



Faculty Of Engineering

**MECHANICAL PROPERTIES OF CONCRETE WITH CLAM SHELL
POWDER AS PARTIAL CEMENT REPLACEMENT**

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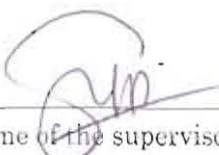
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To my beloved family and friends

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ABSTRACT

Concrete is the backbone to the infrastructure development of a nation and the most important material that make a concrete workable is cement. The quality of cement reflects the character or strength of the concrete. However, the production consumes a lot of natural resources is not beneficial to the environment. There are researches conducted to find possible alternative materials to replace cement in concrete. Clam shell powder (CSP) is a type of municipal waste that is studied in this research. This research focuses on compressive strength of concrete containing different percentages of CSP. The amount of cement in concrete tested is replaced by 5%, 10% and 15% of CSP. The result of the compressive strength test is then compared to the conventional concrete, also known as control concrete. This control concrete does not contain any CSP. The result obtained show that CSP can be used as partial cement replacement material in concrete. The result obtained shows that the compressive strength increases as the percentage of CSP in concrete increases until the percentage reaches 15%. Concrete containing 15% CSP has lower compressive strength compared to concrete containing 5% and 10% CSP but still higher than the control concrete. It is also found out that the concrete containing 15% CSP is the most similar to the control concrete compared to the other specimens.

ABSTRAK

Konkrit ialah tunjang kepada pembangunan infrastruktur sesebuah negara dan bahan yang paling penting untuk membolehkan konkrit untuk dikerjakan ialah simen. Kualiti simen mempengaruhi ciri-ciri dalaman atau kekuatan konkrit. Walaupun begitu, penghasilan konkrit banyak menggunakan sumber semulajadi dan memberikan impak yang negatif kepada alam sekitar. Beberapa kajian telah dijalankan untuk mencari bahan alternatif kepada simen dalam konkrit. Dalam kajian ini, sejenis sisa buangan rumah telah digunakan iaitu *clam shell powder* (CSP). Kajian ini memfokuskan kepada kekuatan kompresif konkrit yang mengandungi peratusan CSP yang berlainan. Simen dalam konkrit telah diagantikan dengan 5%, 10% dan 15% CSP. Keputusan eksperimen konkrit yang mengandungi CSP telah dibandingkan dengan konkrit kontrol yang tidak mengandungi CSP langsung. Keputusan makmal menunjukkan bahawa kekuatan kompresif konkrit meningkat sejajar dengan peratusan CSP dalam konkrit sehingga peratusan penggantian simen mencecah 15%. Konkrit yang mengandungi 15% CSP mempunyai kekuatan konkrit yang lebih rendah berbanding konkrit yg mengandungi 5% dan 10% CSP. Bagaimanapun, kekuatan kompresif konkrit yang mengandungi 15% CSP masih lebih tinggi nilainya berbanding konkrit kontrol. Selain itu, keputusan makmal juga menunjukkan bahawa konkrit yang mengandungi 15% CSP memiliki karakter yang terdekat dengan konkrit kontrol berbanding spesimen yang lain.

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LIST OF ABBREVIATIONS

CSP	Clam chell powder
ASTM	American Society of Testing and Materials
OPC	Ordinary Portland Cement
FA	Fly ash
SF	Silica fume
RHA	Rice husk ash
GGFBS	Ground granulated blast furnace slag
MS	Micro silica
ESP	Egg shell powder
ANOVA	Analysis of variance
BS	British standard
SL	Standard length
SH	Shell height
SW	Shell width
UL	Umbo length
AL	Anterior length
PL	Posterior length
LL	Ligament length

LCT	Cardinal tooth length
AW	Anterior adductor muscle scar width
PW	Posterior adductor muscle scar width
LPAS	Length from anterior adductor muscle scar to posterior adductor muscle scar
AAAM	Length from anterior adductor muscle scar to anterior margin
PAPM	Length from posterior adductor muscle scar to posterior margin
PVM	Length from ventral margin to pallial line
VPN	Ventral posterior margin length

CHAPTER 1

INTRODUCTION

1.1 Background of study

The construction industry in Malaysia is considered as a promising and stable industry. The demand of the construction of new infrastructures such as office buildings, houses, roads and bridges is increasing as Malaysia continues to develop throughout the years.

The most commonly used material in the construction industry is concrete. Hence, it is also known as the backbone to the infrastructure development of a nation (Dhanalakshmi et al., 2015). Typically, concrete is made up of mix proportions of coarse aggregates (gravel or crushed stones), fine aggregates (sand), cement and water. The strength of the concrete is affected much by the proportions of these elements and the curing process period of the concrete.

The cement undergoes a chemical reaction named hydration where the cement hardens and gains strength forming hard, solid mass called concrete. Concrete, is plastic and malleable when newly mixed and becomes durable as it hardens.

These qualities have explained how one material, the concrete can build huge buildings and withstand an enormous amount of loads. Cement, when mixed with water, forms paste that coats each particle of the fine and coarse aggregates.

