PALM KERNEL SHELL AS PARTIALLY REPLACEMENT OF FINE AGGREGATES IN CONCRETE

AHMED ASHRAF ZAKI BIN MOHD

B.ENG. (HONS.) CIVIL ENGINEERING

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AHMED ASHRAF ZAKI BIN MOHD

Final Year Report submitted in partial fulfilment of the requirements for the award of the degree of Bachelor of Civil Engineering

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DEDICATION

Million and million thanks of appreciation dedicated for:

The Almighty

Parents

Family

The great supervisor

Beloved friends

for all contribution and supports they had given me doing this final year project.

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ABSTRACT

This final year project discussed mainly about the feasibility of using the palm kernel shell as a partial replacement of fine aggregates in concrete. This studied were used the different percentage of palm kernel shell as a partial replacement of fine aggregates in concrete at 1%, 2%, and 3% by volume of sand. Palm kernel shells are derived from the oil palm tree (elaeis guineensis), an economically valuable tree because of its oil. Palm kernel shells have been used as aggregates in light and dense concretes for structural and non-structural purposes. Palm kernel shell were obtained from the Lepar Hilir palm oil mill and sieved with size between l.5mm to 2.36mm. The objectives of this final year project are to determine the workability, compressive strength and also flexural strength of concrete when adding with 1%, 2% and 3% of palm kernel shell as a replacement of fine aggregates in concrete. All of the testing were followed the British standard. The workability of concrete were tested by using slump test to check the consistency of freshly made concrete. For compressive strength total of 27 cubes with size 150mm x 150mm x 150mm were used to determine the compressive strength of concrete when replace with 1%, 2% and 3% of palm kernel shell as a replacement of fine aggregates in concrete. Then for flexural strength total of 27 beams with size 100mm x 100mm × 500mm were used to determine the flexural strength of concrete when replace with 1%, 2% and 3% of palm kernel shell as a replacement of fine aggregates in concrete. Compressive and flexural strength were conducted at 7 days, 14 days, and 28 days to get the strength of concrete. All of the testing were compared with normal concrete. As the result were obtained, it can concluded that replacement of palm kernel shell with 1% replacement had a probability to use as a sand replacement in construction industry.

ABSTRAK

Projek ini merangkumi kemungkinan penggunaan tempurung buah kelapa sawit sebagai bahan ganti pada pasir di dalam konkrit. Kajian ini dijalankan menggunakan beberapa sampel yang mengandungi peratusan tempurung buah kelapa sawit yang berbeza sebagai pengganti pasir di dalam bancuhan konkrit. Peratusan gentian yang digunakan adalah 1%, 2%, dan 3% daripada jumlah isipadu pasir. Tempurung buah kelapa sawit berasal dari pokok kelapa sawit (Elaeis guineensis), iaitu pokok yang berharga dari segi ekonomi kerana minyaknya. Tempurung buah kelapa sawit telah digunakan sebagai agregat dalam konkrit ringan dan padat untuk binaan struktur dan bukan struktur. Tempurung buah kelapa sawit diperolehi dari kilang pemprosesan kelapa sawit yang terletak di Lepar Hilir dan disaring dengan saiz antara l.5mm sehingga 2.36mm. Objektif projek tahun akhir ini adalah untuk menentukan kebolehkerjaan, kekuatan mampatan dan kekuatan lenturan konkrit apabila diganti dengan 1%, 2% dan 3% daripada tempurung buah kelapa sawit sebagai pengganti pasir di dalam konkrit. Semua ujian yang dijalankan mengikut piawaian *British Standard*. Kebolehkerjaan konkrit telah diuji dengan menggunakan ujian kemerosotan untuk menyemak ketekalan konkrit yang baru dibuat. Untuk kekuatan mampatan sebanyak 27 kiub dengan saiz 150mm x 150mm x 150mm telah digunakan untuk menentukan kekuatan mampatan konkrit apabila diganti dengan 1%, 2% dan 3% daripada tempurung buah kelapa sawit sebagai pengganti pasir di dalam konkrit. Kemudian, untuk kekuatan lenturan sebanyak 27 rasuk kecil dengan saiz 100mm x 100mm × 500mm digunakan untuk menentukan kekuatan lenturan konkrit apabila diganti dengan 1%, 2% dan 3% daripada tempurung buah kelapa sawit sebagai pengganti agregat halus dalam konkrit. Kekuatan mampatan dan lenturan telah dijalankan pada 7 hari, 14 hari, dan 28 hari. Semua uji kaji yang dijalankan dibandingkan dengan konkrit yang biasa. Berdasarkan keputusan yang diperolehi, didapati bahawa penggantian tempurung buah kelapa sawit dengan penggantian 1% mempunyai kebarangkalian yang positif untuk digunakan sebagai pengganti pasir di dalam industri pembinaan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

Mpa	MegaPascal
mm	Milimeter
kg	Kilogram
kg/m^3	Kilogram per meter cubic
kg/cm^2	Kilogram per centimeter square
mm/s	Kilogram per second
°C	Degree Celcius
kN/mm^2	KiloNewton per milimeter square

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Concrete is a composite static material containing of aggregates, water and cement. Concrete has been created a long time ago for constructing various structures around the world, such as, buildings, bridges, dams and etc. Nowadays, some countries are undergoing rapid infrastructure development, thus increase the demand of concrete. As an example, the mass rapid transit project that are being construct in Malaysia required to use mass volume of concrete. The cost of concrete at these days are currently so high probably because of the increasing of demand. Besides, the strength of concrete is important to avoid the natural disasters, such as, earthquake, tsunami, tornadoes and flooding which may cause the people to get hurt or death. So, to overcome this problem, the cheap locally available waste material need to be adopt.

Nowadays, the construction industries have been searching the alternatives product that can help to minimize the cost of concrete. There are some waste material that have been identified which can help to reduce the volume of materials in concrete, such as, coconut shells, egg shells, and etc. Among of the waste material that have been identified, there are known to have good characteristic in increase the strength of the concrete which results in reducing the amount of waste and materials in concrete.

Oil palm is truly a golden crop of Malaysia. Oil palm is grown for its oils. As vegetable oil seed crop, the oil palm is an efficient converter of solar energy into biomass. Besides being a prolific producer palm and kernel oil, it also generates a number of residues and by product. The residues of oil palm industry are from the field and mill.

Palm kernel shells are one of the wastes from palm oil industry, which have long been used as fuel in boiler to produce steam and electricity for mill processes. Palm kernel shell is the hard shell of the oil palm fruit seed that is broken to take out the kernel used for extracting palm oil. Thus, it is the by-products of palm oil processing during which the palm oil is extracted.

1.2 PROBLEM STATEMENT

For thousands of years, sand and gravel have been used in the construction of roads and buildings. Today, demand for sand and gravel continues to increase. Mining operation, in conjunction with cognizant resource agencies, must work to ensure that sand mining is conducted in a responsible manner. Excessive instream sand and gravel mining causes the degradation of rivers and lowers the stream bottom, which may lead to bank erosion. Besides, depletion of sand in the streambed and along coastal areas causes the deepening of rivers and estuaries, thus enlargement of river mouths and coastal inlets. In addition, sand mining also lead to increase of sea level, saline-water intrusion from the nearby sea, and loss to the system.

To overcome this problem, this study will studied the feasibility of using the palm kernel shell as a partial replacement of fine aggregates to reduce the problems.

1.3 OBJECTIVES OF STUDY

i. To determine the workability of concrete when replace with 1%, 2% and 3% of palm kernel shell as a replacement of fine aggregates in concrete.
ii. To determine the compressive strength of concrete when replace with 1%, 2% and 3% of palm kernel shell as a replacement of fine aggregates in concrete.
iii. To determine the flexural strength of concrete when replace with 1%, 2% and 3% of palm kernel shell as a replacement of fine aggregates concrete.

1.4 SCOPE OF STUDY

Based on the objective, this study was conducted to determine the workability and strength of concrete when replace of fine aggregate with 1%, 2% and 3% of palm kernel shell. The scope of work mainly focuses on:

i. The experiments that will be conducted are slump test, compression test and flexural test.
ii. All the testing conducted will be follow British Standard.
iii. The compression test and flexural test will be conducted at 7 days, 14 days and 28 days to get the strength of concrete.
iv. The size of concrete cube will be 150mm x 150 mm x 150 mm.
v. The size of concrete beam will be 100mm x 100 mm x 500 mm.
vi. The cement-aggregates ratios will be 1:2:4, that means, one part of cement, 2 part of fine aggregates and 4 part of coarse aggregates.
vii. The size of palm kernel shell that used were passing sieve 2.36mm.
viii. The percentage of palm kernel shell that will be replace fine aggregate at 1%, 2% and 3% replacement by volume of fine aggregate.

1.5 SIGNIFICANCE OF STUDY

This research will be carried out to examine the feasibility of using the palm kernel shell as a partial replacement of fine aggregates in concrete. This research also determine the workability, compressive strength and flexural strength of concrete when replace with 1%, 2% and 3% of palm kernel shell as a fine aggregates in concrete in order to reduce the demand of sand and the effect of sand mining to ecosystems.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

There have been a number of advances in new concrete technology in the past ten years. There have been advancements made in almost all areas of concrete production including materials, recycling, mixture proportioning, durability, and environmental quality. However, many of these innovations have not been adopted by the concrete industry or concrete users. There is always some resistance to change and it is usually based on cost considerations and lack of familiarity with the new technology (Martin Dawson, 2010).

The latest new concrete technology is beginning to gain acceptance in the industry. Some of the more interesting new concretes are called high performance concrete (HPC), ultra high performance concrete, and geo-polymer concrete. They have significant advantages and little or no disadvantages when compared to standard concrete in use today (Martin Dawson, 2010).

High performance concrete usually contains recycled materials and thereby reduces the need to dispose of these materials. Some of these materials include fly ash, ground granulated blast furnace slag, and silica fume. But perhaps the biggest benefit of using some of these other materials is the reduction in the need to use cement, also commonly referred to as Portland cement. The reduction in the production and use of cement will have many beneficial effects. These benefits will include a reduction in the creation of carbon dioxide emissions and a reduction in energy consumption, both of which will improve the global warming situation. It is estimated that the production of cement worldwide contributes five to eight percent of global carbon dioxide emissions. In addition, the use of fly ash and furnace slag is usually cheaper than cement and they have properties that improve the quality of the final concrete (Martin Dawson, 2010).

