MECHANICAL PROPERTIES OF CONCRETE INCORPORATING PORCELAIN GRANITE TILES AS PARTIAL AGGREGATE

CHRISTINE WONG

B. ENG (HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

UNIVERSITI MALAYSIA PAHANG

DECLARATION OF THESIS AND COPYRIGHT

Author's full name	:	CHRISTINE WONG
Date of birth	:	12 SEPTEMBER 1992
Title	:	MECHANICAL PROPERTIES OF CONCRETE INCORPORATING PORCELAIN GRANITE TILES AS PARTIAL AGGREGATE
Academic Session	:	2015/2016

I declare that this thesis is classified as :

☐ **CONFIDENTIAL**	(Contains confidential information under the Official Secret Act 1972)*
☐ **RESTRICTED**	(Contains restricted information as specified by the organization where research was done)*
☑ **OPEN ACCESS**	I agree that my thesis to be published as online open access (Full text)

I acknowledge that Universiti Malaysia Pahang reserve the right as follows:

1. The Thesis is the Property of University Malaysia Pahang
2. The Library of University Malaysia Pahang has the right to make copies for the purpose of research only.
3. The Library has the right to make copies of the thesis for academic exchange.

Certified By:

(Student's Signature)	(Signature of Supervisor)
920912-08-6006	DR. DOH SHU ING
New IC / Passport Number	Name of Supervisor
Date : 22 JUNE 2016	Date : 22 JUNE 2016

NOTES : *If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization with period and reasons for confidentiality or restriction

MECHANICAL PROPERTIES OF CONCRETE INCORPORATING PORCELAIN GRANITE TILES AS PARTIAL AGGREGATE

CHRISTINE WONG

Thesis submitted in fulfillment of the requirements
for the award of the degree of
B. Eng (Hons.) Civil Engineering

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2016

SUPERVISOR'S DECLARATION

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 degree of Bachelor of Engineering (Hons.) Civil Engineering

Signature	:	
Name of Supervisor	:	DR. DOH SHU ING
Position	:	SENIOR LECTURER / DEPUTY DEAN
Date	:	22 JUNE 2016

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature :

Name : CHRISTINE WONG

ID Number : AA12086

DATE : 22 JUNE 2016

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

%	Percentage
mm	Millimeter
km	Kilometer
sec	Second
N/mm^2	Newton per millimeter square
kg	Kilogram
kN	Kilo Newton
°C	Degree Celsius
g	Gram
w/c	Water to cement ratio
mm^2	Millimeter square
min	Minute
µm	Micrometer
MPa	Mega Pascal
±	Plus-Minus

LIST OF ABBREVIATIONS

A0	0 % of Tile Aggregate
A1	10 % of Fine Tile Aggregate and 10 % of Coarse Tile Aggregate
A2	20 % of Fine Tile Aggregate and 10 % of Coarse Tile Aggregate
A3	30 % of Fine Tile Aggregate and 10 % of Coarse Tile Aggregate
A4	40 % of Fine Tile Aggregate and 10 % of Coarse Tile Aggregate
A5	50 % of Fine Tile Aggregate and 10 % of Coarse Tile Aggregate
ACV	Aggregate Crushing Value
AIV	Aggregate Impact Value
BS	British Standard
CWA	Ceramic waste aggregate
C&D	Construction and demolition
DoE	Department of Environmental
FA	Fly ash
OPC	Ordinary Portland Cement
PCCA	Porous ceramic coarse aggregate
RCA	Recycled Concrete Aggregate
UPV	Ultrasonic Pulse Velocity

MECHANICAL PROPERTIES OF CONCRETE INCORPORATING PORCELAIN GRANITE TILES AS PARTIAL AGGREGATE

CHRISTINE WONG

Thesis submitted in fulfillment of the requirements
for the award of the degree of
B. Eng (Hons.) Civil Engineering

