A STUDY OF FLEXURAL STRENGTH OF PRISM USING OIL PALM SHELL (OPS) AS A PARTIAL REPLACEMENT OF COARSE AGGREGATE

MOHD ABDUL HADI BIN MOHD ZAID

B. ENG (HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

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MOHD ABDUL HADI BIN MOHD ZAID

Thesis submitted in fulfillment of the requirements for the award of the degree of
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ABSTRACT

The purpose of this study was conducted to determine the use of oil palm shell (OPS) as coarse aggregate in concrete to replace granite in concrete mixture. The main objective of this study is to determine the workability, compressive strength and flexural strength of concrete using oil palm shells (OPS) as partial replacement of coarse aggregate compare to normal concrete. Experimental work was conducted in laboratory to determine the characteristic of oil palm shell concrete by using weight method. In this studies, there are different concrete mixes with different the combination of natural material content namely 0%, 5%, 10%, and 15%. There are 36 prism are provided with different ratio which are 0%, 5%, 10%, and 15% with partial replacement coarse aggregate in this project. The size of the prism is 150 X 150 X 750 mm. There are 36 cubes (150 X 150 X 150mm) are provided to get the average results of the compressive test. Each ratio have three sample specimen prepared for each concrete mixes. The laboratory tests conducted including sieve analysis, slump test, compressive strength test, and flexural strength. The results show that the oil palm shell concrete has strong compressive strength. Using the oil palm shell as aggregate in concrete can reduce the material cost in construction because of the low cost and abundant agricultural waste. In this experiment, there are several things that can be expected when finish. The following are some of the expected result for this experiment is to get higher compressive strength in lower density of concrete and to achieve the specified strength of OPS concrete that same to the control concrete at 28 days.

ABSTRAK

Tujuan kajian ini dijalankan untuk menentukan penggunaan tempurung kelapa sawit sebagai agregat kasar dalam konkrit untuk menggantikan batu baur di dalam campuran konkrit. Objektif utama kajian ini adalah untuk menentukan kebolehkerjaan, kekuatan mampatan dan kekuatan lenturan konkrit menggunakan tempurung kelapa sawit (OPS) sebagai sebahagian bahan gantian daripada agregat kasar berbanding dengan konkrit normal. Kajian ini telah dijalankan di makmal untuk menentukan ciri-ciri konkrit tempurung kelapa sawit dengan menggunakan kaedah berat. Dalam kajian ini, tiga konkrit yang berbeza bercampur dengan kombinasi berbeza kandungan bahan semulajadi iaitu 5%, 10%, dan 15%.Terdapat 36 prisma disediakan dengan nisbah yang berbeza yang 0%, 5%, 10%, dan 15% dengan penggantian sebahagian agregat kasar dalam projek ini. Saiz prisma 150 X 150 X 750 mm. Terdapat 36 kiub (150 X 150 X 150mm) disediakan untuk mendapatkan keputusan purata ujian mampatan. Setiap nisbah mempunyai tiga sampel spesimen akan disediakan bagi setiap campuran konkrit. Ujian makmal dijalankan termasuk analisis ayak, ujian kemerosotan, ujian kekuatan mampatan, dan ujian lenturan. Hasil kajian menunjukkan bahawa tempurung kelapa sawit konkrit mempunyai kekuatan mampatan yang kukuh. Menggunakan tempurung kelapa sawit sebagai agregat dalam konkrit boleh mengurangkan kos bahan pembinaan kerana kos rendah dan sisa pertanian yang melimpah. Dalam eksperimen ini, ada beberapa perkara yang boleh di angkakan apabila selesai. Berikut adalah beberapa keputusan jangkaan bagi eksperimen ini adalah untuk mendapatkan kekuatan mampatan yang lebih tinggi dalam ketumpatan konkrit yang lebih rendah dan untuk mencapai kekuatan tertentu daripada konkrit tempurung kelapa sawit yang sama dengan konkrit kawalan di 28 hari.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

In many developed countries, due to the increasing cost of raw materials and the continuous reduction of natural resources, the use of waste materials is a potential alternative in the construction industry. This will have the double advantage of reduction in the cost of construction material and also as a means of disposal of waste. It can be used as building materials of high quality and can be used in construction in the near future.

Recycling or use of solid waste generated from most agricultural and manufacturing industries is very profitable. The anxiety about enormous waste production, resource preservation, and material cost has focused attention for the reuse of solid waste. Material recovery from the conversion of agricultural wastes and industrial wastes into useful materials has not only environmental gains, but may also preserve natural resources. It is desirable that a study on the use of various types of solid waste effective has received greater attention in the last few decades.

