were difficult to extinguish and would release harmful chemicals into the environment resulting in regulations making it illegal to do so in many countries. With approximately 3663 thousand metric tons of tires generated in 2015 in the United States alone, it is critical to continue finding innovative ways to use this waste material (TMA (U.S. Tire Management Association) 2017).

Ultimately, the purpose of this study was to assess the use of recycled tyre particles as a replacement of fine aggregate which is sand with tyre waste powder or crumbs. The effects of replacement on fresh and hardened concrete properties were

determined. In each instance, the fine aggregate, sand, was replaced volumetrically in 5% increments up to the maximum of 15%.

Through this study, we will be working on determining concrete strength on each cube, type of failure on each cube, the UPV test and also the rebound hammer test. All the cubes at different sand replacement percentage will be tested to compare the concrete strength of the cubes. The type of crack on the cubes will be determined. Therefore, in the end of this study, the feasibility of using rubber tyre waste as partial replacement of fine aggregate in concrete will be verified.

1.2 Problem Statement

Daily, there are tons of tire waste being produced worldwide and even in Malaysia. These tire wastes are stored and doesn't have proper disposal methods. With the rapid usage of automobile in Malaysia the number of cars has increased substantially in the last decade and reached over 120 million in 2016. The weight of waste rubber from tyre wastes is about 15 million tons at present which is very big concern to the authorities. Waste rubber disposal is a major environmental concern in Malaysia, mainly due to this material being a non-decaying material. Stockpiling of these materials is very dangerous because it presents a fire hazard and provides breeding ground for rats, mice and mosquitoes (Liu and Lei, 2015).

The question of suitability of tyre waste material being used as sand replacement is asked because of the properties of tyre waste being an aggregate in concrete. The effects of tyre waste in concrete have been tested in previous studies but not till an extent of knowing its suitability in using tyre waste as sand replacement in concrete for construction purposes.

1.3 Objectives

The objectives of the study are as follows:

- i. To investigate the suitability of tyre waste as partial sand replacement.
- ii. To investigate the Optimum Mix Design of this concrete mix that has the highest compressive strength.
- iii. To investigate the mechanical properties of concrete with tyre waste as partial sand replacement.

1.4 Scope of Research

This research focused on investigating the properties of tyre waste powder as partial sand replacement in concrete. The concrete properties those were determined through compressive strength test, UPV test and the rebound hammer test. In this study, only one type of mix was used which was the normal concrete mix with cement and aggregate. There was 4 different groups of concrete tested with 9 cubes per group that had sand replacement percentage at 0%, 5%, 10% and 15%.

For compressive strength test, UPV test and the rebound hammer test, the concrete was casted in cube moulds of (150 x 150 x 150) mm³ which contained tyre waste powder as partial sand replacement with a ratio of 5%, 10%, and 15% respectively. After casting the cubes and moulding it, they were kept in the water for water curing. Tests were conducted on the concrete cubes on the 7th, 14th and 28th day according to the existing standards.

1.5 Significance of Research

The main motive of this research is to reduce the environmental pollution that is caused by the accumulation of waste tyre in many parts of Malaysia. Besides that, we can also save the space that is used in storing these waste tyres and transforming the waste into fortune. This can be made possible if waste tyres are recycled and used in the

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