Faculty of Civil Engineering and Earth Resources
UNIVERSITI MALAYSIA PAHANG

JUNE 2016

ABSTRACT

Natural aggregate comprises about 75 % of the components of concrete by volume. The consumption of natural aggregate is high in producing concrete. Thus, making aggregate resources available for our country's increasing needs will be an ongoing challenge. On the other hand, construction and demolition waste disposed at landfill also increases due to urbanization. The objective of this research is to evaluate the effect of the incorporation of crushed porcelain granite tiles as partial replacement of both coarse and fine aggregate on the mechanical properties of concrete. Six different concrete mixes of C40 grade were cast to test these hardened properties: a conventional reference concrete and five concrete mixes with combination replacement ratios of 10 %, 20 %, 30 %, 40 % and 50 % of natural fine aggregates and 10 % natural coarse aggregate by crushed porcelain granite tiles. In this research, the maximum compressive strength is 65.15 MPa at the combination replacement ratio of 10 % for both coarse and fine aggregate compared to conventional reference concrete, which is 63.11 MPa. The strength increases by 3.23 %. Meanwhile, the maximum flexural strength is 8.47 MPa at the combination replacement ratio of 30% for fine aggregate and 10 % for coarse aggregate, which is 15.07 % of its compressive strength. Nowadays, environmental awareness among the public is affecting the production of natural aggregate. Hence, replacement of natural aggregates with construction and demolition waste materials such as crushed porcelain granite tiles will help in reducing the rate of environmental exploitation, environmental pollution and also landfill waste.

ABSTRAK

Agregat semulajadi terdiri daripada kira-kira 75 % dalam komponen-komponen konkrit mengikut isipadu. Penggunaan agregat semulajadi adalah tinggi dalam menghasilkan konkrit. Oleh itu, sumber agregat yang berterusan merupakan satu cabaran berikutan keperluan yang semakin meningkat di negara kita. Selain itu, sampah daripada aktiviti-aktiviti pembinaan dan perobohan yang dibuang di tapak pelupusan juga meningkat kerana pembandaran. Objektif kajian ini adalah untuk menilai kesan penggabungan jubin porselin granit yang telah dihancurkan sebagai pengganti separa agregat kasar dan agregat halus pada sifat-sifat mekanikal konkrit. Enam campuran konkrit gred C40 yang berbeza telah dibuat untuk menguji sifat-sifat keras konkrit: konkrit rujukan konvensional dan lima campuran konkrit dengan kombinasi nisbah penggantian 10 %, 20 %, 30 %, 40 % dan 50 % daripada agregat halus semulajadi serta 10 % agregat kasar semulajadi dengan jubin porselin granit. Dalam kajian ini, kekuatan mampatan maksimum adalah 65.15 MPa pada kombinasi nisbah penggantian 10 % untuk agregat kasar dan halus berbanding dengan konkrit rujukan konvensional, iaitu 63.11 MPa. Kekuatan mampatan meningkat sebanyak 3.23 %. Sementara itu, kekuatan lenturan maksimum ialah 8.47 MPa pada kombinasi nisbah penggantian 30 % untuk agregat halus dan 10 % untuk agregat kasar. Kekuatan lenturan tersebut merupakan 15.07 % daripada kekuatan mampatan. Pada masa kini, kesedaran alam sekitar di kalangan orang ramai telah menjejaskan pengeluaran agregat semulajadi. Oleh itu, penggantian agregat semulajadi dengan bahan buangan daripada aktiviti-aktiviti pembinaan dan perobohan seperti jubin porselin granit akan membantu dalam mengurangkan kadar eksploitasi alam sekitar, pencemaran alam sekitar dan juga sisa tapak pelupusan.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The construction industry continues to grow all over the world, benefitting the nation's economy while providing essential infrastructure. It is one of the main contributors that contribute to the development of a nation. Construction industry fosters employment opportunities while promoting local and foreign investment opportunities which benefit the nation's economy. However, the rapid development of a nation leads to a growing amount of construction and demolition (C&D) waste. C&D waste is one of the most voluminous waste streams generated and it increases the burden on landfill sites. Besides, C&D waste has been recognized as a major issue in the construction industry due to its direct impact on both the environment and the efficiency of the construction industry. According to Tam et al. (2014), pollution generated from construction industry activities bring on major challenges to the environmental management. C&D waste that is not managed properly may lead to soil and water pollution. Besides, construction material wastage also accounts for project cost overrun. Generally, about 21-30% of construction material wastage contribute to the cost overrun occurred in construction projects (John & Itodo, 2013).

