AN INVESTIGATION ON COMPRESSIVE STRENGTH OF CEMENT MORTAR WITH SEASHELL POWDER ADDITIVE

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ABSTRACT

In order to improve performances of cement mortar and cost consideration, several alternatives have been selected. Among several of natural additives, seashells have been chosen. This is due to its high percentage of calcium carbonate which contributes to toughness property. Moreover, environmental pollution might occur if seashells are not properly disposed of. Hence, the potential of seashell powder as an additive for cement mortar has been investigated. The objectives of this research are to identify the best compressive strength of cement mortar with acceptable percentages of seashell powder, to determine modification of modulus elasticity of cement mortar as well as to investigate the time to failure against force. A total of 30 cubes of cement mortar samples were prepared with 0%, 1%, 2%, 3% and 4% seashell powder additive. Cube specimens of 100mm x 100mm x 100mm were moulded and cured for 7^{th} and 28^{th} days. After that, the compressive strength of cement mortar samples with seashell powder additive was tested using Universal Tensile Machine. The results revealed that the compressive strength of cement mortar with 1% seashell powder additive is higher than control sample. In term of failure, the cement mortar with seashell powder additive obtained longer time to failure compared to control sample. In general, seashell powder has potential become partially substitution of cement and improve performances of cement mortar.

ABSTRAK

Dalam usaha untuk memperbaiki prestasi mortar simen dan pertimbangan kos, beberapa alternatif telah dipilih. Antara beberapa bahan tambahan semula jadi, kerang telah dipilih. Ini adalah kerana peratusan yang tinggi daripada kalsium karbonat yang menyumbang kepada sifat keliatan. Selain itu, pencemaran alam sekitar mungkin berlaku jika kerang tidak dibuang dengan cara yang tepat. Oleh itu, potensi serbuk kerang sebagai bahan tambahan untuk simen mortar telah disiasat. Objektif kajian ini adalah untuk mengenalpasti kekuatan mampatan yang terbaik daripada mortar simen dengan peratusan serbuk kerang yang sesuai, untuk menentukan pengubahsuaian modulus keanjalan simen mortar dan juga untuk menyiasat masa untuk kegagalan terhadap kuasa. 30 kiub simen mortar telah disediakan dengan 0 % , 1% , 2% , 3% dan 4% peratusan serbuk kerang. Spesimen kiub 100mm x 100mm x 100mm telah dibentuk dan sembuh untuk 7 dan 28 hari . Selepas itu, kekuatan mampatan mortar simen dengan kerang serbuk tambahan telah diuji menggunakan Universal Testing Machine. keputusan mendedahkan bahawa kekuatan mampatan mortar simen dengan 1% serbuk kerang tambahan adalah lebih tinggi daripada sampel kawalan. Dalam jangka kegagalan, mortar simen dengan serbuk kerang tambahan diperolehi masa yang lebih lama untuk kegagalan berbanding dengan kawalan sampel. Secara umum, serbuk kerang mempunyai potensi untuk meningkatkan kualiti simen mortar.

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LIST OF SYMBOLS

GPa	Giga Pascal
kg	Kilogram
mm	Millimeters
MPa	Mega Pascal
%	Percent

LIST OF ABBREVIATIONS

$CaCO_3$	Calcium Carbonate
Ca^{2+}	Calcium cation
SS	Seashells
UTM	Universal Testing Machine

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Waste materials can be described as no value. With the development of green technology that is widely promoted in these few years, many researchers had come across using waste materials as partially or fully substitution of construction material that could save the production cost and performs similar as conventional material, with sustainable development and acceptable result.

Therefore, seashell which acts as waste material has been selected in this study to add partially in cement. Although when the seashells die, their muscles and other soft parts decay and becomes food for other animals in the ocean, their hard shells still remain and might become fossils. This is due to chemical composition of hard shells have 90% of calcium carbonate which contributes to hardness and behaves as protective outer layer of animals that live in sea. This composition is similar to limestone powder which used to produce cement.

Hence, it would be an alternative of using seashell as substitution of cement in construction field. It can reduce costing as cement production costing has increased over the years. In addition, it helps public health by eliminating waste materials.

