MODIFICATION OF COMPRESSIVE STRENGTH OF CEMENT MORTAR BY OIL PALM SHELL ASH

LIM YEN PING

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ABSTRACT

Oil palm shell (OPS) ash is one of the waste products from industry sector during the palm oil extraction process. Since the ash is being light and in small size of particle, it is easily to carry away by wind. As a result, the smog causes the air pollution which reduces the visibility and eventually creates traffic hazard. In order to reduce the waste products extracted from the OPS which is being dumped without a proper management, it will cause in the result of atmospheric pollution, if possible, among other applications, to use it as the admixture in the cement mortar. Therefore, in this research, the main characteristics of the cement mortar are presented and compared with those of the additional of admixtures. The experimental study shows the possibility and effect of adding in the OPS into the cement mortar for the improving on its compressive strength. This research was conducted to determine the compressive strength of cement mortar by using different percentage of OPS ash. Besides, the research also examines the modulus of elasticity behavior on cement mortar with the present of admixture. The size of cube specimens used was 100mm x 100mm x 100mm. About five types of sample which containing 0%, 1%, 2%, 3% and 4% of OPS ash were tested. Meanwhile 0% of OPS ash was used as the control sample. Compressive strength of the cement mortar made with and without OPS ash was determined at 7 and 28 days. The findings revealed that the 4% proportion of OPS ash added in the cement mortar is suitable. The compressive strength for mix type of 46% cement + 50% sand + 4% OPS ash reached a maximum value which is 46.378 MPa and much greater than mix type of 50% cement + 50% sand (control sample) which possesses 42.839 MPa. The OPS ash up to 4% does not have negative effect on cement mortar quality. The time to failure increases with the increases of force applied. It showed a positive result on the modulus of elasticity towards cement mortar.

ABSTRAK

Abu tempurung kelapa sawit (OPS) adalah salah satu bahan buangan yang boleh diperolehi dari sektor industri pemprosesan minyak kelapa sawit. Sifat abu dan habuk kelapa sawit yang memiliki saiz zarah yang kecil dan ringan menyebabkan ia mudah tersebar ke udara. Tanpa pengurusan yang bijak oleh pihak industri dalam pelupusan bahan buangan ini memberi kesan kepada pencemaran udara. Kabus yang terhasil dari abu dan habuk tempurung kelapa sawit yang terkumpul akan meningkatkan risiko berlakunya jerebu, kesesakan pernafasan, mengurangkan jarak penglihatan pengguna jalanraya dan menyumbang kepada kesesakan lalu lintas. Oleh itu, hasil penyelidikan dan inovasi memungkinkan ia dapat digunakan sebagai bahan tambah dalam simen mortar. Dalam kajian ini, ciri-ciri utama simen mortar dipertengahkan dan dibandingkan setelah dicampurkan dengan bahan tambah. Kajian ini menunjukkan kesan penambahan abu OPS ke dalam simen mortar bertujuan untuk meningkatkan kekuatan mampatan dengan menggunakan peratusan abu OPS yang berbeza-beza. Selain itu, kajian ini juga bertujuan mengkaji tindak balas modulus keanjalan simen mortar. Saiz kiub spesimen yang digunakan adalah 100mm x 100mm x 100mm. Lima jenis sampel yang mengandungi 0%, 1%, 2%, 3% dan 4% abu OPS telah diuji. Sementara itu, kiub yang mengandungi 0 peratus abu OPS bertindak sebagai sampel kawalan. Kekuatan mampatan simen mortar pada setiap sampel yang mengandungi peratusan abu OPS yang berbeza-beza ditentukan pada hari ke-7 dan ke-28 hari. Hasil kajian mendapati bahawa sampel yang mengandungi 4% abu OPS ditambah dalam simen mortar menunjukkan hasil yang positif. Kekuatan mampatan untuk sampel campuran 46% simen, 50% pasir dan 4% abu OPS mencapai nilai yang tertinggi iaitu 46,378 MPa. Nilai kekuatan mampatan yang terhasil adalah lebih besar berbanding sampel campuran 50% simen dan 50% pasir (sampel kawalan) yang mempunyai kekuatan mampatan 42,839 MPa. Abu OPS yang dicampurkan sehingga 4% ke dalam simen mortar sebagai bahan tambah tidak memberi kesan negatif ke atas kualiti simen mortar. Selain itu, ia menunjukkan kesan positif terhadap modulus keanjalan dengan peningkatan tempoh masa kegagalan apabila beban dikenakan terhadap sampel simen mortar yang mengandungi bahan tambah.

