PHYSICAL AND MECHANICAL PROPERTIES OF CONCRETE USING FLY ASH AND RECYCLED CONCRETE AGGREGATES

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To my beloved parents

&

Assoc. Prof. Dr. A.S.M. Abdul Awal

Thanks for your guidance and support to me

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ABSTRACT

In this research, physical and mechanical properties of concrete were investigated by using fly ash and recycled concrete aggregates (RCA) as partial replacement. Fly ash was collected from the Tanjung Bin Power Plant at Pontian and recycled concrete aggregates were obtained from waste at laboratory. So, 20% of total amount of cement was replaced by fly ash as partial replacement but for recycled concrete aggregates, it was replaced coarse aggregates as 0%, 25%, 50%, 75% and 100% to check which is the best combination. The dosage of superplasticizer in this study was 1.5% of weight of cement and 0.4 water/cement ratio was used in the mixture.. A number of tests were conducted to investigate fresh and hardened state properties like slump, ultrasonic pulse velocity, compressive, tensile and flexural strength of fly ash and recycled aggregates concrete. Test specimens comprising of cube, cylinder and prism were prepared and tested after 1, 7, 28 and 56 days of water curing. It was found that the workability of the concrete was reduced as the percentage of RCA increased. The range of the workability of the fresh concrete was fall at 65 mm to 130 mm. However, high content of RCA was increased the water absorption of the concrete. The result has obtained that the water absorption of concrete was in the range of 5.38% to 8.65% among the samples. A reduction on compressive, tensile and flexural strength occurred as the content of replacement increased. As conclusion, concrete with 20% of fly ash and 25% of recycled aggregates as partial replacement was concluded as the best mixed ratio since the mechanical properties of the concrete was almost equal to the conventional concrete. The maximum compressive strength of the sample was 34.55 MPa while splitting tensile strength and flexural strength have achieved 3.7 MPa and 4.35 MPa.

ABSTRAK

Dalam kajian ini, sifat-sifat fizikal dan mekanikal konkrit telah disiasat dengan menggunakan abu terbang konkrit dan agregat dikitar semula (RCA) sebagai pengganti separa. Abu terbang dikumpulkan dari Loji Tanjung Bin di Pontian dan agregat konkrit kitar semula yang diperolehi daripada sisa buangan di makmal. Oleh itu, 20% daripada jumlah simen digantikan dengan abu terbang sebagai sebahagian penggantian tetapi untuk agregat konkrit kitar semula, ia telah digantikan agregat kasar sebagai 0%, 25%, 50%, 75% dan 100% untuk memeriksa kombinasi yang terbaik. Dos superplasticizer dalam kajian ini adalah 1.5% daripada berat simen dan nisbah air/simen digunakan adalah 0.40. Beberapa ujian telah dijalankan untuk mengkaji sifat-sifat konkrit dalam keadaan segar dan keras seperti kemerosotan, halaju denyutan ultrasonik, mampatan, tegangan dan kekuatan lenturan abu terbang dan dikitar semula agregat konkrit. Spesimen ujian yang terdiri daripada kiub, silinder dan prisma telah disediakan dan diuji selepas 1, 7, 28 dan 56 hari pengawetan air. Ia telah mendapati bahawa kebolehkerjaan konkrit telah dikurangkan apabila peratusan RCA meningkat. Julat kebolehkerjaan konkrit segar adalah 65 mm hingga 130 mm. Walau bagaimanapun, kandungan tinggi RCA telah meningkat penyerapan air konkrit. Hasilnya telah mendapat bahawa penyerapan air konkrit adalah dalam lingkungan 5.38% hingga 8.65% di kalangan sampel. Pengurangan pada mampatan, tegangan dan kekuatan lenturan berlaku apabila kandungan RCA sebagai penggantian meningkat. Kesimpulannya, konkrit dengan 20% abu terbang dan 25% agregat kitar semula disimpulkan sebagai nisbah campuran yang terbaik kerana sifat-sifat mekanikal konkrit yang hampir sama dengan konkrit konvensional.