1.2 PROBLEM STATEMENT

In Malaysia, it was reported that the production of seashells was 45,133.20 tons in year 2012 (Annual Fisheries Statistics, 2012). Besides Malaysia, there is approximately 300,000 tons of waste oyster shell that are generated per year in Korea. Generally, most of the seashells have no further uses once the fleshes are stripped off except that a small amount is used for art creation. The hard shells are dumped at open sites and leading economy and environment problem. If the dump site waste is left untreated for long periods, it has the high possibility produce foul smelling odours because of the decaying of leftover fleshes that still attached to seashells.

Recycling of seashells is one of the measures to solve these problems. The oyster shells can be used to produce medium and high quality cement (B.Y. Zhong, 2012). Besides that, periwinkle shells have been used as conglomerate in concrete reinforcement for over 30 years and utilised to construct road, slab and home (Olufemi Isaac Agbede, 2009). Furthermore, (Ohimain, 2009) mentioned that waste shells act as an essential material in construction of foundations and elevated concrete slab due to scarcity of construction materials in Nigeria.

The effective utilization of these seashells wastes which are widely available, low cost and in abundance can help to reduce pollution tendency and reduce amount of cement used in concrete work. Hence, this study aims to determine the best compressive strength of cement mortar with various percentage of seashell powder.

1.3 RESEARCH OBJECTIVES

The objectives of this research are:

i. To identify the best compressive strength of cement mortar with acceptable percentages of seashell powder.
ii. To determine modification of modulus elasticity of cement mortar.
iii. To investigate the time to failure against force.

1.4 RESEARCH QUESTIONS

i. What is the best compressive strength of cement mortar with acceptable percentage of seashell powder?
ii. What is modification of modulus elasticity of cement mortar?
iii. What is the time to failure against force?

1.5 SCOPE OF STUDY

This research is mainly focuses on the compressive strength of cement mortar with additional of natural additives which is seashell powder on samples. The control samples are designed with cement and sand without any additives. The percentage of seashells used are 0% as control, 1%, 2%, 3% and 4% by weight of the mix proportion and fixed water-cement ratio which is 0.40. The seashells samples are washed thoroughly to remove dirt and sun-dried for three days. The seashells samples are then crushed into a powdered form using crusher. All the seashells samples will be sieved and passing 300μm size. Cube specimens of 100mm x 100mm x 100mm are moulded for compressive strength test. Apart from that, each type of sample mix proportion consists of three cubes respectively. All samples are placed in the water as curing condition and tested under compression test for 7^{th} days and 28^{th} days. Overall, a total of 30 cubes of cement mortar samples will be prepared. The experimental is conducted at the Concrete Laboratory of University Malaysia Pahang

Table 1.1: Number of Samples and Tests for Laboratory Work

Percentages		**0% SS**		**1% SS**		**2% SS**		**3% SS**		**4% SS**	
Test	**Curing**	**7**	**28**	**7**	**28**	**7**	**28**	**7**	**28**	**7**	**28**
Compression Test	Water	3	3	3	3	3	3	3	3	3	3
Total Samples		**30 of samples**									

1.6 EXPECTED OUTCOMES

The important parameters of seashells are its hardness, size and shape. From the observation, it is obvious that seashells have hard outer layer as protection and shelter. Besides that, the surface texture of the seashells has irregular lines. In addition, the compressive strength of cement mortar with seashell powder additive is higher compared to conventional cement mortar. When seashell powder is mixed with cement, there is a considerable environmental and economic benefit. In general, the seashell powder satisfies the cement requirement used for cement mortar production.

1.7 SIGNIFICANCE OF STUDY

This study is conducted to investigate the benefits of using seashell powder additives on cement mortar. Reuse seashells wastes provide sorts of benefits for instance reduction in using of raw materials such as cement as well as contributing to an economy of natural resources. This is significant as this can reduce disposal of waste shells and protects environment from pollution. It provides a cheaper costing and substitution to fulfill demand of construction field. The additional of seashells can enhance the compressive strength in cement mortar.