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LIST OF ABBREVIATIONS

OPS Oil Palm Shell

OPC Ordinary Portland Cement

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Waste-by-product is considered as any type of materials from human being or industrial activities that has no lasting value. Since the country is developing and growing year by year, so do the amount and type of wastes being generated. Many wastes produced today will remain in the environment for hundreds and perhaps of thousands years. The creation of non-decaying waste materials, combined with a growing consumer population and inadequate management of construction and demolition waste, has affected the environment. These effects may occur at any point in manufacturing product like concrete, whether during the initial phase of obtaining raw materials, during the transformation and phase, or when the manufacturer must dispose of the unused products.

1.2 BACKGROUND OF STUDY

In tropical countries, palm oil plays an important role in the development of economic. For example, palm oil is one of the natural resources that can be finding in Malaysia in a huge of quantity. However, during the process of oil-palm fruit extraction, palm oil mill produces a considerable amount of solid waste by-products. Those waste products are in the form of nutshells, fibers, and empty fruit brunches. The nutshells and fibers are widely used as fuel for the production of steam in the palm oil mills. After combustion in the steam boiler, the oil palm ash is being produced and yet it is thrown in open area without an adequate management on it. This phenomenon seriously affected the environment of surrounding.

On the other hand, the practice of dumping with inadequate management of waste products from the various manufacturing sectors provides a negative impact and leading to the existing of environmental problems. Adding of waste material in the cement mortar not only increase its quality, but also helps to properly solve the problem of inadequate management of waste products. Besides, with the development of green technology that is being widely promoted in recent years, using of these waste products in the construction field may come out with a result of save the production cost and even improve the quality of the products.

1.3 PROBLEM STATEMENT

Payam (2011) states that almost 80% of the volume from the processing of the fresh fruit bunch is removed as waste. Oil palm shell (OPS) ash is one of the waste products from industry sector during the palm oil extraction process. Since the ash is being light and in small size of particle, it is easily to carry away by wind. As a result, the smog causes the air pollution which reduces the visibility and eventually creates traffic hazard.

In order to reduce the waste products extracted from the OPS which is being dumped without a proper management, it will cause in the result of atmospheric pollution, is possible, among other applications, to use it as the admixture in the cement mortar. Therefore, in this research, the main characteristics of the cement mortar are presented and compared with those of the additional of admixtures.

The experimental study shows the possibility and effect of adding in the OPS into the cement mortar for the improving on its compressive strength. The investigation from previous research showed that cement mortar can be partially replaced by oil-palm shell and finer ash for cement mortar making. However, this research presents the study on the effect of OPS ash as an admixture on the cement mortar.

1.4 RESEARCH OBJECTIVES

The research objectives of this study are:

i. To determine the compressive strength of cement mortar by using different percentages of oil-palm shell (OPS) ash.
ii. To examine the modulus of elasticity behaviour on cement mortar with the present of admixture.
iii. To find the relationship between time to failure against force towards the cement mortar.

1.5 SCOPE OF STUDY

This study mainly focuses on the compressive strength of cement mortar when the admixture of oil-palm shell (OPS) ash is added in. Five types of sample which containing 0%, 1%, 2%, 3% and 4% of OPS ash are prepared and tested. Meanwhile, the samples for 0% of OPS ash are used as the control sample. The size of OPS ash used is passing the sieve of 300μm.

The scope of this study includes the following procedures:

i. Raw material such as water, admixture, fine sand and Ordinary Portland Cement are mixed accordingly.
ii. For every percent of samples, three samples are made for the testing for 7 and 28 days.
iii. The size of cube specimens used is 100mm x 100mm x 100mm.
iv. Universal Tensile Machine (UTM) is used to carry out the cube test to measure the strengthening for each cube.