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LIST OF SYMBOLS

p	-	Density
V	-	Pulse Velocity, m/s
s	-	Distance between Centers of Transducer Faces, m
t	-	Transit Time, s
σ_{ct}	-	Splitting Tensile Strength, N/mm^2
F	-	Maximum Load, N
π	-	Pi
L	-	Length of Specimen, mm
D	-	Cross Section Dimension Specimen, mm
f_{cf}	-	Flexural Strength, N/mm^2
d1 & d2	-	Lateral Dimension of the Cross Section, mm

LIST OF ABBREVIATIONS

FA	-	Fly Ash
RCA	-	Recycled Concrete Aggregates
NA	-	Normal Aggregates
OPC	-	Ordinary Portland Cement
PC	-	Plain Concrete
RAC	-	Recycled Aggregates Concrete
ACI	-	American Concrete Institute
ACAA	-	America Coal Ash Association
BS	-	British Standard
ASTM	-	American Society for Testing and Materials

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Concrete is one of the most common construction materials used in construction for long time ago due to its flexibility usage and it is better than materials like steel and timber. Concrete is combined of cement, sand, aggregates and water yet additives will be added into concrete to improve or achieve higher strength.

Fly ash is fine residue from the combusted powdered coal for generating electric purpose. A pozzolan is a siliceous or aluminous material that mixing with lime and water will form a cementations compound. Since fly ash has the characteristic of pozzolan, so fly ash occupies a portion in producing cement. Under a microscope, fly ash is finer than cement and it has almost totally spherical in shape. When fly ash is presence in concrete, the finer size of fly ashes are filled up the microscopic space in concrete and make the concrete stronger and durable. Therefore, volume of water required for the concrete is reduced.

By using fly ash as partial replacement in concrete, it can reduce the demand of cement production. Hence, architects and engineer can be cooperated in designing the building by using fly ash material to promote the sustainable growth and responsible building practices. Furthermore, fly ash concrete can meet the requirement of “Build Green” yet without reduce the cost and quality of the concrete.

On the other hand, concrete recycling is common method to reuse the concrete aggregates in construction. When the structural are renovated or demolished, the concrete can be collected and put into the crushing machine to obtain the recycled concrete aggregates (RCA). This recycling method has reduced the concrete waste dispose to environment yet it can be reused in construction and cut down the construction cost. The recycled concrete aggregates must be from uncontaminated concrete like must be free of trash, wood, plastic and other material due to will affect the performance and quality of the aggregates. Normally, the recycled aggregates are used as base material for roadways rather than buried it in a landfill.

1.2 Problem Statement

Fly ash is a residue or byproduct of combusted coal where obtained from power plant. According to ASTM, there are two types of fly ash which are class C and class F. Generally, class F fly ash is used widely in the market compare to class C fly ash due to class F fly ash able to produce higher ultimate strength in concrete. Fly ash particles have the spherical shape with the size of 45μm which slightly finer than cement. Therefore, fly ash can act as filler which can be filling up the void within concrete yet increased the concrete compression strength and having longer life span.

The total volume of fly ash which is generated by electric power plants or incinerator plants in Malaysia is increasing year by year in Malaysia due to high demand of the population. Based on the report of 1987 – 1989, there were 415 million tons of fly ashes were produced all over the world but only 16 % of the totals were utilities in construction sector (Baykal & Doven, 2000).