Today's new concrete technology has produced new types of concrete that have live spans measured in the hundreds of years rather than decades. The use of fly ash and other by-product materials will save many hundreds of thousands of acres of land that would have been used for disposal purposes. Fly ash and other by-products from burning coal, are some of the most abundant industrial waste by-products on the planet. The elimination of burial sites for these waste by-products will translate into less risk of contamination of surface and underground water supplies. When compared to standard concrete the new concretes have better corrosion resistance, equal or higher compressive and tensile strengths, higher fire resistance, and rapid curing and strength gain. In addition, the production and life cycle of these new concretes will reduce greenhouse gas emissions by as much as 90% (Martin Dawson, 2010).

2.2 CONCRETE

Concrete is a composite inert material comprising of water, cement and aggregate. Often, additives and reinforcements are included in the mixture to achieve the preferred physical properties of the finished material. When these ingredients are mixed together, they form a fluid mass that was easily molded into shape. Usually, the concrete forms was a hard medium which binds the rest of the ingredients together into a durable stone.

Concrete is used more than any other man made material on the planet. The annual consumption of concrete is as much as two tones per person per year globally. Conventional concrete generally use widespread as the building construction materials on site which produced by following the instructions that usually consists of cement, sand or other common material as the aggregate, and often mixed with additives. Commonly conventional concrete have high self-weight due to the normal aggregates weight, use and cost for conventional production is really high.

Concrete has unlimited opportunities for innovative applications, design and construction techniques. Its versatility and relative economy in meeting wide range of needs has made it a very competitive building material. Both natural and artificial aggregates are used in the production of concrete in the construction industry. Fine and coarse aggregates which generally occupy 60% to 75% of concrete volume strongly influence concrete's freshly mixed and hardened properties as well as its mix proportions and economy (A. Acheampong et al., 2013).

2.3 WASTE MATERIAL WITH PARTIALLY REPLACEMENT

Nowadays, there are some waste material which are being identified to be replace of fine aggregate in concrete production. As an example, according to D. Dahiru and J. Usman (2012), polymer waste material were identified to be partial replacement of fine aggregate in concrete production. Polymer waste material which are include polyethylene packing bags and pure water bags were collected from dump and processed to be fine aggregate with size 4.75mm. The result showed increase of 30% of polymer waste material leads to decrease of 53% compressive strength and decrease of 73.3% in tensile strength (D. Dahiru and J. Usman, 2012).

According to Sadoon Abdallah and Mizi Fan (2014), waste glass were studied to be replace of fine aggregate in concrete production. Waste glass which from used windows were used as a material of the study. The result showed the increase of percentage of replacement of waste glass would increase the compressive strength of concrete.

According to Sreekrishnaperumal Thanga Ramesh, et al. (2013), furnace slag and welding slag were studied to be replace of fine aggregate in concrete production. Furnace slag and welding slag were collected from local fabrication industries were used as a material. Normal concrete with zero replacement were used as a reference materials. The result showed the better performance of the concrete as a partial replacement of concrete. The compressive strength on seventh day of concrete cubes increases from 10% to 15% replacement of sand by welding slag than the reference materials. Similarly 10% of furnace slag showed an optimum strength of 21.1 N/mm2. The compressive strength on

28th day of concrete cubes increases from 5% to 15% of replacement of sand by welding slag than the reference materials. The optimum compressive strength of slag concretes has been found to be 41 N/mm2 for 5% welding slag and 39.7 N/mm2 for 10% furnace slag. The results show that 5% of welding slag and 10% furnace slag replacement with sand is very effective for practical purpose.

Then, according to Dr. Festus A. Olutoge, et al. (2012), palm kernel shell ash can be used as a replacement of cement. Palm kernel shell which were collected from palm oil mill were burnt and grinded into fine ash particles. Palm kernel shell ash were sieved through 45um sieve in order to remove any foreign material and bigger size ash particles. The result showed the concrete strengths were increased with the increase of curing age but were decrease with increasing percentage of palm kernel shell ash in concrete.

2.4 CEMENT

Cement is a binder, a substance that sets and hardens and can bind other materials together. Cements used in construction can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to be used in the presence of water. Non-hydraulic cement will not set in wet conditions or underwater, rather it sets as it dries and reacts with carbon dioxide in the air. It can be attacked by some aggressive chemicals after setting while the hydraulic cement is made by replacing some of the cement in a mix with activated aluminium silicates, pozzolanic, such as fly ash. The chemical reaction results in hydrates that are not very water-soluble and so are quite durable in water and safe from chemical attack. This allows setting in wet condition or underwater and further protects the hardened material from chemical attack (S. P. Arora, 2010).

There are many types of cements were available in markets with different compositions and for use in different environmental conditions and specialized applications such as ordinary Portland cement, rapid hardening Portland cement, low heat Portland cement, sulphate resisting Portland cement, pozzolanic cement, white Portland cement etc. As an example, ordinary Portland cement which is made by heating limestone with small quantities of other material such as clay, is the most common type of cement in general use around the world (S. P. Arora, 2010).

2.4.1 Chemical Composition of Portland Cement

Generally, the chemical compositions of Portland cement were varying due to supply from different manufacturers. Normally Portland cement contained the highest content of limestone, alumina and silica.

Table 2.1: General Composition Limits of Portland Cement

Oxide	Content, %
Calcium Oxide (CaO)	60 - 67
Silicon Dioxide (SiO_2)	17 - 25
Aluminium Oxide (Al_2O_3)	3- 8
Ferric Oxide (Fe_2O_3)	0.5 – 6.0
Magnesium Oxide (MgO)	0.5 – 4.0
Sodium Oxide (Na_2O)	0.3 – 1.2
Sulphur Oxide (SO_3)	2.0 – 3.5

Source: Lim Ooi Yuan, (2012)

A general idea of the composition of cement is presented in Table 2.1 (Lim Ooi Yuan, 2012). The content of limestone was the highest, followed by silica and alumina.as these chemical compositions are important for the formation of calcium silicate hydrate gel during hydration process. Besides, Portland cement also contain small content of iron, magnesium, and sodium.

2.5 COARSE AGGREGATES

Coarse aggregates are materials retained on 5mm (3/16 inches) test sieve and containing only so much finer material as permitted from the various sizes.

Table 2.2: Type of Coarse Aggregate and Source

Types	Source
Uncrushed gravel	From natural disintegration of rock
Crushed stone	From crushing of gravel or hard stone
Partially crushed gravel	Product of the blending of the uncrushed and crushed gravel

Coarse aggregate may be described into three major part which are uncrushed gravel, crushed stone or crushed gravel and partially crushed gravel when it is the product of bending of uncrushed and crushed gravel. Table 2.2 shows the different type of coarse aggregate and their source which all of them are from rock. According to Suryakanta, (2014), size coarse aggregate is described as graded aggregate of its nominal size. As an example, a graded aggregate of nominal size 20 mm means an aggregate most of which passes 20 mm sieve.

2.6 FINE AGGREGATES

Sand may be described into three major parts, which are natural sand, crushed stone and crushing gravel sand.

Table 2.3: Type of Fine Aggregate and Source

Type	Source
Natural sand	From natural disintegration of rock
Crushed stone sand	From crushing of hard stone
Crushed gravel sand	From crushing of natural gravel

Table 2.3 shows the different type of coarse aggregate and their source which all of the fine aggregate are from rock. According to Suryakanta, (2014), commonly, fine aggregate passed 4.75mm sieve and contains only so much coarser as is permitted by specification. Normally, river sand and crushed sandstone with fineness modulus of 1.78 were passed through a 2.36 mm sieve analysis. Commonly, material used are having maximum particle size with 2.36 mm diameter.

Figure 2.1: Natural Sand

Figure 2.2: Crushed Stone Sand

2.7 WATER CEMENT RATIO

The water–cement ratio is the ratio of the weight of water to the weight of cement used in a concrete mix and has an important influence on the quality of concrete produced. A lower water-cement ratio leads to higher strength and durability, but may make the mix more difficult to place. According to Rakennustekniikan koulutusohjelma (2010), water-cement ratio is a very important factor in concrete production, and it has crucial effects to both, fresh and hardened concrete properties. A difference in water amount as small as 5 kg/m3 can cause tremendous effects to workability of fresh concrete. The main variation in water amount comes from the aggregates, and aggregate moisture contents may vary due to the fact that aggregates from a new delivery with different moisture content are used. Also during wintertime when the aggregates are heated in order to get warm concrete, the aggregate mass can locally differ in temperature and moisture content affecting the workability of the concrete.

2.8 CURING PROCESS

Curing is the name given to the procedures used for promoting the hydration of the cement, and consists of a control of temperature and of moisture movement from and into the concrete. Curing allows continuous hydration of cement and consequently continuous gain in the strength, once curing stops strength gain of the concrete also stops. Proper moisture conditions are critical because the hydration of the cement virtually ceases when the relative humidity within the capillaries drops below 80%. With insufficient water, the hydration will not proceed and the resulting concrete may not possess the desirable strength and impermeability. The continuous pore structure formed on the near surface may allow the ingress of deleterious agents and would cause various durability problems. Moreover due to early drying of the concrete micro-cracks or shrinkage cracks would develop on surface of the concrete. When concrete is exposed to the environment evaporation of water takes place and loss of moisture will reduce the initial water cement ratio which will result in the incomplete hydration of the cement and hence lowering the quality of the concrete. Various factors such as wind velocity, relative humidity, atmospheric temperature, water cement ratio of the mix and type of the cement used in the mix will affect the curing of concrete. Evaporation in the initial stage leads to plastic shrinkage cracking and at the final stage of setting it leads to drying shrinkage cracking (Yash Nahata et al., 2013).

Curing of the concrete is also governed by the moist-curing period, longer the moist-curing period higher the strength of the concrete assuming that the hydration of the cement particles will go on. Curing has a strong influence on the properties of hardened concrete; proper curing will increase the durability, strength, volume stability, abrasion resistance, impermeability and resistance to freezing and thawing (Yash Nahata et al. 2013).

According to Yash Nahata et al. (2013), there are three method of curing, air curing, water curing and saturated wet covering. Air curing is a curing method wherein the concrete cubes are left in open air to be cured at room temperature, water curing is a curing method wherein the concrete cubes were cured in water tank at room temperature, and saturated wet covering is a curing method wherein moisture retaining fabrics such as burlap cotton mats, gunny bag and rugs are used as wet covering to keep the concrete in a wet condition during the curing period.