1.6 EXPECTED OUTCOMES

The important parameter is that the specific surface area of OPS ash is finer than the Ordinary Portland Cement. OPS ash has spherical in shape. Its fineness is almost similar to the fineness of Ordinary Portland Cement. Hence, it shows positive effect to the workability of the cement mortar. It also contributes to the full compaction of

cement mortar. Besides, OPS ash is a good pozzolanic material. It has good pozzolanic properties to be acted as partial replacement of cement in cement mortar. When OPS ash is added in the cement mortar, there is a considerable environment and economic benefit. In general, the OPS ash shows a positive affect towards the compressive strength of cement mortar.

1.7 SIGNIFICANCE OF STUDY

Using OPS ash in cement mortar offer a series of benefits such as reduction in the use of raw materials and contributing to an economy of natural resources. Besides, this method gains importance because it protects the environment and eliminates the disposal of wastage due to the OPS ash are unusable in other cycles of production. Therefore, they are useless in practice and lead to disposal of wastage which causes damages to the environment. Moreover, it also protects the natural resources and save the cost of Ordinary Portland Cement. Although the cost of Ordinary Portland Cement is not very expensive and it is not necessary to added in the OPS ash as partial replacement of Ordinary Portland Cement, it becomes important and practical in future when there is a shortage of Ordinary Portland Cement.

1.8 CONCLUSION

This chapter has explained the background information of the research itself in terms of disposal of OPS ash problem and the properties of OPS ash. Problem statement, research objectives and significance of research are discussed to explain the purpose and needs of this research. Lastly, the scope of the research and expected outcomes are stated to ensure that the research objectives could be achieved.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Nowadays, the variety of waste materials has been suggested as viable, or even beneficial, additives to cement mortar. OPS ash is one of the waste materials investigated for its potential use in construction field. The cement mortar is mixed with OPS ash in different volume proportions. Many researchers found that partially replacing the Ordinary Portland Cement in cement mortar with OPS ahs can improve its quality by increasing its compressive strength.

Over a recent year, significant emphasis has been placed on the use of recycled products in highway and construction materials. Waste materials such as plastic, glasses, ceramic tiles, oil palm shell and so forth may be used with the conventional materials either as aggregate, sand or cement replacement. Due to the increasing of oil palm shell waste around the world, the existence of it in the cement mortar may decrease the number of cement used and automatically reused them. Further study about the OPS ash as additive in cement mortar is needed to investigate the impact of cement mortar with ceramic waste on construction and how does it bring advantages in construction.

2.2 MATERIAL

2.2.1 Cement Mortar

Cement mortar is made from a mixture of Ordinary Portland Cement, sand and water. It is also known as Portland cement mortar. It can be used to fill the gap and

between the constructions block or bind them together. In the ancient years, the very first mortar was made of clay and mud. Due to the lack of abundance clay and stone, they had used the pitch or lime for mortar during the construction of baked brick. Besides, in the early Egyptian pyramids, limestone blocks were bounded by the mortar of clay and mud, or sand and clay. However, in later Egyptian pyramids, the mortar was made by lime or gypsum. Gypsum mortar is soft and it required the mixture of sand and plaster.

In addition, Portland cement mortar was invented in 1794. It was a result of various scientific efforts to develop stronger mortars than existed at the time. The outstanding advantages of this Portland cement mortar were that it allows a faster pace of construction and sets hard and quickly. Different ratio of cement, sand, lime and water in each cement mortar produces their own strength respectively. The formulations for each type are specified by the ASTM standards organization.

Moreover, when cement mortar is mixed with the present of aggregates, it will bind with the aggregates and formed concrete. Concrete is an artificial conglomerate stone that is one of the most commonly used structural materials (Scrivener, 2006). It is a very low impact material compared to other materials such as steel, wood and others. Besides, concrete is a sustainable building material because it has greater durability and long lasting structures that will not ruse and burn (He, 2012). It also ensures longevity which is an integral part of reducing cost and use of resources in a project.