In addition, the advantages of using seashell powders are discussed in term of ultimate strength which responding to the compressive strength. Other engineering behavior that discussed is included for instance modulus elasticity. Other than that, this study is used to determine the most suitable percentage of seashell powder to be added that would enhance compressive strength of cement mortar. The compressive strength obtained will be compared in 7^{th} and 28^{th} curing day for all mix proportion of the cement mortar.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Seashell is known as local bivalve molluscs that grow well in coastal regions of South East Asian particularly in Malaysia. In 2012, the production of cockles was 42132.03 tonnes which the retail value is RM 70 million (Annual Fisheries Statistics, 2012). These figures indicate the availability of cockles as well as amount of waste shells generated. Pollution problems and environmental damage may rise if the waste shells has dumped and left untreated without proper management (Dj.M. Mohamed, 2012). The amount of waste shells would be reduced by integrating this waste shell as one of the mixing ingredient in concrete or cement mortar production (K. Muthusamy, 2012). Thus, this paper mainly discuss about the compressive strength of cement mortar with acceptable seashell powder additive.

2.2 MATERIALS

2.2.1 Cement Mortar

Cement mortar is a mixture of cement, sand and water. Various combinations of binder types would affect the quality and purposes of mortar that is produced for specific situations. The Ordinary Portland Cement is the binder type to produce cement mortar. Besides that, additional of water can cause the chemical reaction and the cement to set. Characteristics of cement mortar can be affected by proportions of combination and additives as well (Information For Historic Building Owners, 2007).

Generally, cement mortar is often used in repairing of structures, plastering of walls and masonry construction. Benefits of using cement mortar such as high tensile bond strength to hold masonry units together, allow less water penetration through the wall system and fast hardening process. In addition, cement mortar are still currently used in engineering construction because of low production and maintenance costs, durability as well as fire resistance (Her-Yung Wang, 2013).

However, there are some limitations of cement mortar. Due to less water penetration, the water would trap in the wall resulting in damage of faces of the bricks or stones. Although cement mortar behaves hard, it is brittle as it starts to decompose when get hardened. Thus, additives on cement mortar would increase performances of cement mortar.

2.2.2 Seashell Powder Additive

Seashells are used as mixing ingredient of cement or sand replacements in concrete or mortar production for cost saving (Mosher et al., 2010). The major composition of oyster shell was $CaCO_3$ of mineral crystallization. It was stable and would not produce free Ca^{2+}, so it would not affect the cement stability (Bin-Yang Zhong, 2013). Due to the high content of calcium carbonate in oyster shells, several studies on the recycling of the shells have been conducted (Barros et al., 2009, Chong et al., 2006, Fujita et al., 1990, Jung et al., 2006, Kwon et al., 2004, Presznhuk et al., 2003 and Yang et al., 2005).

2.3 METHOD

2.3.1 Compressive Strength Test

Compressive Strength tests of resistance to compression are widely accepted as the most convenient means of quality control of cement mortar produced. It measures the highest compressive force that cement mortar can withstand before it fails. (Her-Yung Wang, 2013) finds that the compressive strength of cement mortar made with fly ash and oyster shell sand is similar to the control group at 28 days. Moreover, the

substitution of oyster seashells as a fine aggregate as 10% and 20% shows an insignificant effect on compressive strength of concrete at 28 days (Eun-Ik Yanga, 2010).

Besides that, (Wen-Ten Kuo, 2013) mentions that the highest compressive strength of controlled low-strength materials belongs to 5% replacement of fly ash and waste oyster shells as the age increases till 90 days. The compressive strength decreased when replacement was followed by 10%, 15 % and 20% which is lower than of control group. In addition, (Benjamin R. Etuk, 2012) indicates that the compressive strength of mortar cubes decreases with increase in the amount of the shell ashes in the cement paste at 7 days. This is because pozzolanic activity is slow as it allows for hydration of cement.

On the contrast, compressive strength of mortar is reduced when increasing of percentage replacement of ground short-necked clam, oyster and cockle shells. The compressive values obtained are lower than of the control mortar at 7 days and 28 days (Pusit Lertwattanaruka, 2012). It may cause by less reactive material of ground seashell mixed with the portland cement.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will discuss about materials used, mix proportion, method of testing and instruments used to make cement mortar cube with additional of various percentages of seashell powders. Compressive strength of cement mortar cube is mainly investigated on this study. Thus, comparison will be made between control samples and cement mortar with various percentages of seashell powders.