Usually, cement makes up about 10 to 15 percent of the concrete mixture; another 85 to 90 percent is divided to 60 to 75 percent of coarse and fine aggregates, 15 to 20 percent of water and 5 to 8 percent of entrained air.

The quality of cement reflects the character or strength of the concrete. Insufficient paste will produce rough and porous concrete as the voids between the aggregates are not properly filled in. On the other hand, excess paste will produce smooth surface but is not economical as well as easily cracked. High quality concrete has a lower water-to-cement ratio. Hence, this means that we can increase the quality of concrete by lowering the water-to-cement ratio to a limit where the workability of a fresh concrete is not sacrificed or affected.

There have been studies that a low fraction of cement can be substituted with other materials such as municipal solid waste. Municipal solid waste such as clam shells contains calcium carbonate, which is the same brittle white stuff that made up the limestone (where cement are obtained from) (Karthick et al., 2014).

1.2 Problem statement

The amount of cement has been known as the major contributor in achieving higher concrete strength. Cement is obtained from limestone quarry. This has caused an environmental concern as cement production consumes a lot of natural resources that will eventually be used up and no virgin material will be left for future generation. In fact, for every 1000kg of cement produced, 900kg of carbon dioxide, CO_2 , is produced. This number contributes about 5% of carbon dioxide global emission to the atmosphere (Dhanalakshmi et al., 2015).

Apart from that, two-third of the construction cost originated from the raw materials used in the construction site. The total construction cost is affected by the increasing price of raw materials and as a consequence, the property is becoming less affordable for the citizens to own. Thus, many researches have been done to substitute a lower percentage of the raw materials, especially cement with alternative materials but at the same time, remaining the quality of the end product. These researches are hoped to reduce the construction cost in terms of the cost of raw materials used as well as minimizing the effects to the environment.

In fact, in Malaysia, municipal solid waste has been an environmental concern since years ago. Rapid economic development and population growth, inadequate infrastructure and expertise, and land scarcity has made the municipal solid waste management become one of Malaysia's most critical environmental issues (Hassan, 2002). As a consequence, these days, over 23,000 tonnes of solid waste is being produced each day and this number is expected to increase to 30,000 tonnes each day by the year 2020. Of all these solid waste, only 5% is being recycled (Budhiarta et al., n.d.).

Due to the large amount of waste and their disposing method such as incineration, the global citizens are exposed to the decline in the quality of environment such as pollutions. As a matter of fact, environmental concern regarding to municipal solid waste is not only at the nation level, but also globally. Kitchen or food waste has been identified as the major contributor, contributing 38.1% of the global municipal solid waste, as of 2012.

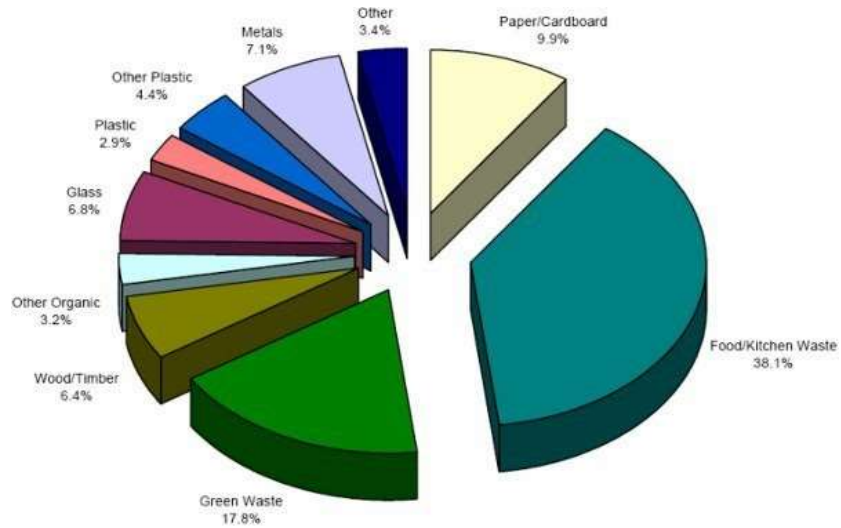


Figure 1. 1: Typical components of municipal solid waste in urban location

(Barker, 2012)

One of the ways to ease the environmental concern regarding to the increasing amount of global municipal solid waste is waste minimization. The objective of waste minimization is to minimize the amount of pollutant that requires treatment before it is discharged (Woodard and Curran, 2006). Waste minimization may mean to ultimately reduce the source of raw materials used. However, it is important for the reduction of raw materials to go hand in hand with the product efficiency.

In fact, that is the reason this research is done; to determine the possibilities of substituting raw materials with municipal solid waste. In this research, the raw material meant is the cement and municipal solid waste is the clam shell. The utilization of the municipal solid waste and its substitution of raw material at a low fraction can help to minimize the waste as well as to ease the environmental concern.

1.3 Objectives and scope of study

The objectives of this research are:

1. To determine the mechanical properties of concrete containing clam shell powder (CSP) as partial cement replacement material at low fraction.
2. To compare the mechanical properties of concrete with CSP as cement replacement at low fraction with conventional concrete.
3. To determine the possibilities of the usage of CSP as cement replacement in concrete.