2.2.2 Oil Palm Shell Ash as Admixture of Cement Mortar

Oil palm is the most important product of Malaysia that has helped to change the scenario of its agriculture and economy. However, despite the obvious benefits, oil palm mill significantly contributes to environmental degradation, both at the input and the output sides of its activities. It contributes to large quantities of solid waste, wastewater and air pollution. According to N. Abdullah; F. Sulaiman, oil palm waste is a reliable resource because of its availability, continuity and capacity for renewable energy solution.

Besides, it was estimated that over 4.56 million tonnes of waste oil palm shell is produced annually. Almost 80% of the volume from the processing of the fresh fruit bunch is removed as waste (Payam Shafigh, 2011). Those waste products are dumping at the open area and become the waste disposal. However, the current waste disposal practice of incineration within the industry is normally done in an uncontrolled manner and contributes significantly to atmospheric pollution.

In addition, oil palm shell ash is the ashes produced from husk fibre and shell of palm oil burning by generation plant boiler which generate energy to be used in palm oil mill in order to extract palm oil. According to Basri (1998), the effect of oil palm shell ash as partial cement replacement has better workability while its 28 days air dry density was 19 – 20% lower than ordinary cement mortar. Therefore, oil palm shell ash can be used as an admixture of cement mortar.

Moreover, oil palm shell ash have the potential to be used as recycle construction materials as pozzolans. It is found having a high pozzolanic material and it is not just can be used as partial cement replacement but also can increase the compressive strength and durability of cement mortar. The application of pozzolans in concrete give the better result in 30% optimum mixing which is more 10% better than the normal cement mortar.

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.

From the previous research, Sooraj (2013) revealed that oil palm shell ash is an excellent pozzolanic material and can be used as an alternative cement replacement in cement mortar. The result showed that at 28 days, up to 20% replacement of cement by oil palm shell ash achieved a compressive strength of 30 MPa. However, when more

than 20% is replacing, the compressive strength goes below than targeted strength of 30 MPa. Hence, it is recommended that the optimum replacement level of Ordinary Portland Cement by oil palm shell ash is 20% for a good strength in compressive test.

Besides, Ahmad et al. (2008) studied that cement mortar with 15% replacement gave the highest compressive strength and only series of concrete incorporating of fly ash surpass the strength of oil palm shell ash cement mortar. However, by adding oil palm shell ash into the mixture, it gave the compressive strength up to 45 MPa at 28 days of curing.

In addition, blended cement containing ash derived from oil-palm waste shows satisfactory setting times and soundness test results. Joo-Hwa Tay; Kuan-Yeow Show (1994) showed that compressive strength of the cement moratr decreases with the ash content in the cement. Up to 10% by weight of ash addition, no adverse effect on the strength was observed for the cured for 1 years. The results suggest that the ash could possibly be blended in small amounts with ordinary Portland cement for cement mortar making.

2.3.2 Properties of Cement Mortar with Admixture of Oil Palm Shell Ash

From the previous research, they found that the specific surface area of oil palm shell ash is finer than the Ordinary Portland Cement. The ash is spherical in shape and its fineness is almost similar to the Portland cement fineness. The spherical shape will help the workability of the cement mortar and it contributes to the full compaction of cement mortar. In the meanwhile, oil palm shell ash with a suitable fineness has been used as a pozzolanic material to produce high strength concrete as high as 100MPa at 90 days (Awal, 1997; Jaturapitakkul, 2007; Sata, 2007)

Besides, from the experimental laboratory studies, it shown that oil palm shell ash has good pozzolanic properties which have the potential to act as the replacement of cement in mortar and cement mixes. Sumadi et. al (1993) found that from the aspect of physical properties and chemical analysis, oil palm shell ash is a pozzolanic material. This pozzolanic material can be grouped to Class C and Class F as specified in ASTM

C618 (ASTM, 2001). In addition, oil palm shell ash is moderately rich in silica content meanwhile lime content is very low as compared to Ordinary Portland Cement (Awal; Hussin, 1997).