The palm oil industry in Malaysia accounts for more than half of the total world production of palm oil and is expected to rise again as a result of the increase in global demand for vegetable oil. However, it is also a main contributor to the pollution problems in the country, covering 2.6 million tons of annual production of solid waste in the form of oil palm shell (OPS) (M.N. Amiruddin, 1998). contributing to the many environmental problems associated with diverse ecosystem (Tomas U. Ganiron Jr, 2013).

OPS are hard endocarp surrounding the palm kernel. Wide availability of resources is still not used commercially. The practice of burning waste disposal in the industry is usually done in a way that is not under control and many contribute to environmental pollution.

OPS are light and naturally-sized, they are best suited to replace the aggregate in concrete construction. Become hard and organic origin, they will not contaminate or leach to produce toxic substances when they are bound in a matrix of concrete. OPS concrete can be potentially used in concrete applications that require low medium strength such as path and infill panel for floorings and walls. The use of oil palm shell will cause lighter concrete because of the low density (Mannan, M. A and Ganaphaty, C, 2002).

One of the suggestions in the forefront has been the sourcing, development and use of alternative, non-conventional local construction materials including the possibility of using some agricultural wastes and residues as construction materials. As the natural fibres are agriculture waste, manufacturing natural product is, therefore, an economic and interesting option. Palm oil shows diversity in size, weight, shape and colour, depending on genetic diversity and maturity of the nut at harvest (Ohler, 1999).

1.2 PROBLEM STATEMENT

The development of the industry intensified today has brought a lot of revenue and the rest of the industry such as oil palm shells. The rest of the industry should be dealt with a perfect or original use the rest of the waste material this by generating a new product.

Additionally, this natural raw material resources increasingly limited means of disposal is the need to have other alternatives to make natural material waste to useful materials. One way is by using the Palm shells to replace the course aggregate in concrete. However, the test needs to be done in advance against the concrete to make sure it went through the concrete specifications has been defined in terms of strength and long-term durability. Example, desert sand generally not suitable to use for construction because the wind erosion of sand in the desert results in smooth and desert The next problem is noise pollution from the quarry of sound emitted as a result of fragmentation of rocks to produce aggregate. With the availability of replacement of natural ingredients such as palm oil shell, then the use of the aggregate can be reduced and can reduce breakage of rocks on a hill and necessarily will reduce noise noisy as a result of bombs breaking and machinery used.

1.3 OBJECTIVES OF STUDY

The main objective of this study is to determine the effectiveness of using oil palm shells in the product of concrete. The following are some of the objectives set to achieve the goals:

(a) To determine the workability of concrete using oil palm shells as partial of coarse aggregate compare to normal concrete.

(b) To determine the flexural strength and compressive strength of concrete using oil palm shells as partial of coarse aggregate compare to normal concrete.

(c) To investigate the optimum percentage for oil palm shells concrete which affect the flexural strength and compressive strength.

1.4 SCOPE OF STUDY

Scope of this study focus on the influence of using oil palm shells as partial replacement of coarse aggregate in concrete production. This study is also focusing on the characteristics of concrete grade C25/30 using Oil Palm shells as coarse aggregate in concrete material spare parts to replace the granite at a different percentage replacement 0%, 5%, 10%, and 15% of the coarse aggregate volume. Studies using the cube size 150mm x 150mm x 150mm and prism size 150mm x 150mm x 750mm. The study carried out for comparison with normal concrete made in terms of strength, workability, and mode of failure.C25/30. The concrete mix was using Composite Portland cement. The cube test and flexural test for concrete were tested within the range of 7, 14 and 28 days according to the curing period.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In construction, concrete plays an important role and it is the main ingredient in structure. Concrete is a building material that is widely used in the construction industry, so the techniques to make a good quality concrete must be understood and observed carefully. Generally, they consist of a mixture of cement, sand, aggregate and water with a certain ratio or designed, the reaction between cement and water will produce C-S-H gel to form the bond between aggregate will give strength and durability to concrete. Concrete in construction is widely used in civil engineering projects around the world with for the following reasons, namely it has good resistance to water, precast concrete structures can be shaped into a variety of shapes and sizes and usually, it is the cheapest and most readily available materials for work (Mehta and Monteiro, 2006).