2.9 OIL PALM

Figure 2.3 shows the oil palm and also known as Elaeis guineensis Jacquin, was first introduced into Malaysia in 1870, through the Botanic Gardens in Singapore, while the oil palm industry was introduced to Malaysia in 1917 (Elham P. B, 2001). According to Elham P. B, (2001) also, currently, there are about 326 oil palm mills in Malaysia with a total production more than 8.32 million tonnes per year. Then, there are about 45 palm oil refeneries in Malaysia with a total capacity of 12.73 million tonnes crude palm oil per years and Malaysia ranked as the world's largest producer and exporter of palm oil. The oil palm fruit produces two distinct oils which are palm oil and palm kernel oil. Palm oil is obtained from the mesocarp while palm kernel oil is obtained from the seed or kernel. Palm oil is used mainly for the production of margarine and compounds in cooking fats and oils and also for the production of candles, detergents, soap and cosmetic products. Production of palm kernel oil is about 12% of the production of its palm oil (N. Abdullah and F.Sulaiman, 2013).

Figure 2.3: Oil Palm

Figure 2.4 shows the past and forecast oil palm acreage in Brazil, Malaysia and Indonesia which are from year 1970 until year 2020. The statistic shows the oil palm will increase dramatically by year. Oil palm is the most important product of Malaysia that has helped to change the scenario of its agriculture and economy. The Malaysian government is fully committed to the expansion of the industry and encourages global expansion of palm oil production. Palm oil is now readily accepted globally and Malaysia has exported palm oil to more than 140 countries in the world. The success of the Malaysian palm oil industry is the result of the ideal climatic conditions, efficient milling and refining technologies and facilities, research and development, and efficient and adequate management skills. Practically all palm oil mills generate their own heat and power through the co-generation system (N. Abdullah and F. Sulaiman, 2013).

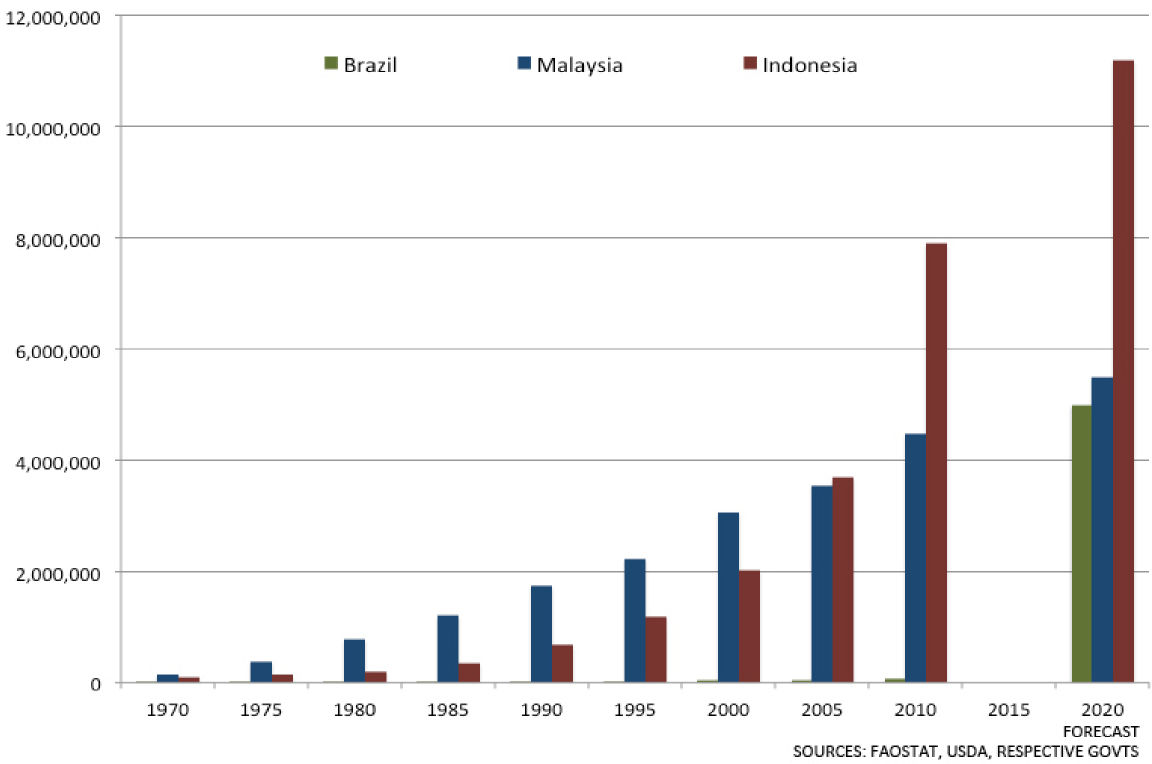

Figure 2.4: Past and Forecast Oil Palm Acreage (ha)

Source: N. Abdullah and F. Sulaiman, (2013)

The fact is the industry has an impact on the environment issues which cannot be denied. The palm oil mill generally have excess fibre and shell which are not used and to be dispose of separately otherwise contribute to environmental pollution (Elham, 2001). Figure 2.5 shows simplified process flow diagram of an oil palm mill which palm kernel shell were produced about 11.5% from a fresh fruit bunches after they were process. Referring to Figure 2.5, as the fresh fruit bunches reach the processing plant, the sterilization process begins with the steam temperature at 140°C, pressure at 2.5 to 3.2 kg/cm2 for 50 minutes. After this process, the stripping process will take over. In the stripping process, a rotating divesting machine is used to separate the sterilized oil palm fruit from the sterilized bunch stalks. The empty fruit bunches (EFB) will fall in the collector and are brought to the burning place as a fuel. After the fruit bunches have been stripped, the sterilized fruits are fed into a digester where water at 80°C is added. This is performed in steam heated vessels with stirring arms, known as digesters or kettles. The most usual method of extracting oil from the digested palm fruit is by pressing. Then, Centrifugal and vacuum driers are used to further purify the oil before pumping it into a storage tank. When the digested fruit is pressed to extract the oil, a cake made up of nuts and fibre is produced. The composition of this cake varies considerably, being dependent on the type of fruit. The cake is given a preliminary breaking treatment before being fed into the nut separator called depericarper. When the fibre has been separated from the nuts, the latter can then be prepared for cracking. Any uncracked nuts must be removed and recycled and the shell separated from the kernels. The waste fibre and shell are also transported to the burning place as a fuel (N. Abdullah and F. Sulaiman, 2013).

For each kg of palm oil, roughly a kg of wet empty fruit bunches is produced. Most crude palm oil mills harness the energy from the fibre and shell in their own low pressure boilers and normally, this burning operation cause air pollution. This operation gave returned to the plantation in term saving cost (N. Abdullah and F. Sulaiman, 2013).

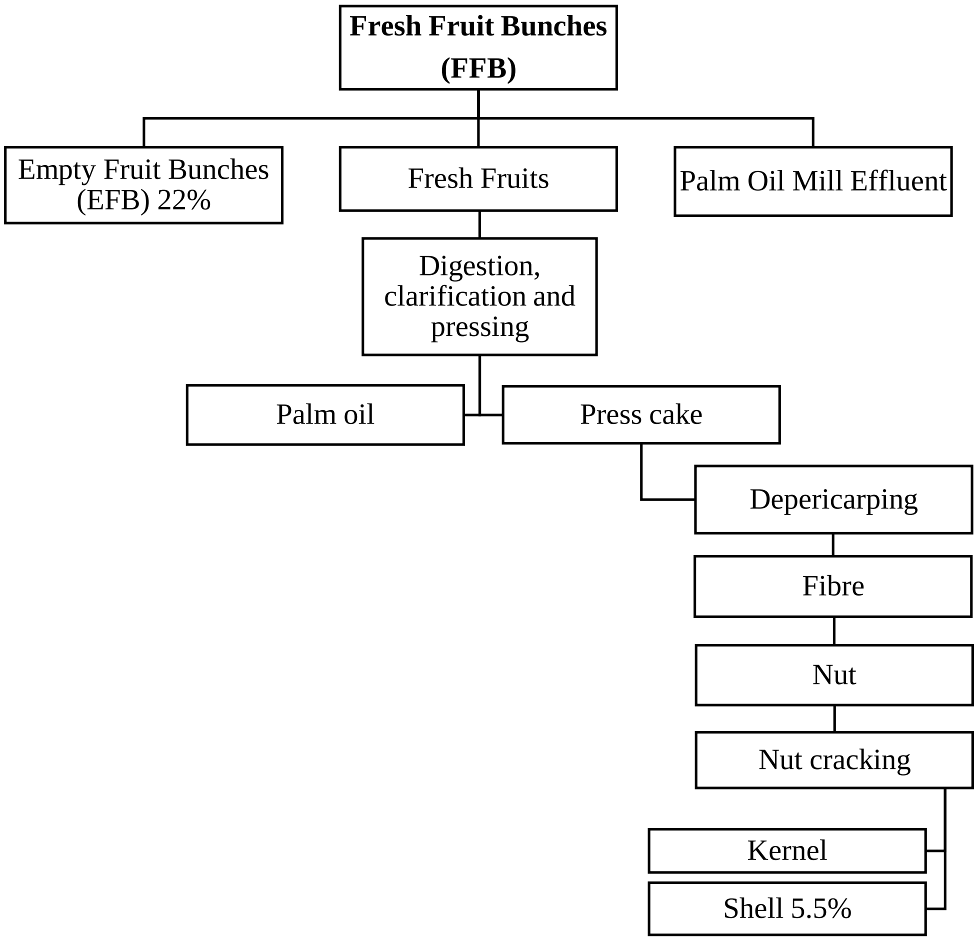

Figure 2.5: Simplified Process Flow Diagram of an Oil Palm Mill

Source: N. Abdullah and F. Sulaiman, (2013)

2.10 PALM KERNEL SHELL

Figure 2.6 shows the palm kernel shell which are obtained after extraction of the palm oil the nuts are broken and the kernels are removed with the shells mostly left as waste (Dagwa et al., 2012). According to William et al. (2014), palm kernel shells are gotten from threshing or crushing mill to remove the palm seed after the palm kernel oil has been extracted. Palm kernel shell are naturally sized, light in weight and are appropriate for replacing coarse aggregates in lightweight construction, since known to be hard and of organic origin, once used to produce concrete. Palm kernel shell can be used for lightweight concrete and has an advantage over aerated concrete, since permeability is low and the chance for carbonation is reduced.