Furthermore, according to Chindaprasirt et al. (2008), he studied the ability of oil palm shell ash mortar to resist the chloride ions penetration. The results showed that the resistance to chloride penetration of oil palm shell ash mortar was substantially improved. All researchers attributed the improvements in oil palm shell ash mortar and cement mortar behavior to the pozzolanic reaction where the hydration products react with the silica contained in oil palm shell ash resulting highly dense and impermeable matrix.

2.4 CONCLUSION

Based on the literature review above, the properties of cement mortar mixed with OPS ash are closed to the conventional cement mortar. However, the Ordinary Portland Cement cannot fully replaced by the OPS ash in cement mortar production. It is suggested to use the Universal Testing Machine to conduct the experiment due to the accuracy in determining the exact amount of OPS ash required to produce optimum strength of cement mortar. In addition, it is time and cost saving and feasible as the test can be conducted in the concrete lab. The replacement of waste OPS ash could provide a more economical product and environmental friendly besides in reduction of landfills in future.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will discuss on the materials, method of testing and instrument used in preparation of cement mortar specimens. OPS ash is used as the additive in cement mortar by partially replaced with Ordinary Portland Cement. Compressive strength of cement mortar is mainly focused on this research.

3.2 RESEARCH DESIGN

The research design which will be used is experiment related to our purpose of study. The purpose of this study is to determine the compressive strength of cement mortar by using different percentage of oil-palm shell ash. Besides, this research study is also to examine the modulus of elasticity behaviour on cement mortar with the present of admixture.

3.3 MATERIAL SELECTION

The raw materials used in cement mortar mix to produces cement mortar cubes will comprise of Ordinary Portland Cement (OPC), water, sand and oil-palm shell ash.

3.3.1 Cement

There are many types of cement which are artificially manufactured. For example, gray Ordinary Portland Cement, white Portland cement, masonry or mortar,

oil-well cement and so on. Generally, cement can be illustrated as a material with bonding agent and cohesive properties, which make it proficient of bonding mineral fragments into a solid whole. In this research, Ordinary Portland Cement (OPC) will be used in the cement mortar mix. When water is added to the cement and constituents are mixed to form cement paste, chemical reaction known as hydration takes place and the mix becomes stiffer with time and sets (Setareh et al., 2007). Besides, cement used must not contain excessive quantities of certain substances such as lime, magnesia, and calcium sulphate that may expand on hydration or react with other substances in the aggregate and cause the cement mortar to disintegrate (Setareh et al., 2007). Figure 3.1 shows the picture of Ordinary Portland Cement.

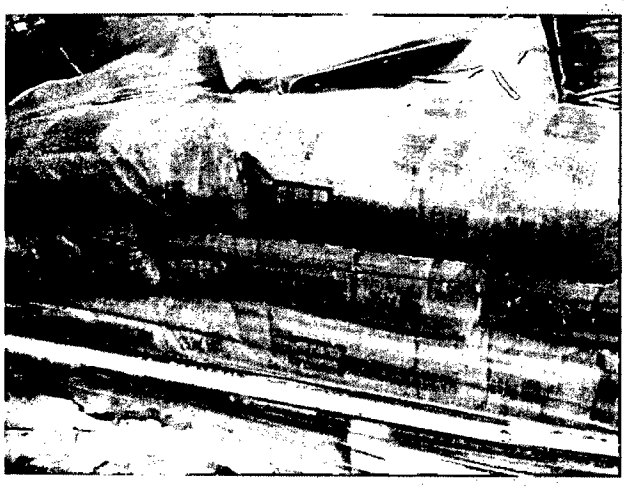

Figure 3.1: Ordinary Portland Cement

3.3.2 Water

Supplied tap water will be used during the mixing, curing and other processes. The function of water is to utilize for hydration of cement causing it to set and harden. The remaining water must be kept to the minimum, as too much water reduces the strength of cement mortar. Besides, Surahyo (2002) also noted that water used in cement mortar mix should be clean and free from objectionable quantities of organic matter, silt, clay, acids, alkalis and other salts and sewage. Generally, water with pH of 6.0 to 8.0 which does not taste saline is suitable for use.