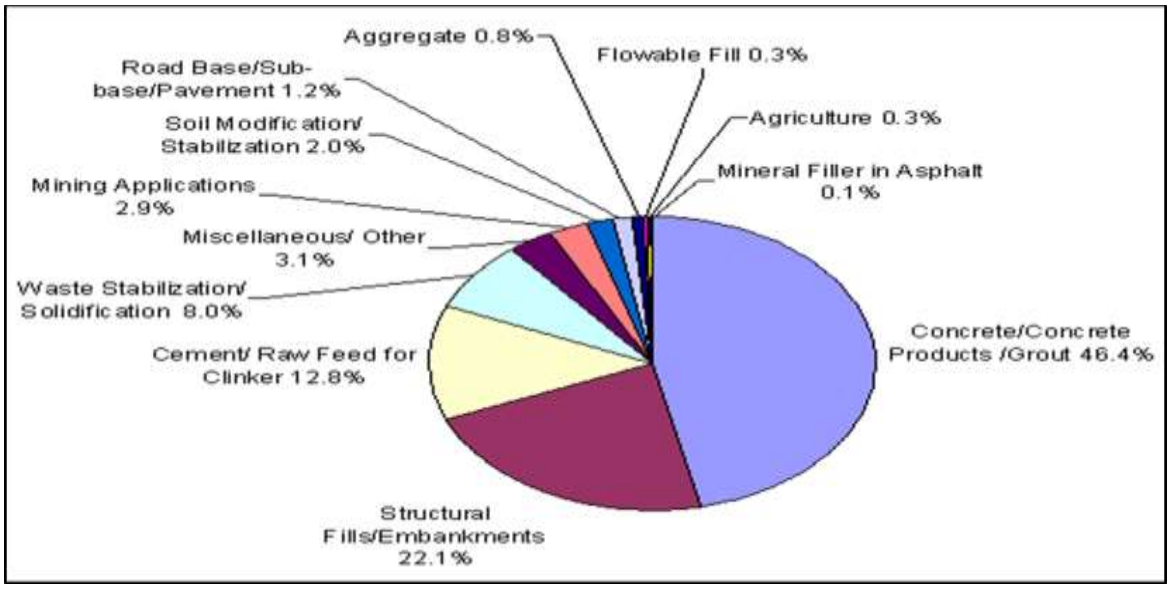

Figure 1.1: The Percentage of Fly Ash Use in Application Construction in 2006 (America Coal Ash Association, 2007).

In Figure 1.1, approximately 29.3 million metric tons (32.4 million tons) of fly ash were used (ACAA, 2007). Embankment and fill material of fly ash has been used for landfill purpose since fly ash can be used as a substitute for natural soils. Fly ash in this application must be stockpiled and its condition must be optimum moisture content for having better management. When compacted at or near optimum moisture content and evaluated at in field stress conditions, fly ash mixtures will perform in an equivalent manner to well-compacted soil.

Recently, most of the concretes in the market are using fly ash as partial replacement in cement. Indeed, the optimum replacement of fly ash is 15% to 25% for producing economic concrete (Feng & Clark, 2011). Somehow, there is a problem when the content of fly ash exceeds 25% is use as partial cement replacement in concrete mixture, it will decrease the bonding ability between the particles in concrete like cement, sand, and aggregates. Besides that, this situation cause fly ash concrete requires longer time to setting which means the hydration rates is increased compare to conventional concrete (Obla, 2008). This makes fly ash concrete is not suitable to apply onto marine structure projects or other tight schedule projects which required faster setting or harden time of concrete.

Furthermore, recycled concrete aggregates were collected from waste and it will be crushed into small pieces and sieved it to obtain maximum size of 10 mm for the purpose of partial replacement in coarse aggregates. Since the RCA was covered by cement and sand, it will affect overall performance of concrete. Besides that, mortar which attached on the recycle aggregates will have better water absorption characteristic compared to the normal concrete.

Therefore, this research will contribute to the new findings of the suitability of fly ash and RCA as partial replacement in cement and aggregates, plus it can helps to reduce the demand of cement and aggregates in the world. So, this research can help to reuse the fly ash and RCA in proper ways rather dispose it into environment. Thus, this not only can protect the environment yet produce high performance concrete in better usage in constructions field.

1.3 Objectives of Study

In this study, the objectives were stated as following:

i. To study the fresh properties of fly ash and RCA concrete.

ii. To examine the mechanical properties of concrete mixed with fly ash and recycled concrete aggregates.

iii. To identify the best ratio of RCA and fly ash as partial replacement of coarse aggregates and cement in the production of concrete.

1.4 Scope of Research

This research was emphasized the study of mechanical properties of concrete mixed with fly ash and recycled concrete aggregates compared to ordinary concrete. In this research, Ordinary Portland Cement (OPC) was used and the size of the coarse aggregates maximum was 10 mm. Besides that, 20% of total amount of cement was replaced by fly ash as partial replacement but for recycled concrete aggregates, it was replaced coarse aggregates as 0%, 25%, 50%, 75% and 100% to check which is the best combination.

Furthermore, concrete cubes with the size of 100 mm x 100 mm x 100 mm have been produced to check the mechanical properties like compressive test, splitting tensile test and flexural test on the age of 1 day, 7 days, 28 days and 56 days. Adding up to that, nondestructive test and testing on the workability of fresh concrete were also been carried out.

1.5 Significance of Study

There are several significance of study can be obtained through this research by using fly ash and recycled concrete aggregates as partial replacement of cement and coarse aggregates:

i) It can reduce the cost for a construction since these waste products can be used as partial replacement of cement and coarse aggregates.

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ii) These waste products become new type of resources which can be used to produce an acceptable quality of concrete and solved the issue lack of construction materials.

iii) The recycling and reuse of the waste products can be reduced the impact done to environmental which can minimize the problem of landfill and effect of air and water pollution.

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