Figure 2.6: Palm Kernel Shell

Palm kernel shell are known to have stony and hard endocarps that serve as protective covering for the palm kernel which are usually in diverse sizes and shapes. According to Dagwa et al. (2012), palm kernel shell are hard stony endocarps that surround the kernel and the shells come in different shapes and sizes.

According to William et al. (2014), palm kernel shell to have irregular shape after cracking and therefore its shape cannot be defined. The shape takes pattern of cracking on the shell and usually composed of many shapes ranging from semi-circular shapes, parabolic, other irregular and flaking shapes. After cracking, the edges of the shells are rough and spiky and the overall shape becomes concave and convex with a fairly smooth surface. In addition, here is no fixed thickness for the shell, this depends on the species from which it is obtained, ranging from 1.5 mm to 4 mm and usually between 2 mm and 3 mm.

Many varieties of palm exist, which include Dura, Pisifere and Tenera and recognized mainly by the thickness of their shell (endocarp) and fibrous oily part (mesocarp) and the fruits. Dura variety has very thick shell and thin fibrous part only. In the Pisifera variety, the shell is almost absent or very tiny, the bulk of the fruit being fibrous mainly produce little or no kernel. The Tenera variety is the hybrid of dura and pisifera. The thickness of the shell and the fibrous part are of medium size (Usman et al. 2012).

a) Dura b) Tenera c) Pisifera

Figure 2.7: Varieties of Palm Oil

Source: Rajinder Singh et al. (2013)

Palm kernel shell have some properties, such as, black in colour, have light weight, porous in nature, and hard. Normally, palm kernel shells were used for the source of fuel for domestic cooking in most area where they occur, dumped as waste products of the oil industry, the shell were used by the blacksmith and goldsmith to make bellow for melting iron and making terrazzo, used as fill materials for filling pot holes in muddy areas in some localities, and for thermal insulation (Usman et al. 2012).

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The research methodology in this study more based on experiments and testing to investigate the workability and the strength of the PKS concrete. The PKS concrete cube and beam specimens were produced by partially replace the fine aggregate with 1%, 2% and 3% of palm kernel shell. First, the collection and preparation of raw materials were discussed in details followed by mixing and testing process of the specimens.

3.2 METHODOLOGY

Methodology flowchart were presented in Figure 2.1. This study involved two main phases consist of seven stages. The first phase is laboratory work and the second phase is writing. Material preparation, concrete mixing process, curing process and testing were conducted under the first phase, laboratory work phase. In the writing phase, the result will be analyse and detail discussion and conclusion will end this writing phase.

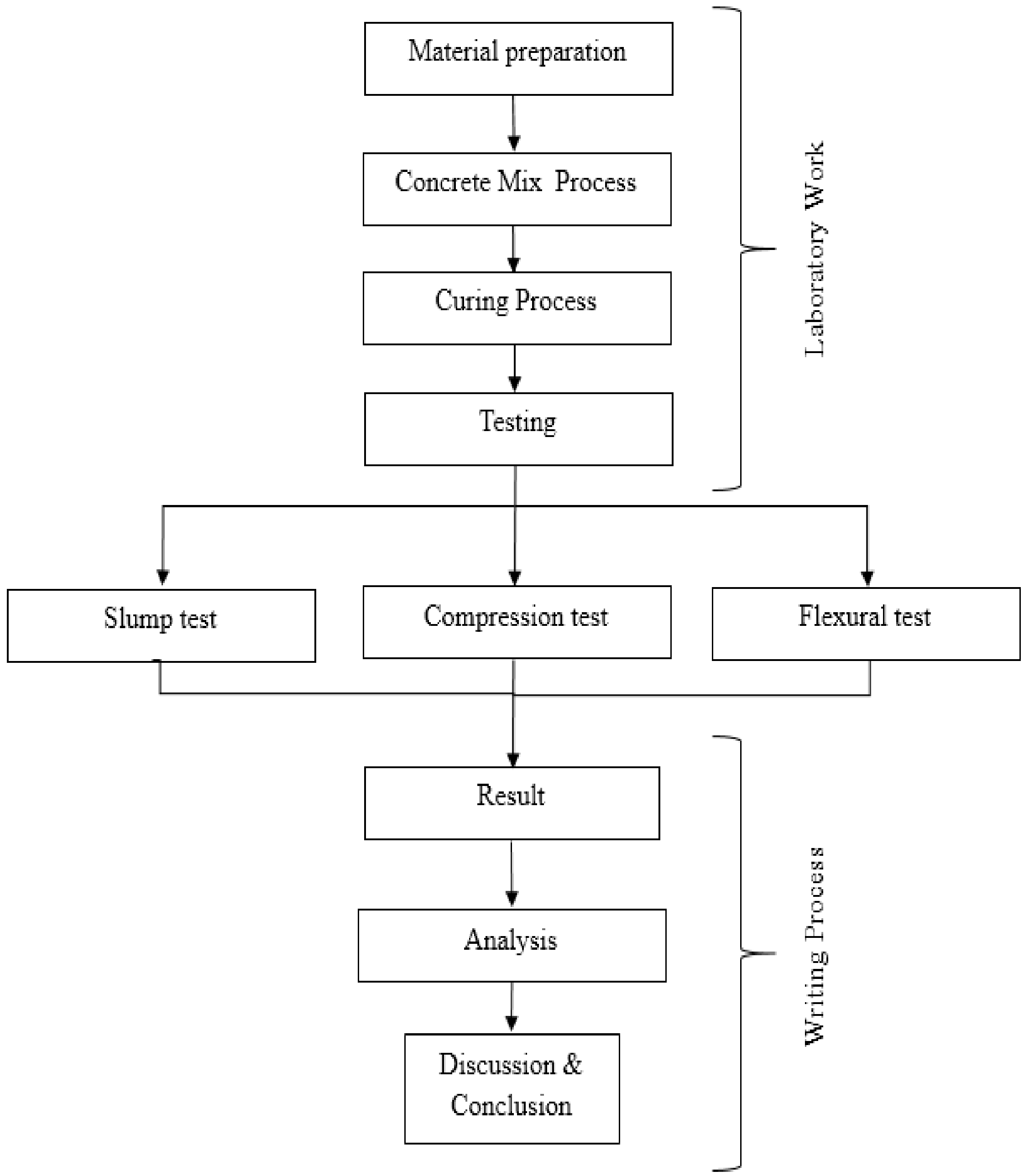

Figure 3.1: Methodology for evaluating the effectiveness of three different percentages on the performance of palm kernel shell as partially replacement of fine aggregate in concrete

3.3 PREPARATION OF MATERIALS

The making of concrete with partially replacement of fine aggregate consist of five types of raw material, namely palm kernel shell, fine aggregate, coarse aggregate, ordinary Portland cement and water.

3.3.1 Palm Kernel Shell

As mentioned earlier, palm kernel shell was the shell fractions left after the nut has been removed after crushing in the palm oil mill. Figure 3.1 showed the palm kernel shell that had been sieved passing through 2.36mm. Palm kernel shell which were obtained from the Lepar Palm Oil Mill with various size were washed and dried for one day to prevent the palm kernel shell to cling each other and easier for sieve process. Then, it were sieved by using sieve shaker with range between l.5mm to 2.36mm as shown in Figure 3.2.

Figure 3.2: Palm Kernel Shell with size between l.5mm to 2.36mm

Figure 3.3: Sieve Shaker

3.3.2 Fine Aggregates

Fine aggregates may be described into two major parts, which are natural sand and crushed stone or crushing gravel sand. In this study, river sand with fineness modulus of 1.78, that passed through a 2.36 mm test sieve were used as shown in Figure 3.3. The sand was sun dried for at least 24 hours to remove moisture in it. The dried sand was then sieved through a 2.36 mm sieve.

Figure 3.4: Fine Aggregate

Commonly, river sand were used in the construction industry mainly for concrete production and cement-sand mortar production. River sand is obtained by dredging from river beds. It has the major characteristics that since it has been subjected to years of abrasion, its particle shape is more or less rounded and smooth, and since it has been subjected to years of washing, it has very low silt and clay contents. The characteristics of river sand would improve the workability of concrete and mortar compared to the use of alternatives such as crushed rock fine.

The use of river sand would, for a given workability requirement, reduce the water demand and superplasticizer demand, and thus allow a lower water content and a lower cement content to be adopted in the mix design. With lower silt and clay contents, the use of river sand would improve the quality control of the concrete production because the presence of too much silt or clay would adversely affect the workability and strength of the concrete produced.

3.3.3 Coarse Aggregate

Coarse aggregate may be described into three major part which are uncrushed gravel, crushed stone or crushed gravel and partially crushed gravel. In this study, crushed gravel with size maximum 20mm were used as shown in Figure 3.4. Crushed gravel were sieve by using sieve shaker. The shape and size of coarse aggregates was very important to get high workability concrete.

Figure 3.5: Crushed Gravel

3.3.4 Ordinary Portland Cement

Ordinary Portland cement (OPC) brand “ORANG KUAT” by YTL Cement Sdn. Bhd. was used throughout the study as shown in Figure 3.5. The OPC was sieved through 300μm sieve. The sieved OPC was kept in an airtight container to prevent air moisture contact as hydrated cement particle would affect the formation of calcium silicate hydrate gel. Portland cement is the most common type of cement use around the world, used as a basic ingredient of concrete, mortar, stucco, and most non-specialty grout. It developed from other types of hydraulic lime in England in the middle 19th century and usually originates from limestone. It is a fine powder produced by heating materials in a kiln to form what is called Portland cement clinker, grinding the clinker, and adding small amounts of other materials. Several types of Portland cement are available with the most common being called ordinary Portland cement (OPC) which is grey in colour, but a white Portland cement is also available.

Figure 3.6: Ordinary Portland Cement

3.3.5 Water

Water is one of the most important constituents to produce concrete. The water used shouldn't contain any substance as the presence of any other substance can be harmful to the process of hydration of cement and durability of concrete. In this study, tap water was used to cast concrete cube and beam with 1%, 2% and 3% replacement of fine aggregate.