3.3.3 Sand

Sand is an important element in affecting strength of the cement mortar cube. In this research, fine sand was collected in Kuantan, Pahang. Sand are considered clean if they are free of excess clay, silt, mica organic matter chemicals salt and coated grains. Figure 3.2 shows the picture of fine aggregate.

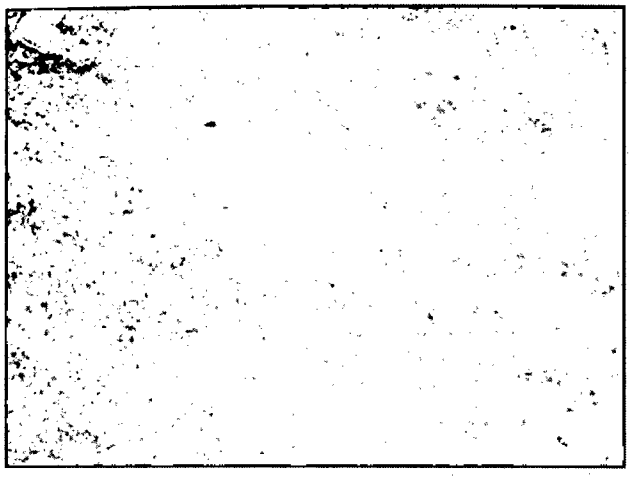

Figure 3.2: Fine Aggregate

3.3.4 Oil Palm Shell Ash

In this research, oil-palm shell ash acts as an admixture in the cement mortar. Oil palm shell ash is sieved by size of 300 μm. It also was kept in an airtight container and stored in the humidity controlled room to prevent from being exposed to moisture.

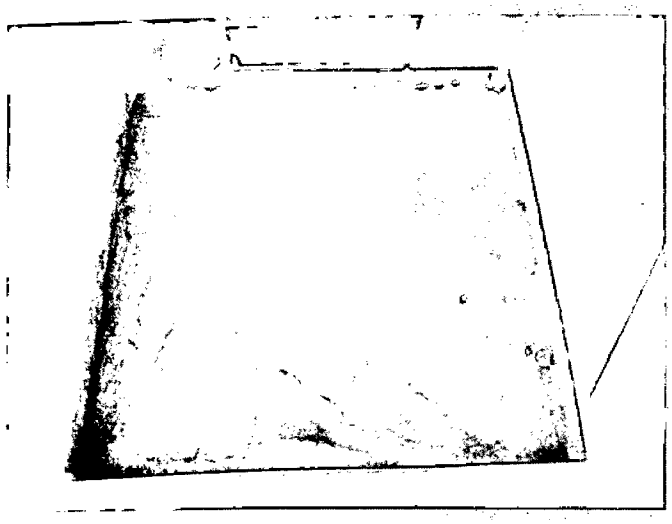

Figure 3.3: Oil Palm Shell Ash

3.4 SPECIMEN PREPARATION

The sample preparation is conducted in the FKASA concrete lab in Universiti Malaysia Pahang. Oil-palm shell ash is sieved passing 300 μm before stored in a dry place. Water cement ratio of 0.4 is used to prepare five mixture proportions of cement mortar which contains 0%, 1%, 2%, 3% and 4% of oil-palm shell ash as an admixture by weight of the total cementitious material in the production of cement mortar. Each mixture proportion contains 3 cubes of sample for the testing at 7 and 28 days. Samples for 0% of oil-palm shell ash are used as the control sample.

The materials used for each mix proportion are weighted based on the cement mortar mix design as calculated. Firstly, water is poured into the stirrer machine following by the admixture of oil-palm shell ash and mixed for about one minute. After that, cement is poured slowly and mixed until it is fully mixed with the water and admixture. Finally, sand is poured slowly and stirred until it is well-mixed.

The dimension of mould used is 100mm x 100mm x 100mm. The moulds are filled with ready-mixed cement mortar in three equal layers and vibrated using the vibration machine to remove the air which is enter during the casting process. Once the cubes are finished cast, they are covered with a damp cloth. It will be taken out after 24 hours and then immersed in the water until the testing is done.