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**INTI INTERNATIONAL UNIVERSITY**

Faculty of Science, Technology, Engineering & Mathematics

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**EXPERIMENTAL INVESTIGATION ON THE PROPERTIES  
OF CONCRETE WITH COCONUT SHELL AS  
REPLACEMENT FOR COARSE AGGREGATES AND PALM  
OIL FUEL ASH FOR CEMENT**

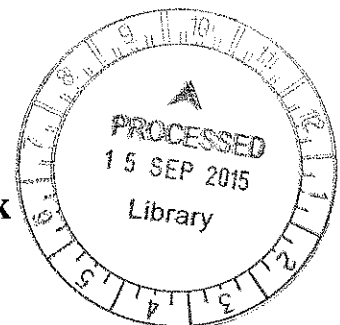
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## ABSTRACT

This research involves the investigation of coconut shell and palm oil fuel ash in the production of light weight structural concrete. The aim of this research is to discover more sustainable materials that can be used in the construction industry. These materials have to meet up with the standard qualities that the current materials are offering and provide ease of access to the material and also to be economical.

The laboratory experiment was conducted on concrete that was incorporated with different composition of C.S. and POFA replacement for the coarse aggregate and cement relatively. The percentages that were analysed are 0%, 10% and 20% of C.S. combined with 10%, 15% and 20% of palm oil fuel ash. These ratios were calculate using weight and a target compressive strength of 20 MPa on day 28 using ordinary Portland cement, the mix proportions of the concrete are based on the D.O.E mix design to determine the weight required for each materials. The mechanical testing for the samples involved compressive strength, flexural strength and slump test to determine workability. All specimens were cured in water and there are 3 cube samples for compressional test and 2 beam samples for flexural test were tested for each set of samples on day 7, day 14 and day 28.

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## CHAPTER 1 INTRODUCTION

The research of adding coconut shell to concrete as replacement for coarse aggregates and the palm oil fuel ash as replacement for cement has been purposed as the important of using waste or recyclable materials in the production of concrete. The replacement of the coconut shell and palm oil fuel ash would solve the environmental issue of reducing the solid wastes from the production of the raw materials while not affecting the mechanical strength of the concrete. At the same time the usage of the coconut shell and palm oil fuel ash will promote sustainability and green building in the construction engineering.

The demand of the construction materials such as concrete is keep increasing due to the development of this industry will evolve rapidly in the developing country. Aggregates and cement are the major ingredients for concrete. The production of aggregate and cement will cause environmental impact such as noise pollution, water pollution and air pollution. The process of exploitation natural stone will require a lot of energy consumption before it can be served for different purpose. It will cause severe air pollution because it will produce a lot of tiny particle or powder during the process of crushing natural stone and it will affect and disrupt the growth of flora and fauna around the area. At the same time, the operation of the machine will produce a very high frequency noise that will cause the noise pollution. Some of the aggregate is combined with the soils and it need to be washed before it can be used for the construction, a lots of water is consumed and it will cause water pollution because the waste will flow into stream. The composition of the cement is mainly calcium oxide, silicon dioxide and aluminium oxide. These compounds can be found from the natural materials such as limestone, clay, mudstone and shale. The extraction of large amount material will cause environment issue too and high energy is required to produce the cement. Hence, it is important to find the alternative materials that is more environmental friendly and less energy consumption as replacement for using coarse aggregate and cement. Besides that, the excavation of the raw materials can be reduced when the replaced materials is used for the concrete.

## 1.1 BACKGROUND INFORMATION OF THE MATERIALS

Coconut is an organic product from the fruit of the coconut palm, which belongs to family *Arecaceae*. The coconut is suitable to grow in the tropical climate like South East Asia and the largest producer is the Philippines and Indonesia is the second largest producer. The coconut is normally use for culinary, non-culinary and handicrafts or decoration purpose. Coconut have very high economic value because coconut can be fully utilised, such as shells of the coconut is one of the fuel source and raw material for the charcoal. The coconut fibre is used to manufacture mattress and rope. The density of the coconut shell is about 1.60 g/cm<sup>3</sup>.

Oil palm tree is a species of palm and the scientific name is *Elaeis guineensis*. Palm oil fuel ash is the waste material from the extraction of palm oil, which is the combination of burnt palm oil shell and palm oil husk in the boiler of palm oil mill. The waste is about 70% of its weight during the extraction of the palm oil in the form of empty fruit branches, fibre, shell and liquid effluent. The quantity of the waste is huge because Malaysia is the second largest producer in the worlds. The method to handle the residues is mostly burnt in open space or disposed into ponds. Hence, many research has been conducted for the potential of palm oil fuel ash and it commercial value.