3.4 STRUCTURAL REQUIREMENT FOR CUBE AND BEAM

The most important structure that required to construct concrete cube and beam is formwork. Formwork is a die or a mould including all supporting structures, used to shape and support the concrete until it attains sufficient strength to carry its own weight. Formwork has been use since the beginning of concrete construction. Formwork can be made out a large variety of materials. The material most commonly being used to date is timber. However, due to depleting forest reserves and increasing cost of timber, the use of alternate materials such as plywood and steel has become prominent. The advantage of steel formwork is no danger of formwork absorbing water from the concrete and hence minimizing honeycombing. In this study, the size of cube formwork is 150mm x 150mm x 150mm, while for the beam formwork is 100mm x 100mm x 500mm as shown in Figure 3.6 and Figure 3.7 respectively.

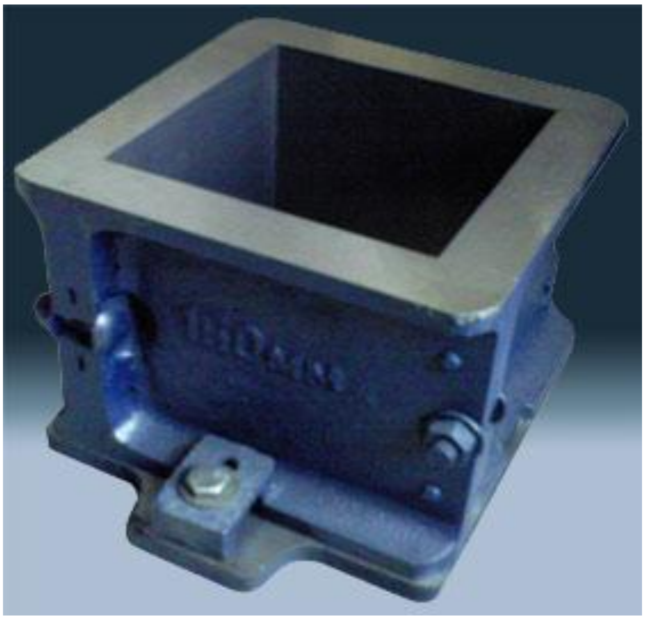

Figure 3.7: Cube Mould

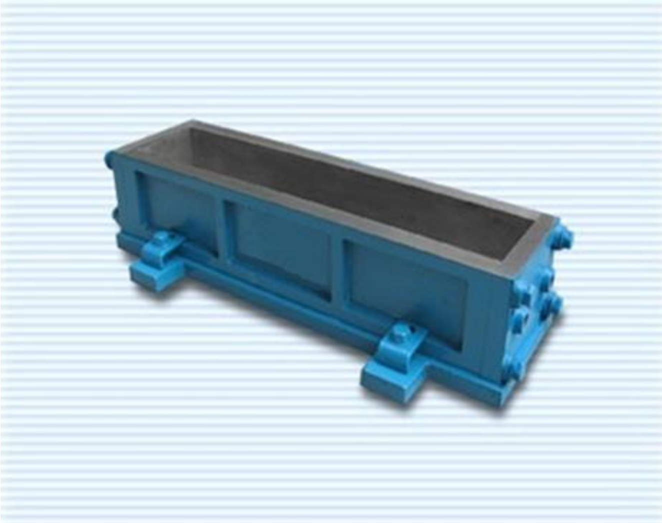

Figure 3.8: Beam Mould

3.5 CONCRETE MIXTURE

Sand, gravel, cement, water and palm kernel shell were mix by using concrete mixer as shown in Figure 3.9. This method had a lot of advantages, such as, could save time, less energy was needed and could mix all the material easily.

Figure 3.9: Concrete Mixer

Table 3.1: Number of cubes

Percentage of Replacement PKS	Number of Cubes		
	7 day	**14 day**	**28 day**
Control	3 cubes	3 cubes	3 cubes
1%	3 cubes	3 cubes	3 cubes
2%	3 cubes	3 cubes	3 cubes
3%	3 cubes	3 cubes	3 cubes

Table 3.2: Number of beams

Percentage of Replacement PKS	Number of Beams		
	7 day	**14 day**	**28 day**
Control	3 beams	3 beams	3 beams
1%	3 beams	3 beams	3 beams
2%	3 beams	3 beams	3 beams
3%	3 beams	3 beams	3 beams

Table 3.1 shows the number of cubes that were casted for the compressive strength test. For the control, 3 cubes were casted at 7 days, 14 days and 28 days respectively. Then, for 1%, 2% and 3% replacement of fine aggregates in concrete, also 3 cubes were casted at 7 days, 14 days and 28 days respectively. Overall, there are 36 cubes were casted for the compressive strength test.

Table 3.2 shows the number of beams that were casted for the flexural strength test. For the control, 3 cubes were casted at 7 days, 14 days and 28 days respectively. Then, for 1%, 2% and 3% replacement of fine aggregates in concrete, also 3 cubes were casted at 7 days, 14 days and 28 days respectively. Overall, there are also 36 beams were casted for the flexural strength test.

Table 3.3: Mix Design for Cubes

Palm kernel shell (%)	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	w/c ratio
0%	1.51	2.05	5.12	0.55
1%	1.51	2.05	5.12	0.55
2%	1.51	2.05	5.12	0.55
3%	1.51	2.05	5.12	0.55

Table 3.4: Mix Design for Beams

Palm kernel shell (%)	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	w/c ratio
0%	2.23	3.58	7.60	0.55
1%	2.23	3.58	7.60	0.55
2%	2.23	3.58	7.60	0.55
3%	2.23	3.58	7.60	0.55

Table 3.3 and 3.4 showed the mix design for concrete cube and beams which both of them were replace of fine aggregate with 1%, 2% and 3% replacement of palm kernel shell in concrete. Mix design is one of the most important parts in the procedure which needs to be prepared to determine the suitable concrete mix proportion. The concrete mixing was carried out by trial and error. Then, concrete grade 15 was use for the performance of concrete with partially replacement of palm kernel shell. Thus, developing proportion on concrete was needed to get the desire concrete grade. Both for concrete cube and beam were used water cement ratio with 0.55 for each mix.

3.6 CURING PROCESS

Curing is the maintenance of a satisfactory moisture content and temperature in concrete for a period of time immediately following placing and finishing so that the desired properties may develop. For this study, water curing was use in the curing process as shown in Figure 3.9. After concrete were casted and hardened for one day, the concrete were curing in the curing tank for 7 days, 14 days, and 28 days until testing ages, respectively.

Figure 3.10: Curing Tank

Concrete properties are considerably dependant of temperature and humidity especially during the curing period. The objectives of curing are to keep concrete saturated or nearly saturated to get the products of hydration of cement. The temperature of curing and the duration of moist curing are the key factors for proper curing (Aminur M.R. et al., 2010).

Generally, concrete properties and durability are influenced by curing condition which greatly affects the hydration of cement. The hydration of cement virtually ceases when the relative humidity within capillaries drops below 80% (Aminur M.R. et al., 2010).

Under an efficient curing method such as water curing, the relative humidity is above 80%, enabling the hydration of cement to continue (Aminur M.R. et al, 2010).

3.7 TESTING SPESIMEN

This study were conducted three testing which are workability test, compressive strength test and flexural strength test.

3.7.1 Workability Test

Referring to Figure 3.10, concrete slump test were used to measure the workability of fresh concrete. The test is carried out using a mould named slump cone or Abrams cone. The cone is placed on a hard non-absorbent surface. This cone filled with concrete in three layers of equal volume. Each layer is compacted with 25 strokes of a tamping rod. At the end of the third stage, concrete is struck off flush to the top of the mould. The mould is carefully lifted vertically upwards, so as not to disturb the concrete cone.

Figure 3.11: Slump Test

In accordance with British Standard (BS 1881: Part 102), commonly, there were three types of slump were encountered. Figure 3.11 shows the various shapes of concrete slump which according to the profile of slumped concrete, the slump is termed as true slump, shear slump or collapse slump. If a shear or collapse slump is achieved, a fresh concrete should be taken and the test repeated. A collapse slump the concrete collapsed completely which an indicator of too wet a mix. A collapse slump will generally mean that the mix is too wet or that it is a high workability mix, for which slump test is not appropriate. Then, in a shear slump the top portion of the concrete shears off and slips sideways while in a true slump the concrete simply subsides, keeping more or less to shape. Only a true slump is of any use in the test.

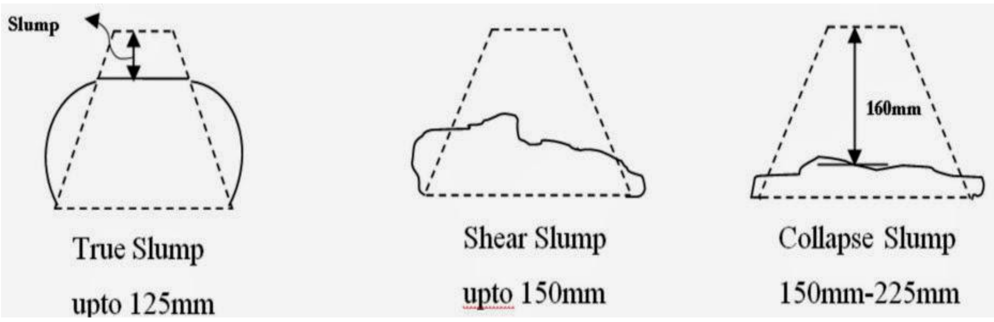

Figure 3.12: Types of Slump

The property of fresh concrete which is indicated by the amount of useful internal work required to fully compact the concrete without bleeding or segregation in the finished product. There are some factors affecting workability, for example water content in the concrete mix, temperature of the concrete mix, method of placement of concrete, method of transmission of concrete, nature of aggregate particles, aggregate grading, humidity of the environment, and mode of compaction.

3.7.2 Flexural Strength Test

Flexural test was performed in accordance with BS 1881: 118. Size of concrete beam was 100mm x 100mm x 500mm. The beams were taken out from water tank and air-dried for two hours before the test was performed. Test specimen was loaded gradually with constant rate of loading of 0.1 mm/min until the specimen fails. Mean value obtained from three beams was then taken as flexural strength for each percentage of concrete mix. Flexural capacity or flexural strength, known as modulus of rupture, bend strength, or fracture strength, a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture.