3.2 RESEARCH DESIGN

The research design that will be used is experimental which is related to our objectives study. The objectives of this research are to identify the best compressive strength of cement mortar with various percentages of seashell powder, to determine modulus elasticity behaviour of cement mortar and to investigate the time to failure against force of cement mortar.

3.3 MATERIALS PREPARATION

The raw materials used to produce cement mortar cube include Ordinary Portland Cement (OPC), sand, water and seashell powder.

3.3.1 Cement

Cement is one of the essential components of concrete production. The cement and water react together chemically to cement paste. There are many varieties of cement such as gray Ordinary Portland Cement, White Portland Cement, Oil-well Cement and Blended Cement. In this study, Ordinary Portland Cement (OPC) is chosen to use as one of the raw materials in cement mortar. The picture of Ordinary Portland Cement is shown as below.

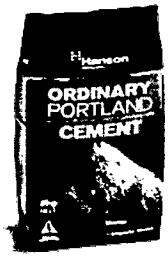

Figure 3.1: Ordinary Portland Cement

3.3.2 Seashell Powder

In this study, seashell powders as waste materials are used as additional material. The seashells are firstly cleaned, dried and then crushed into small pieces by jaw crusher. After crushing, the seashell will be sieved to get 300μm size powder form by vibrator. The percentage of seashell powders used are 0%, 1%, 2%, 3% and 4% by weight of the mix proportion. The picture of seashells is shown as below.

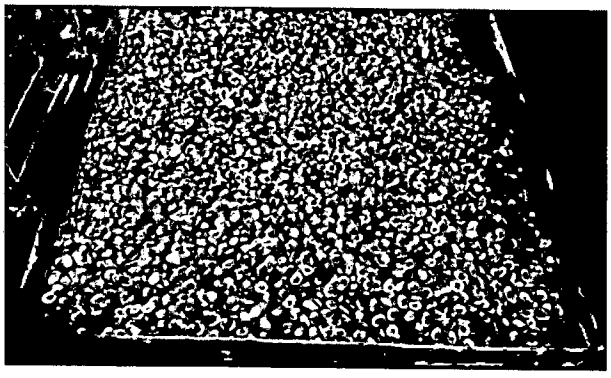

Figure 3.2: Seashell materials

Figure 3.3: Seashell is cleaned using tap water

Figure 3.4: Seashell is crushed into small pieces

3.3.3 Sand (Fine Aggregate)

In this study, fine sand has been collected in Kuantan, Pahang. The sand is dried to remove moisture content in the particles. Sand is considered clean if they are free of excess clay, silt, mica organic matter chemicals salt and coated grains. The picture of sand is shown as Figure 3.5.

Figure 3.5: Fine aggregate

3.3.4 Water

Water is needed to chemically react with cement in order to harden concrete or cement mortar production. Besides that, water will also be used in curing process. The curing process is one of the chemical reactions between cement and water to hydrate the product. Hence, water plays an important role in cement mortar making process. Generally, water with pH of 6.0 to 8.0 is suitable to be used. Tap water is used in this research. Water-cement ratio is 0.40 which is constant for all samples.

3.4 DESIGN MIX PROPORTION

In order to produce cubical molds which are 100mmx100mmx100mm size, they are prepared according to mixture design as shown in Table 3.1. At respective curing day, the average value of three specimens is selected for interpretation.

Table 3.1: Mix designs of various percentage of seashell powder

OPC	Sand	Seashell Powder	W/C ratio
50%	50%	0%	0.40
49%	50%	1%	0.40
48%	50%	2%	0.40
47%	50%	3%	0.40
46%	50%	4%	0.40

3.5 SPECIMEN PREPARATION

3.5.1 Batching

Cement, dried sand and seashell powder will be batched by weight whereas water will be batched by volume. Seashell in the form of solution will be mixed with water and will be used in preparation of cement mortar. In order to produce accurate amount of cement mortar, the total number of test specimens has to be determined primarily.