Cement acts as bonding agents that is mixed with water or other liquid, or both, to become a viscous cementing paste. It can be formed or molded into various shapes while plastic but will set into a rigid shape. Generally there are various type of cement available in the market, such as Portland cement, aluminous cements, coloured Portland cements, limes, gypsum cements and Pozzolan or artificial Pozzolan cements. Among these ordinary Portland cements type I and II are commonly used for structural construction. Besides that, ordinary Portland cement is classified into 33, 43, and 53 three main grade.

Concrete is the mixture combine of the materials such as fine aggregate, coarse aggregate, cement and water. Concrete is widely used for making various types of structures that served different purposed, such as foundations used to transfer the loads from the building to the strong layer of soil, surface of the highways, runways and water retaining structure likes dam and reservoirs. The strength of the concrete is normally between 25N/mm<sup>2</sup> to 50N/mm<sup>2</sup> and it is depends on the function of the structural. The

different strength of the concrete can be achieved by adjust the ratio of the aggregates, cement and water.

## **1.2 PROBLEMS STATEMENT**

Concrete is the most common material in the construction industry. The composition of the aggregate, cement and water will decide the strength of the concrete. In our country, Malaysia, more building is being built as our country develop rapidly, and this eventually consume a lot of raw material such as steel reinforcement bar, cement, coarse and fine aggregate, and wood formwork for the structural and architectural construction. As the same time, it create a lot of material waste and cause pollution to our environment. The sustainability of the materials are become the main concern of this industry at the era of the resource depletion while the demand of the materials is increasing. As the result, the necessity to try and find alternative materials in construction such as coconut shell and palm oil fuel ash. Coconut shell and palm oil fuel ash can be found in the form of by-product abundantly in Asia, especially in our country. Both of this two is the naturally available materials and it is lighter and noncorrosive. The materials is cheaper since it is the waste materials of others' products. The main aspect of this research will be focused on the performance and viability of the coconut shell and the palm oil fuel ash when they are mixed in concrete randomly. This will help to explore the potential of the new environmental friendly materials for construction and find the economic values of the by-product of the palm oil and coconut.

## **1.3 AIM**

The aim of this research is to look for the material characteristic of the concrete when coconut and shell palm oil fuel ash are mixed into it. Different composition of coconut shell and palm oil fuel ash are added as replacement of the coarse aggregates and cement respectively to discover the performance of product whether it is reasonably strong enough and acceptable to be used as one of the materials in construction. In addition, this research desire to determine the appropriate percentage ratio that gives most satisfaction result.

#### **1.4 OBJECTIVES**

- To determine the ratio of the coconut shell and the palm oil fuel ash that gives appropriate mechanical strength such as compression and flexural strength.
- To estimate the workability of different ratios of coconut shell and palm oil fuel ash in fresh concrete.

#### **1.5 SCOPE OF RESEARCH**

This research will perform to investigate the performance of the combination of two materials into concrete, there are coconut shell and palm oil fuel ash. The coconut shell will be crushed until which it pass through 20mm sieve and retain on the 4.75mm (No.4) sieve of the mechanical sieve analysis as the replacement of the coarse aggregates. The palm oil fuel ash is used as a replacement of the cement. Both of the materials will be placed the coarse aggregate and cement respectively using different ratio of 0%, 5%, 10%, 15% and 20%, the ratio is in term of weight but not volume for the calculation of the composition of coconut shell and palm oil fuel ash. A total of 150 specimens will be produced and investigation for physical characteristic of concrete with coconut shell and palm oil fuel ash will be done compare to normal concrete specimens. 90 out of 150 specimens will be tested for compressive strength while the balance will be tested for flexural strength.

## **CHAPTER 2 LITERATURE REVIEW**

### **2.0 INTRODUCTION**

The literature review will look for the information from the past research that have been carried out by the professional research individuals or institutes which are using similar materials for the research. The results obtained from the previous research in relation to the application of coconut shell and palm oil fuel ash will be provided relevant and useful information for the research. In addition, it is a general guidelines of the nature for the steps which will be conducted in this research from the past research that have been done and obtained acceptable and reasonable results. Furthermore, the review included the properties of the coconut shell and palm oil fuel ash, the reasons of finding alternative material for concrete, relevant information of the concrete, the recommended methodologies for the laboratory specimens' test and other applied concepts and analysis of previous research. These information will provide an outline about the research such as the appropriate range of percentage for the replacement materials and the difficulty that will be met during the laboratory's work.