Figure 3.13: Flexural Strength Machine

According to Pecmurugan (2014), flexural strength is one measure of the tensile strength of concrete. It is a measure of unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 6 x 6 inch (150mm x 150mm) concrete beams with a span length at least three times the depth.

3.7.3 Compressive Strength Test

Compressive strength test is a mechanical test measuring the maximum amount of compressive load a material can bear before fracturing. The compression test was conducted by using compressive strength machine. The test was performed in accordance with BS 1881: Part116. An axial compressive load with a specified rate of loading was applied to 100mm cube until failure occurred. Mean value obtained from three cubes was then taken as cube compressive strength for each percentage of concrete mix. The cubes were then taken out from water tank and air-dried for two hours before the test was performed. Followed by that, the test specimen was placed at the center of the testing machine. Test specimen was loaded gradually with constant rate of loading of 0.02 mm/s until the specimen fails.

Figure 3.14: Compressive Strength Machine

Concrete mixtures can be designed to provide a wide range of mechanical and durability properties to meet the design requirements of a structure. The compressive strength of concrete is the most common performance measure used by the engineer in designing buildings and other structures. The compressive strength is calculated from the failure load divided by the cross-sectional area resisting the load and reported in units or MPa in SI units.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

In this study, palm kernel shell with size passing 2.36mm were used as partially replacement in concrete and the behaviour of concrete was investigated. All results were obtain from the testing conducted during laboratory and the result were discussions and the conclusion were made. Comparison of PKS concrete with normal concrete Grade 15 were discussed in this chapter.

4.2 WORKABILITY TEST

Concrete slump test were used to measure the workability of fresh concrete. There were three types of slump which true slump, shear slump and collapse slump. Conventionally, when shear or collapse slump occur, the test is considered invalid. However, due to recent development of self-compact concrete, the term of collapse slump has to be used with caution.

Table 4.1: Height of Slump of Concrete

Specimens	Height of slump(mm)	Type of slump
Control	80	Shear slump
1% PKS	75	Shear slump
2% PKS	77	Shear slump
3% PKS	78	Shear slump

Table 4.1 shows the result of slump test for concrete G15 with 1% PKS, 2% PKS and 3% PKS as partially replacement of fine aggregate in concrete. The result shows the shear slump type for all specimens. The height of slump for requirement were range between 50-100mm. Based on Figure 4.1, the height of slump was fluctuate with the increasing of percentage replacement of fine aggregate in concrete. The highest slump was at control with 80 mm, while the lowest was at 1% replacement of palm kernel shell with 75 mm. However, the result were still can be accepted because they were still within the range 75 ± 25 mm.

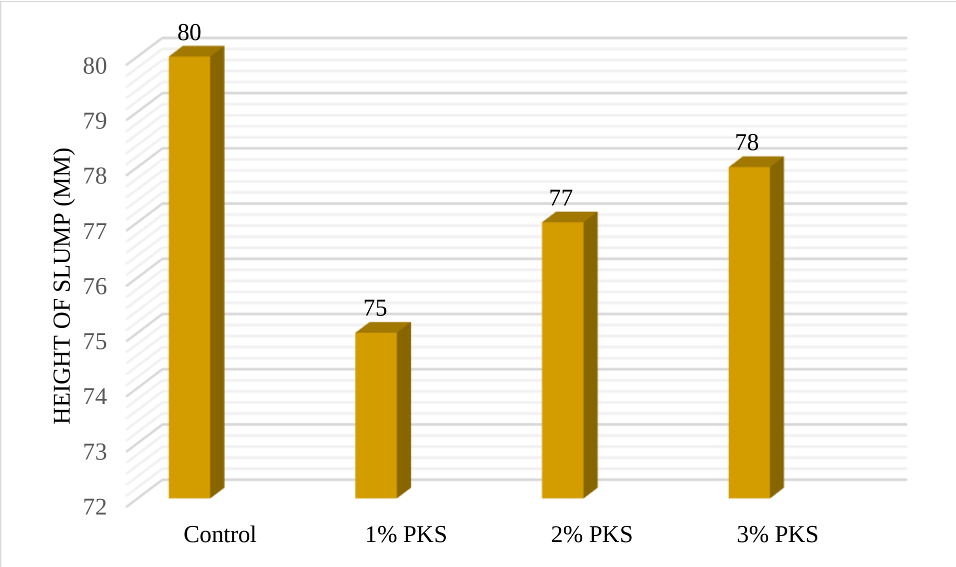

Figure 4.1: Slump Test Result

4.3 COMPRESSIVE STRENGTH TEST

Compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. It can be measured by plotting applied force against deformation in a testing machine. Some materials fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load. Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether concreting has been done properly or not.

.4.3.1 Compressive Strength Test Result at 7 Days

Table 4.2: Compressive Strength Test Results at 7 Days

Specimens		Weight (kg)			Compressive strength (MPa)			Average (MPa)
Control		8.00	7.75	7.75	25.67	25.97	25.01	25.55
Percentage of PKS (%)	1%	7.65	7.70	7.70	15.83	15.37	15.34	15.51
	2%	7.60	7.30	7.00	20.15	18.79	19.47	19.47
	3%	7.60	7.55	7.65	21.85	19.49	22.91	21.42

Table 4.2 shows the result of compressive strength at 7 day with concrete G15 and Figure 4.2 shows the compressive strength were increasing with the increasing of the percentage replacement of fine aggregates. However, all the specimens with 1%, 2%, and 3% replacement of fine aggregate were below the control's strength that was 25.55 MPa. For 1% replacement of fine aggregate, the strength was 15.51 MPa and the difference with control's strength was 10.04 MPa. Then, for 2% replacement of fine aggregate, the strength was 19.47 MPa and the difference with control's strength was 6.08 MPa. For 3% replacement, the strength was 21.42 MPa and the difference with control's strength was 4.13 MPa. Moreover, the difference were slightly high and all the difference higher than 1.0 MPa. Then, this means the compressive strength for all specimens at 7 days curing age were not suitable for palm kernel shell to replace of fine aggregates.

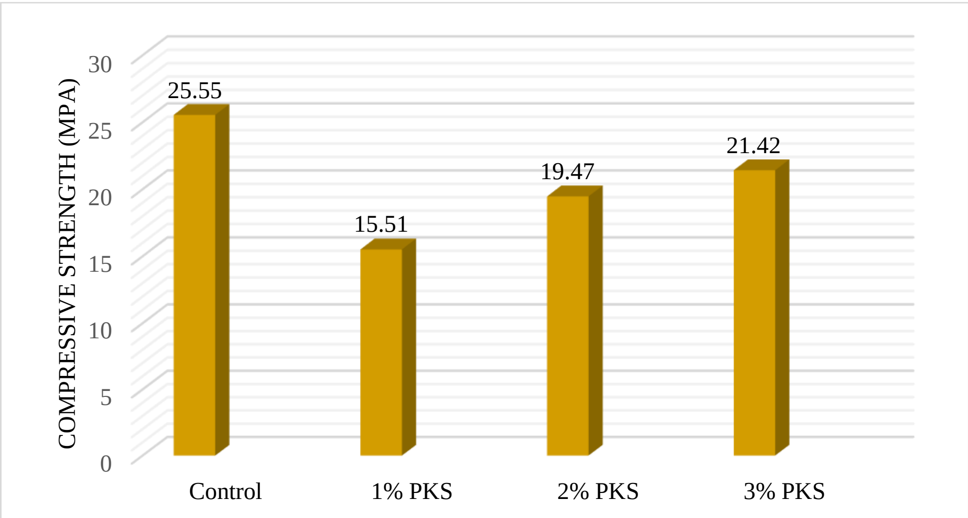

Figure 4.2: Compressive Strength Result at 7 Days

4.3.2 Compressive Strength Test Result at 14 Days

Table 4.3: Compressive Strength Test Results at 14 Days

Specimens		Weight (kg)			Compressive strength (MPa)			Average (MPa)
Control		7.80	7.70	7.80	29.43	23.69	29.18	27.43
Percentage of PKS (%)	1%	7.55	8.05	7.75	25.52	26.72	27.57	26.94
	2%	7.80	7.75	7.55	22.49	23.54	23.54	23.19
	3%	7.70	7.70	7.55	23.51	22.26	23.63	23.13

Table 4.3 shows the result of compressive strength at 14 days with concrete G15 and Figure 4.3 showed the strength wer decreasing with the increasing of the percentage of replacement of fine aggregates. All the specimens with 1%, 2%, and 3% replacement of fine aggregate were below the control's strength that was 27.43 MPa. For 1% replacement of fine aggregate, the strength was 26.94 MPa and the difference with control's strength was 0.49 MPa. Then, for 2% replacement of fine aggregate, the strength was 23.19 MPa and the difference with control's strength was 4.24 MPa. For 3 % replacement, the strength was 23.13 MPa and the difference with control's strength was 4.3 MPa. Moreover, the difference were slightly high and the average difference was higher than 1.0 MPa. Then, this means the compressive strength for all specimens at 14 days curing age were not suitable for palm kernel shell to replace of fine aggregates.