3.5.2 Mixing Process

The components used in the research will be weighed based on ratio as calculated. Then it will be mixed with mixer for about 5 minutes until it is uniformly distributed. The water will be added in the beginning of process and followed by seashell powders, cement and lastly sand. The sand is added before the end of mixing to attain consistent distribution. Then, mixture will be transferred into mould when it is well-mixed. The picture of mixing process using mixer is shown below.

Figure 3.6: Mixing process using mixer

3.5.3 Casting

The cubes will be casted with the various percentage of seashell powder of cement mortar. The mould at first will be filled with cement mortar in two equal layers. After that, the mould will be placed at vibration table to ensure there is no air void presents in the cement mortar. The picture of vibration table is shown as below.

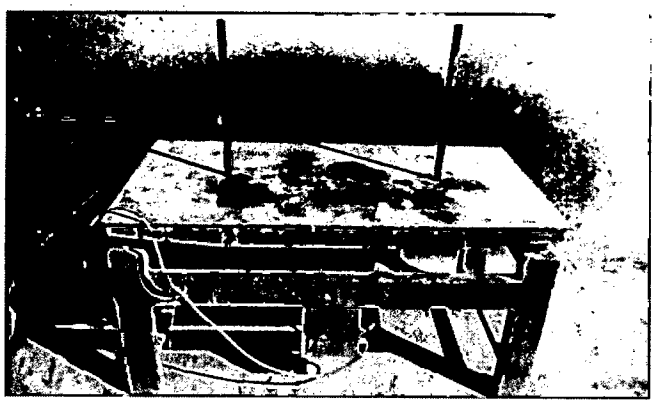

Figure 3.7: Vibration table

3.5.4 Molding

There are few of mould designs for instance cube, cylinder and rectangle that provided in Faculty of Civil Engineering and Earth Resources (FKASA) laboratory. However, cube mould will be used in this research as 100mmx100mmx100mm size of cement mortar cube is going to be produced. The photo of cube mould is shown as below.

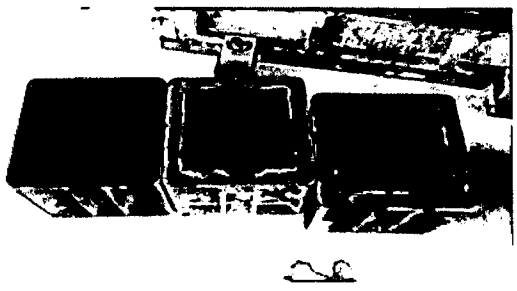

Figure 3.8: Examples of cube mould

3.5.5 Curing

After the test samples have done molded and casted, the samples will be covered with a wet gunny sack. It takes 24 hours for hardening process. The test samples will be placed in the tank and submerges in clear fresh water for duration of 7, 28 and 56 days. The samples will be taken out to be tested for compressive strength test.

3.6 METHOD OF TESTING

3.6.1 Compressive Strength Test

A total of 30 cubes of cement mortar sample including control samples and various percentage of seashell powder which added into cement mortars are tested. All the samples are tested at purposed ages which are 7^{th} and 28^{th} days by using Universal Testing Machine (UTM) which is located at Concrete Laboratory of University Malaysia Pahang.

Before the cement mortar samples are tested, the weight and dimension of each sample are measured. During the compressive testing, an increasing of compressive load is applied to the cement mortar samples until failure happens to obtain the maximum compressive load. The maximum compressive loads are recorded and analyzed using software to present in graph form. Besides that, from the testing, modulus of elasticity can be obtained and time required for failure also recorded to achieve research objectives. The figure of equipment that used to test compressive strength is shown as below.

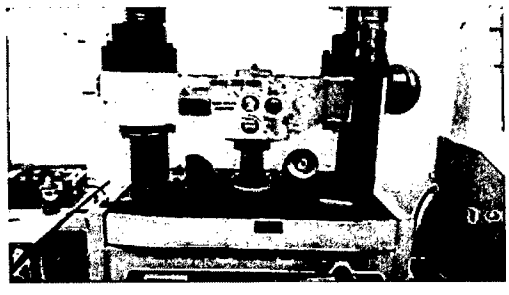

Figure 3.9: Universal Testing Machine with cement mortar