#### **2.0.1 ALTERNATIVE/ SUSTAINABLE MATERIALS**

According to (KIBERT and CHARLES J, 2012) the awareness for sustainable materials for the construction have been risen over passed 2 decades. The development of the sustainable construction is expended internationally and there are almost 60 councils worldwide for the green building. The rapid world population growth rated have significantly increased the demand for accommodation and social activities. It is important to reduce the energy consumption as the construction process will cause the greenhouse effect. The aims of the sustainable construction is to minimize the consumption of the natural resource and the effect on ecological systems. The recycling and reuse of waste product is promoted into construction rather than disposing them into landfill.

According to (MEG CALKINS, 2009) the materials use for the construction should be used efficiently. The durable and renewable waste materials can be replaced the natural resource. The energy consumption is greatly reduced for the waste materials because the process of extraction for the raw materials is not required. The materials used in

construction are preferably not harm human and environmental health at the whole life cycle.

## **2.1 COCONUT**

Coconut is an organic product from the fruit of the coconut palm which is suitable to grow in the tropical climate like South East Asia. The coconut industry is important in developing countries as it have promote economic development. However, the by-product of the coconut industry cause the major problems of pollution as solid waste and coconut shell contribute more than 60% of weight among the solid waste production. It was proposed to use the coconut shell to replace the coarse aggregate in the concrete since the coconut shell's properties meet the requirement for the production of light weight concrete as the same time it help to reduce the environmental issue. Concrete that mixed with coconut shell is suitable for both non-structural and structural application (K.GUNASEKARAN et al. 2011). In addition, (JOSEPH KHEDARI et al, 2001) shown that the concrete mixed with coconut fibre and durian fibre met the basic requirement of construction materials as walls and roofs. The research done by MAJID ALI (2012) proved that the coconut fibre reinforced concrete provided the best properties with a fibre length of 5cm and a fibre content of 5%.

### **2.1.1 COCONUT SHELL**

According to (K.GUNASEKARAN et al. 2010) the materials used to produce light weight concrete is currently volcanic origin material likes pumice and the slug or clinker from expended blast furnace. The by-product from different industries is highly recommended to use as light weight aggregates to achieve more environmental and economical benefits although the current available materials is commercially used. Coconut shell as one of the agriculture waste is highlighted by researchers in this few years to become one of construction materials because it is easily available in tropical countries. Coconut shell have more resistance against crushing compared to normal aggregate. The density of coconut shell is 521.5 kg/m<sup>3</sup>.

According to (AMARNATH YERRAMALA and RAMACHANDRUDU, 2012) studies, increase in coconut shell percentage will decrease density of the concrete.

Workability became lower while coconut shell replacement is increased. Compressive and split tensile strengths of control concrete higher than coconut shell concretes. In addition, coconut shell replaced concretes have higher permeable voids, absorption and sorption than control concrete. The resulted shown above is based on the laboratory experiment of the coconut shell concrete with the replacement of coarse aggregates between 10% - 20% by weight at a water-cement ratio of 0.6. Treatment is not required for coconut shell when used to replace aggregate.

According to (TEJRAJ M. AMINABHAVI and RAMESH C. PATEL, 2004), coconut shell absorb less moisture and more resistant to fire than ordinary cement concrete when it is treated with linseed oil and urea formaldehyde modified resin. Coconut shell were crushed and finely powdered before adding into concrete mix. A high pressure value of 55.2 MPa were applied to obtain uniform bonding. Concrete is tested after 28 days curing under room temperature and results obtained from the laboratory test.



Figure 1: Coconut Shell from Factory.

(Source: Self- taken photo)

## 2.2 PALM OIL FUEL ASH

Oil palm tree is a species of palm and palm oil fuel ash is the waste material from the extraction of palm oil. Palm oil fuel ash have been introduced into concrete construction in recent years as a pozzolanic materials to replacement partial ratio of cement due to the technological advancement and development of the sustainability in the construction industry. Palm oil fuel ash have been proved as a good pozzolanic material to replace ordinary Portland cement because of its siliceous compositions, which have the ability to produce a stronger and denser cement. This agro waste ash by-product would bring benefits to the construction industry in term of reduction in cost for concrete production and reduce environmental impact as the same time it would solve