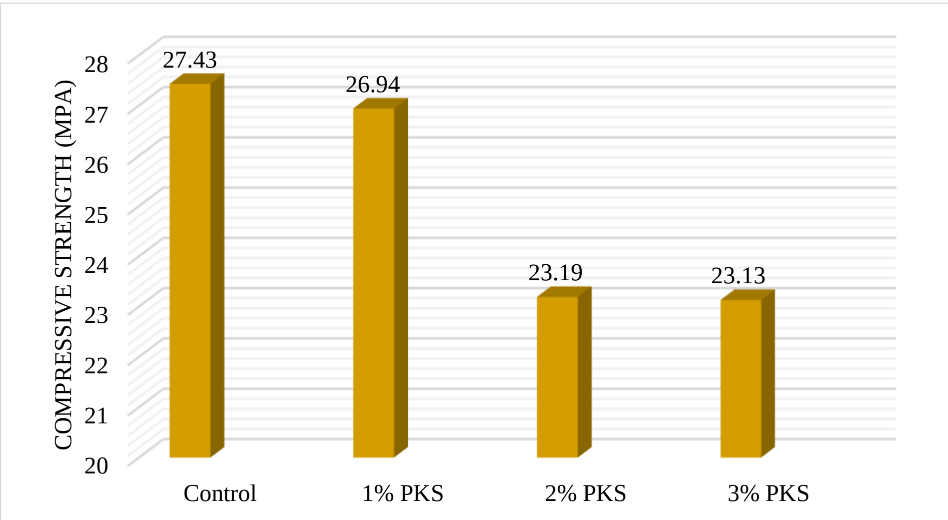

Figure 4.3: Compressive Strength Result at 14 Days

4.3.3 Compressive Strength Test Result at 28 Days

Table 4.4: Compressive Strength Test Results at 28 Days

Specimens		Weight (kg)			Compressive strength (MPa)			Average (MPa)
Control		7.60	7.50	7.60	27.95	27.86	28.07	27.96
Percentage of PKS (%)	1%	7.60	7.65	7.50	27.33	29.51	28.03	28.29
	2%	7.65	7.75	7.80	25.00	24.85	28.06	25.97
	3%	7.00	7.05	7.50	25.87	26.12	27.93	26.64

Table 4.4 shows the result of compressive strength at 28 days with concrete G15 and Figure 4.4 showed the strength were decreasing at 2% and increasing at 3% of the percentage of replacement of fine aggregates. All the specimens with 1% replacement of fine aggregate were higher than the control's strength that was 27.96 MPa. For 1% replacement of fine aggregate, the strength was 28.29 MPa and the difference with control's strength was 0.33 MPa. Then, for 2% and 3% replacement of fine aggregate, the strength were below than the control's strength that was 27.96 MPa. For 2% replacement of fine aggregate, the strength was 25.97 MPa and the difference with control's strength was 1.99 MPa. While for 3% replacement, the strength was 26.64 MPa and the difference with control's strength was 1.32 MPa. Moreover, the difference were slightly high and the differences were higher than 1.0 MPa.

Then, this means the compressive strength for 1% replacement of fine aggregate at 28 days curing age was suitable for palm kernel shell to replace the fine aggregate while for 2% and 3% replacement the compressive strength at 28 days curing age were not suitable for palm kernel shell to replace of fine aggregates.

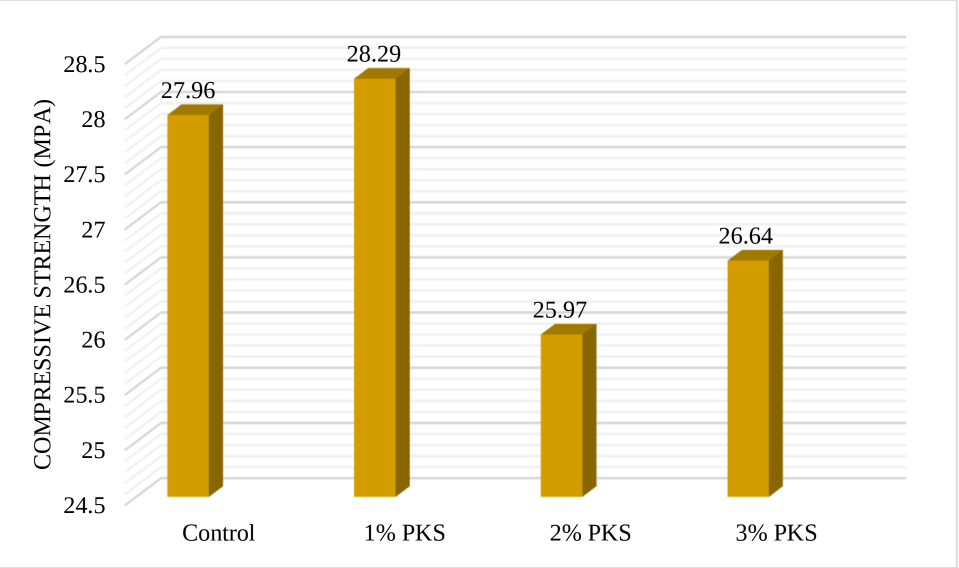

Figure 4.4: Compressive Strength Result at 28 Days

4.3.4 Overall Compressive Strength Test Result

Table 4.5: Overall Compressive Strength Test Result

Compressive strength(MPa)			
Specimens	**7 day**	**14 day**	**28 day**
Control	25.55	27.43	27.96
1% PKS	15.51	26.94	28.29
2% PKS	19.47	23.19	25.97
3% PKS	21.42	23.13	26.64

Table 4.5 shows the result of overall compressive strength with concrete G15 and Figure 4.5 indicate change occur in compressive strength with different percentage of palm kernel shell replacement of fine aggregate. This observation showed the further increase of replacement will increase the compressive strength of the cubes at all curing ages. At 1% replacement with 28 days curing ages showed the compressive strength was higher than strength of control at 28 days.

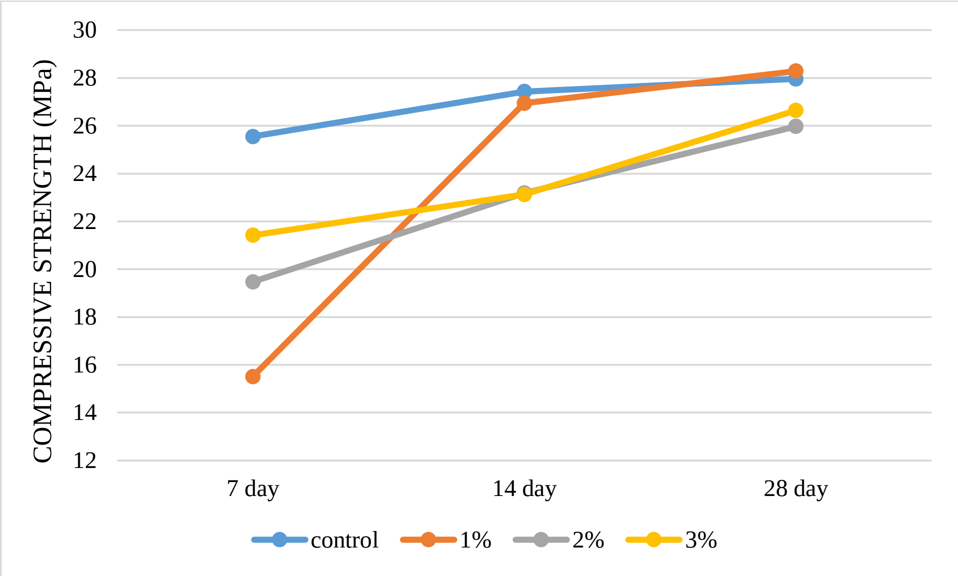

Figure 4.5: Overall Compressive Strength Test Result

4.4 FLEXURAL STRENGTH TEST

Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, is defined as a material's ability to resist deformation under load. In accordance to BS 1881: Part 118, normally, the size of specimen use was 100mm x 100mm 500mm and the maximum size of aggregate were less than 25 mm.

4.4.1 Flexural Strength Test Result at 7 Days

Table 4.6: Flexural Strength Test Results at 7 Days

Specimens		**Weight (kg)**			**Compressive strength (MPa)**			**Average (MPa)**
Control		11.10	11.90	10.65	5.63	3.62	3.14	4.13
Percentage of PKS (%)	1%	10.90	11.90	11.25	6.42	5.90	5.85	6.06
	2%	12.25	12.15	12.45	6.14	5.10	6.32	5.85
	3%	11.85	10.34	12.50	5.86	5.17	5.92	5.65

Table 4.6 shows the result of flexural strength for 7 days with concrete G15 and Figure 4.6 shows all the specimens with 1%, 2%, and 3% replacement of fine aggregate were passed the control's strength that was 4.13 MPa. For 1% replacement of fine

aggregate, the strength was 6.06 MPa and the difference with control's strength was 1.93 MPa. Then, for 2% replacement of fine aggregate, the strength was 5.85 MPa and the difference with control's strength was 1.72 MPa. For 3 % replacement, the strength was 5.65 MPa and the difference with control's strength was 1.52 MPa.

Furthermore, the Figure 4.6 shows the strength was decreasing with the increasing of the percentage of replacement of fine aggregates. Although the Figure 4.6 shows the strength were decreasing, but all the specimens were good result because the strength were passed the control's strength.

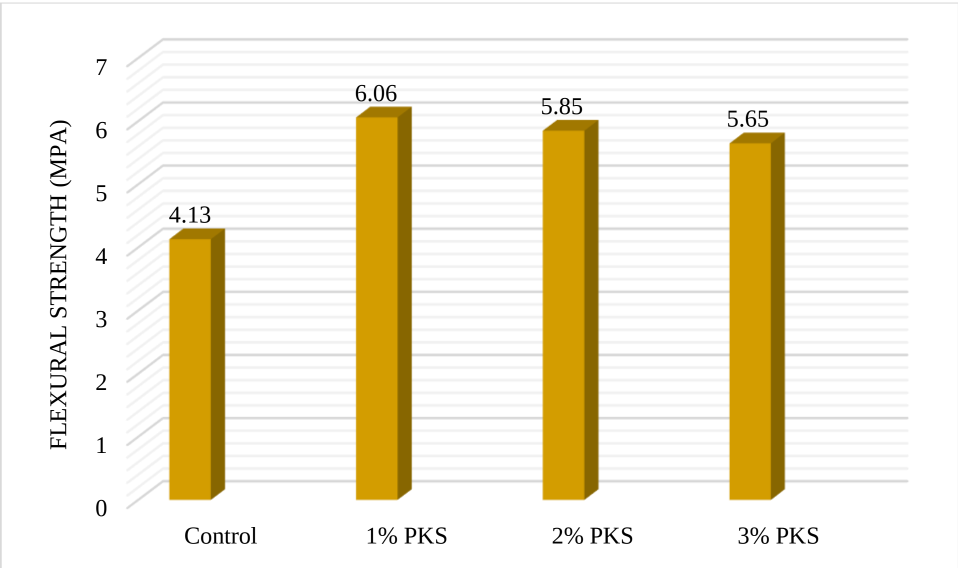

Figure 4.6: Flexural Strength Test Result at 7 Days

4.4.2 Flexural Strength Test Result at 14 Days

Table 4.7: Flexural Strength Test Results at 14 Days

Specimens		Weight (kg)			Compressive strength (MPa)			Average (MPa)
Control		11.45	11.75	11.50	6.99	6.27	5.33	6.20
Percentage of PKS (%)	1%	12.15	11.45	11.57	4.73	7.29	6.52	6.18
	2%	11.60	11.90	11.83	5.44	6.34	6.52	6.10
	3%	11.45	11.70	12.10	5.28	5.68	6.23	5.73

Table 4.7 shows the result of flexural strength for 14 days with concrete G15 and Figure 4.7 shows the strength were decreasing with the increasing of the percentage of replacement of fine aggregates. All the specimens with 1%, 2%, and 3% replacement of fine aggregate were below the control's strength that was 6.20 MPa. For 1% replacement of fine aggregate, the strength was 6.18 MPa and the difference with control's strength was 0.02 MPa. Then, for 2% replacement of fine aggregate, the strength was 6.02 MPa and the difference with control's strength was 0.18 MPa. For 3 % replacement, the strength was 5.73 MPa and the difference with control's strength was 0.47 MPa. Moreover, the difference were not slightly high and all the difference below than 1.0 MPa. Then, this means the flexural strength for all specimens at 14 days curing age were not suitable for palm kernel shell to replace of fine aggregates.