This research is done to determine the mechanical properties of concrete with the introduction of CSP as cement replacement at low fraction. It is important to know the strength of the concrete as the performance of the concrete is measured by its ability to withstand the loads. The performance of the concrete containing low fraction of CSP as cement replacement is determined by investigating its strength properties such as compressive strength test, tensile strength test and flexural strength test.

A conventional or normal concrete is casted as the reference specimen. The other specimens are casted with CSP substituting a small part of the cement by percentages of 5%, 10%, 15% and 20%. All the specimens containing CSP are compared with the reference specimen. All the specimens undergone the curing process and the hardened concrete are tested for its mechanical or strength properties at specific ages of 3 days, 7 days, 14 days and 28 days. The results and information obtained from the strength properties tests are used to fulfill the research objectives.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses information obtained from various reading materials such as journals, books and articles regarding to the feasibility study of partial cement replacement in the construction industry.

This chapter also includes the information regarding to the constituent materials in concrete, including their properties and sources; aggregates, cement, water and admixtures. In admixtures part, previous study and researches regarding to admixtures, also known as partial cement replacement, are included.

Furthermore, this chapter also discusses cement hydration process and pozzolanic reaction. Lastly, it also contains information regarding to the clam “lokan” shell.

2.2 Concrete constituent materials

Concrete is considered to be a composite material, which means that it is made up of few different constituents (Dvorkin and Dvorkin, 2006). In fact, it can be modified or engineered to satisfy a wide range of performance specifications and properties (Ghambir, 2006). Typically, the constituent materials of concrete include fine aggregates, coarse aggregates, cement and water. As engineering advances, mineral or chemical admixtures may be added into these typical constituent materials to improve the performance of the concrete.

2.2.1 Aggregates

By mass, aggregates occupy 70 to 85 percent of the concrete. The sorting of fine and coarse aggregates is done by performing sieving process in accordance to standard practice. Fine aggregates typically consist of natural sand or crushed stones, mostly sizing smaller than 5mm. Fine aggregates almost entirely passes through the No. 4 (4.75mm) sieve (American Concrete Institute Committee 207, 1997).

On the other hand, coarse aggregates are the aggregates that are retained on the No. 4 (4.75mm) sieve (Ghambir, 2006). According to the American Concrete Institute Committee 207 (1997), aggregates are predominantly bigger than 5mm and smaller than 150mm in large structures. Coarse aggregates may consist of one or combination of gravels, crush gravels or crushed rocks.

Aggregates have a significant role in determining the properties of fresh and hardened concrete. As mentioned earlier, aggregates occupy most of the volume and mass of the concrete. Thus, this clarifies the significance of aggregates in producing good quality of concrete.

To achieve that, the aggregates have to be strong and durable as well as free of slits, organic matter, oils and sugars as these impurities may slow down or prevent the process of hydration and further reducing the bond between cement paste and aggregates particle (Newman, 2003).

2.2.2 Cement

Cement is a material with adhesive and cohesive properties which makes it able to act as glue that holds the other constituents in concrete, bonding them into a compact whole (Neville, 1995). According to the American Society for Testing and Materials (ASTM), there are five specifications of Portland cement. The types of Portland cement are distinguished by its mineral composition as well as its chemical and physical characteristics (Somayaji, 1995).

As defined by the ASTM, the specifications of each type of cement are as follows:

Type I General Portland Cement

Type II Moderate-sulfate-resistant cement

Type III High-early-strength cement

Type IV Low-heat-of-hydration cement

Type V High-sulfate-resistant cement

Type I Portland cement is a general purpose cement that is suitable for all uses. It is normally used when the structure is not subjected to specific exposures such as sulfate attack from soil or water. Applications of Type I Portland cement include structures such as pavements and sidewalks, reservoir, water pipes or tanks and bridges.

When moderate sulfate attack is in consideration, for instance, in drainage structure where sulfate concentration is generally higher than normal but not severe, Type II Portland cement is normally used. As Type II generates less heat at slower rate compared to Type I, its usage reduces the temperature rise, which is an important criteria to be considered when the building structure is built in a warm weather area. With its moderate rate of hydration, it is suitable for structures such as heavy retaining walls.

Type III Portland cement is considered as high-early strength cement as it provides a high strength at the early period. It is suitable for applications where the concrete structure is expected to be able function as soon as possible, such as bridge deck repair. It is chemically similar to Type I cement but grounded even finer to increase the rate of hydration.

Type IV is intended for large and massive structures, such as gravity dams, where the rate and amount of heat generated must be minimized. This low heat of hydration cement is suitable for structures where temperature rise resulting from heat generated during curing process is heavily considered.

Last but not least, Type V cement is a sulfate-resisting cement which is used when the concrete is exposed to severe sulfate exposures, such as soils and groundwater with high sulfate content. The resistance to sulfate in Type V is attributed by its low tricalcium aluminate content in the cement.