Construction waste is usually incorporated with demolition waste. Thus, it is defined as the waste produced by new construction, refurbishment or demolition of a structure (Osmani, 2011). Construction waste is different from demolition waste. For instance, the construction masonry wastes are cleaner and newer compare to the demolition masonry wastes. Construction waste is more likely consist of homogeneous materials whereas demolition waste tends to be nonhomogeneous materials. Demolition

wastes mainly consist of mixed materials and debris. Generally, concrete, gravel, bricks, sand, stone, wood, plastic, metal, glass, paper, and etc. are the solid waste generated during C&D activities (Gull, 2011).

Concrete remains an indispensable material in the construction industry. According to Behera et al. (2014), the present usage of concrete is practically 20 billion metric tons per annum. Concrete consist of three basic components which are cement, aggregate and water. Aggregates play a crucial role where it makes up roughly 60% to 75% of ready-mix concrete's volume. Natural aggregates are used in production of concrete, which led to a continuous and increasing demand of natural resources. This inevitably will lead to natural resource depletion in a long run as natural aggregates are not sustainable aggregates.

In recent years, many researches have been done on alternative aggregates as the substitutes of natural aggregates in concrete. Southern European countries practice the usage of ceramic materials in the construction industry (Gonzalez-Corominas & Etxeberria, 2014). For instance, tiles, bricks and blocks which are produced during construction and demolition are used.

1.2 PROBLEM STATEMENT

Production of aggregate from natural resources is an ongoing process to keep up with the development of a country. As envisaged by the year 2020, Malaysia at present is shifting from a developing country status towards achieving a developed nation status (Ismail et al., 2013). The construction industry is considered to be one of the crucial industries as it plays an important role in socioeconomic development of the country.

Natural aggregate is usually obtained by mining or blasting of rocks from quarries. In Malaysia, almost every state carries out its own aggregate production activities (Ismail et al., 2013). The process of extracting these materials is not an environmentally-friendly activity. This gives rise to environmental issues such as ground vibration, dust, noise, disturbed landscapes and habitat, and affected surface or groundwater (Langer et al., 2004). Natural aggregate comprises about 75% of the

components of concrete by volume. Thus, the consumption of natural aggregate is high in producing concrete. The ecological balance of the environment will be deeply affected by the exploitation of natural aggregates. Making aggregate resources available for our country's increasing needs will be an ongoing challenge.

A considerable amount of research on incorporating wastes into production of concrete has been carried out due to increasing environmental awareness (Zimbili et al., 2014). Mainly the wastes used are C&D wastes. In United States, approximately 30% of C&D waste disposed of to landfill annually, which amounts to about 136 million tonnes (John & Itodo, 2013). In Hong Kong, 15.4 million tonnes of solid waste are generated from the construction industry in 2009 (Yu et al., 2013). It is about 23% of the total waste disposed in landfills. According to Liu et al. (2015), 32% of waste generated within United Kingdom and 44% in England are from C&D activities. Currently, a large portion of solid waste in Malaysia is from C&D waste. During construction of a new building, it is estimated that around 27068.40 tonnes of construction waste are generated from the construction site (Ismail et al., 2013).

The average percentage contribution of building material wastage during construction to project cost overrun is between 21 – 30%. Concrete is ranked first among the material wastage that contributes to project cost overrun. Material wastage at sites mainly happened due to poor supervision, re-work, and poor material handling (John & Itodo, 2013). Moreover, concrete which consists of natural aggregate also cost more than concrete with waste materials incorporated as aggregate. Generally, any improvement in the building material wastage level on construction has the potential to enhance the construction industry's performance with cost-saving benefits.

1.3 OBJECTIVE

The main aim of this research project is to incorporate crushed porcelain granite tiles into concrete as partial replacement of both coarse and fine aggregate. The aim of the partial replacement of natural aggregates with waste materials from construction process is to minimize the construction waste being sent to landfill besides from