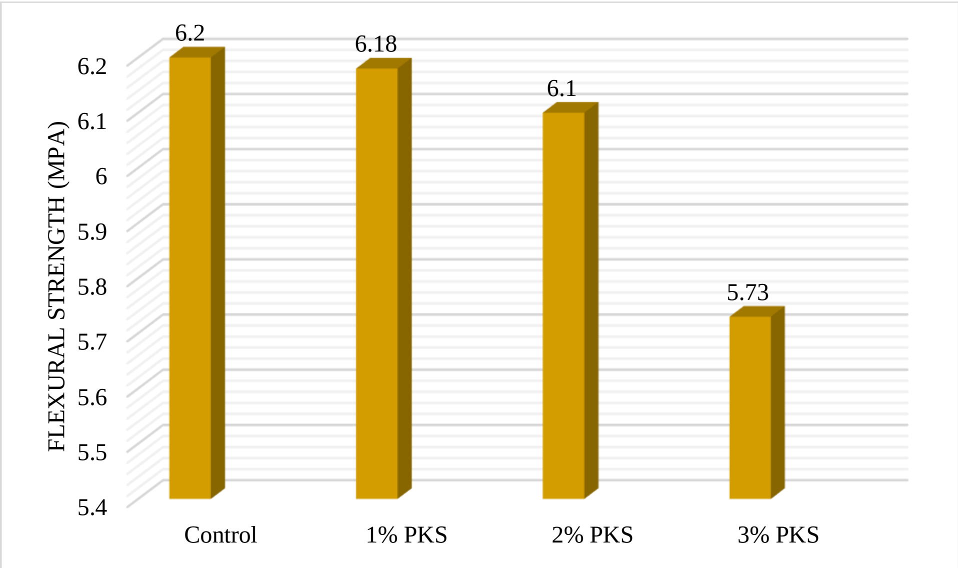

Figure 4.7: Flexural Strength Test Result at 14 Days

4.4.3 Flexural Strength Test Result at 28 Days

Table 4.8: Flexural Strength Test Results at 28 Days

Specimens		Weight (kg)			Compressive strength (MPa)			Average (MPa)
Control		11.85	11.20	12.00	8.20	9.58	10.92	9.57
Percentage of PKS (%)	1%	11.93	12.10	11.20	6.70	6.88	6.08	6.55
	2%	11.75	11.65	11.93	7.59	8.93	7.78	8.10
	3%	11.65	11.86	11.65	7.31	7.89	6.67	7.29

Table 4.8 shows the result of flexural strength for 28 days with concrete G15 and Figure 4.8 shows the strength were flactuate with the increasing of the percentage of replacement of fine aggregates. All the specimens with 1%, 2%, and 3% replacement of fine aggregate were below the control's strength that was 9.57 MPa. For 1% replacement of fine aggregate, the strength was 6.55 MPa and the difference with control's strength was 3.02 MPa. Then, for 2% replacement of fine aggregate, the strength was 8.10 MPa and the difference with control's strength was 1.47 MPa. For 3 % replacement, the strength was 7.29 MPa and the difference with control's strength was 2.28 MPa. The results showed the difference were slightly high and all the difference higher than 1.0 MPa. Then, this means the flexural strength for all specimens at 28 days curing age were not suitable for palm kernel shell to replace of fine aggregates.

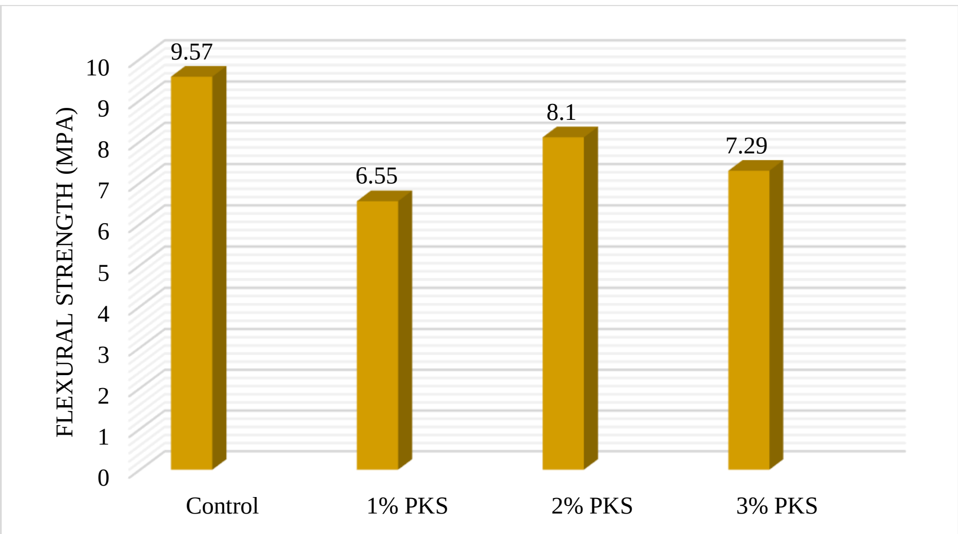

Figure 4.8: Flexural Strength Test Result at 28 Days

4.4.4 Overall Compressive Strength Test Result

Table 4.9: Overall Flexural Strength Test Result

Flexural strength(MPa)			
Specimens	**7 day**	**14 day**	**28 day**
Control	4.13	6.20	9.57
1% PKS	6.06	6.18	6.55
2% PKS	5.85	6.10	8.10
3% PKS	5.65	5.73	7.29

Table 4.9 shows the result of overall flexural strength with concrete G15 and Figure 4.9 indicate change occur in flexural strength with different percentage of palm kernel shell replacement of fine aggregate. This observation showed the further increase of replacement will increase the flexural strength of the beams at all curing ages. At 7 days, all the beams with percentage replacement with 1%, 2% and 3% showed the flexural strength were higher than strength in the control.

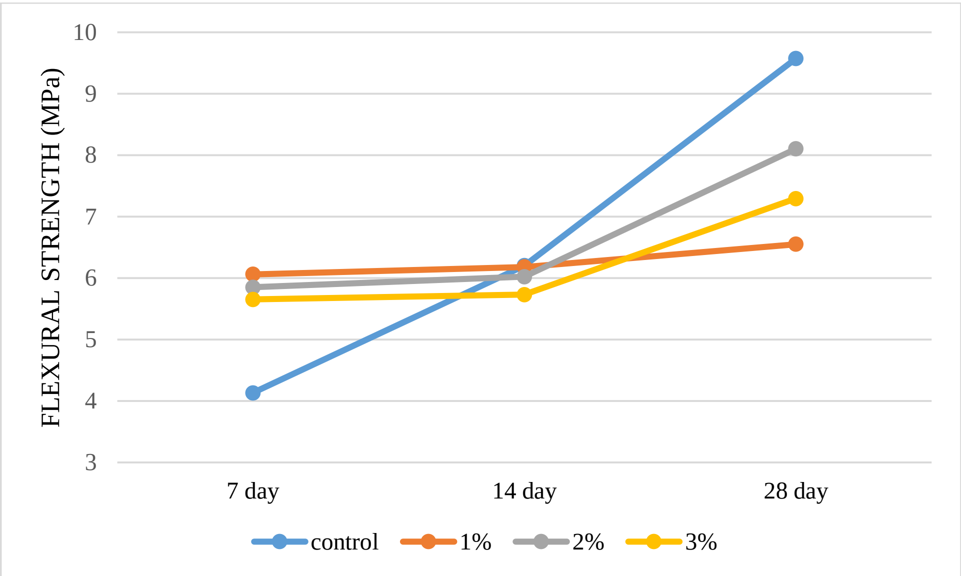

Figure 4.9: Overall Flexural Strength Test Result

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

This chapter was about conclusion made from this study. The conclusion was made based on the objectives listed in subtopic 1.3 in Chapter 1. The recommendations was presented at the end of this chapter.

5.2 CONCLUSION

As a conclusion, the results from the tests show that the palm kernel is suitable to replace the fine aggregate in the concrete mixture. However, only certain percentage can be replaced in the concrete. The main points of this study are outlined below:

i. The type of concrete slump for all the specimens were shear slump. The replacement of palm kernel shell with different percentage affect the workability of the concrete but the reading is still acceptable. The important part in controlling the workability of concrete is due to water cement ratio. The rate show that 80mm, 75mm, 77mm, 78mm, are within the limit which is 75±25mm.

ii. There was only a specimen for cubes that passed the control compressive strength that was at 1% with 28 days. So, compressive strength at this percentage was suitable for palm kernel shell to replace the fine aggregate.

iii. The flexural strength for all the specimens at 28 days were below the flexural strength for control. So, flexural strength were not suitable for palm kernel shell to replace the fine aggregate
iv. Lastly, the percentage of the palm kernel shell replacement can influenced the strength of the concrete. The result show that the increase the percentage, the higher the strength of the concrete.

5.3 RECOMMENDATION

The study work on palm kernel shell with 1%, 2% and 3% replacement of fine aggregate in concrete is still limited. But it promises a great scope for future studies. Following aspects related to the properties of palm kernel shell as a replacement of fine aggregate in concrete need to be further study and investigate:

i. Though the some results indicated the possible use of palm kernel shell as a replacement of fine aggregate, it is recommended that its long term behavior should be investigated to evaluate this possibility.
ii. Plasticizers should be used in works involving palm kernel shell
iii. Further studies are carried to determine the durability and shrinkage characteristics of palm kernel shell concrete.

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