Concrete can be divided into three groups, namely, light weight concrete, normal concrete, and concrete weight. According to BS5328, light weights concrete are classified as concrete has a density not exceeding 2000 kg/m3. While for normal concrete has a density between heavy 2000kg/m3 and not exceeding to 2600 kg/m3. For concrete in excess of 2600 kg/m3 densities was classified as heavy concrete businesses and create less waste. Moreover, these initiative indirectly reducing the expenses in purchases of financial incentive for consumers and businesses.

According to (Alexander M.G. and Sydney Mindness, 2005), between 70 to 80 per cent out of the total volume of concrete is occupied by aggregate. With this large proportion of the concrete occupied by aggregate, it is expected for aggregate to have a profound influence on the concrete properties and its general performance.

Aggregate are essential in making concrete into an engineering material. They tend to give concrete its volumetric stability; they also have a unanimous influence on reducing moistures related to deformation like shrinkage of concrete.

Oil palm shell is an organic waste that is easily available in our country, Malaysia. Palm shells will be used as a material to replace the aggregate in the concrete, it can reduce the density of ordinary concrete and reduces environmental pollution (Mannan, M. A and Ganaphaty, C, 2002). This can be another's waste as the material can be used to produce new products.

2.2 CONCRETE

Concrete is a composite material and has been called pourable stone composed of coarse granular material '(the aggregate or filler)' embedded in a hard matrix of material '(the cement or binder)' that fills the space between the aggregate particles and glues them together. We can also consider concrete as a composite material that consists essentially of a binding medium within which are embedded particles or fragments of aggregates. The simplest representation of concrete is filler plus binder. Greatly tough, it was utilized 3,600 years prior by the Egyptians to fabricate sections that are still standing. It is the most frequently possible utilized basic building material as a part of the United States today, the main component in buildings, bridges, pavement, dams, and breakwaters. It would be hard to imagine modern life today without concrete. Conventional concrete combine sand, gravel and water with Portland cement to ensure a building material that is strong, cheap and durable. Since concrete is used in large quantities, the construction industry has developed an alternative to ordinary concrete that are more sustainable and environmentally friendly.

Concrete consist of a mixture of cement, fine and coarse aggregate are blended well with water according to the ratio set. This mixture will harden according to the grades needed to design done. There are various types of cement used in concrete production according to concrete properties required such as the total number of varying types, structure and size. There is likewise extra basic material to change the properties of concrete such as increasing the strength of the concrete.

Here we should indicate that admixtures are almost always used in modern practice and thus become an essential component of modern concrete. The mixture is defined as materials other than aggregate fine and coarse, water, fiber and cement, which will be included in a batch of concrete immediately prior to or during mixing. The widespread use of add is caused many benefits with their application. For example, a chemical mixture can modify the setting and hardening characteristics of cement by influencing the rate of hydration of cement. Often, additives such as pozzolans or super plasticizers will be included in the blend to improve physical properties wet mixture or material ready.

Most of the concrete poured by strengthening materials such as rebar embedded provide tensile strength, resulting in reinforced concrete. Water-reducing admixture can plasticize fresh concrete mixture by decreasing surface pressure of water, a mixture of air-entraining can improve durability of concrete, and the mix of minerals such as pozzolans containing silica reactive can reduce the heat cracked.

2.2.1 Types of Concrete and Applications

According to the type of binder used, there are many types of concrete. For example, normal concrete, light weight concrete, high strength concrete, mass concrete, ready mix concrete, polymer concrete, shotcrete, per packed concrete, vacuum concrete, roller compacted concrete, pumped concrete, and pozzocrete effective. In construction, types of concrete used are varied and different methods of use. For example, the construction of the fly over, we use the pump concrete to make spam pile while construction using normal concrete is as bungalows, terraced houses, houses shops and etc.

2.2.2 Normal concrete

The concrete in which common ingredients aggregate, water, cement are used is known as normal concrete. It also can called normal weight concrete or normal strength concrete. Although concrete is seen by many as a single material, it can be produced with many variable characteristics including strength, color and weight. It has a setting time of 30 - 90 minutes depending upon moisture in atmosphere, fineness of cement. The development of the strength starts after 7 days the common strength values is 10 MPa (1450 psi) to 40 MPa (5800 psi). At about 28 days 75 - 80% of the total strength is attained. Almost at 90 days 95% of the strength is achieved. This self-weight will make it to some extend an uneconomical structural material. The properties of normal concrete are its slump varies from 25 to 100 mm and it is strong in compression but weak in tension. The normal concrete is not durable against severe condition such as freezing and thawing. For normal concrete, the composition can be shown as follows:

Cement
(+ **Admixture**) → Cement paste
+ Water + → mortar
fine aggregate + → concrete
coarse aggregate

Figure 2.1: Concrete Composition

2.2.3 Light Weight Concrete.

According to (Satish Chandra and Leif Berntsson,2002), the concrete which has substantially lower mass per unit volume then the concrete made of ordinary ingredients is called lightweight concrete. The aggregates used are lighter in weight and has been a feature in the construction industry for centuries, but like other material the expectations of the performance have raised. Now we are expecting a consistent, reliable material and predictable characteristics. Lightweight concrete structural has an in-place density on the order of 1440 to 1840 kg/m^3 compared to normal weight concrete a density in the range 2240 to 2400 kg/m^3. The strength of light weight concrete varies from 17 MPa to 40 MPa. Sometimes Air Entrained Admixtures are also added to it giving resistance to freezing and thawing along with strength. The concrete mixture is made with a lightweight course aggregate and in some cases, the entire fine aggregates may be a lightweight product. Lightweight aggregates used in structural lightweight concrete are typically expanded shale, clay or slate materials that have been fired in a rotary kiln to develop a porous structure.

Light weight concrete can be classification by three types which are low density concrete, moderate concrete, and structural concrete. For low density concrete, there are employing chiefly for insulation purposes. With low unit weight, seldom exceeding 800 kg/m^3, heat insulation value are high. Compressive strength is low, regarding from about 0.69 to 6.89 N/mm2. Besides is moderate strength concrete, the use of these concrete requires a fair degree of compressive strength, and thus they fall about midway between the structural and low density concrete. These are sometimes designed as ‘fill’ concrete. Compressive strength is approximately 6.89 to 17.24 N/mm^2 and insulation values are intermediate. Besides, for structural concrete, Concrete with full structural efficiency contain aggregates which fall on the other end of the scale and which are generally made with expanded shale, clay, slates, slag, and fly-ash. Minimum compressive strength is 17.24 N/mm^2. Most structural light weight concrete is capable of producing concrete with compressive strength in excess of 34.47 N/mm^2. Since the unit weight of structural light weight concrete are considerably greater than those of low density concrete, insulation efficiency is lower. However, thermal insulation values for structural light weight concrete are substantially better than normal weight concrete.

Manufacturing of concrete is not just a matter of mixing the ingredients to produce a mass of plastic, but good concrete has to satisfy performance requirements in the plastic or green state and also the hard circumstances. In the plastic state the concrete should be implemented and free of segregation and bleeding. . Segregation is the separation of coarse aggregate and bleeding is the separation of cement paste from the main mass. Isolation and resulting in poor quality concrete bleeding. In a hard concrete should be strong, durable, and impermeable; and it should have the minimum dimensions change. Among the various properties of concrete, compressive strength that are considered most important and taken as a total quality index. Many other properties of concrete appear generally related to the strength of its compression.

The advantages of light weight concrete are the concrete is economical in the long run as compared to other engineering materials. Except cement, it can be made from locally available coarse and fine aggregates. The concrete possesses a high compressive strength, and the corrosive and weathering effects are minimal. When properly prepared its strength is equal to that of a hard natural stone. The green concrete can be easily handled and molded into any shape or size according to specifications. The form work can be reused a number of times of similar jobs resulting in economy. It is strong in compression and has unlimited structural applications in combination with steel reinforcement. Besides that, the concrete and steel have approximately equal coefficients of thermal expansion. The concrete is extensively used in the construction of foundations, walls, roads, airfields, buildings, water retaining structures, dams, bridges, and etc. Concrete can even be sprayed on and filled into fine cracks for repairs by the guniting process and the concrete can be pumped and hence it can be laid in the difficult positions. It is durable and fire resistant and requires very little maintenance.

Durability of light weight concrete is defined as the ability of a material to withstand the effect of its environment. In a building material as chemical attack, physical stress, and mechanical assault and for the chemical attack, it is a aggregate ground-water particularly sulphate, polluted air, and spillage of reactive liquids light weight aggregate has no special resistant to these agencies. Indeed, it is generally move porous than the ordinary Portland cement and it's not recommended for use below damp-course. A chemical aspect of durability is the stability of the material itself, particularly at the presence of moisture.

Next is the physical stress which means light weight concrete is exposed are principally frost action and shrinkage and temperature stresses. Stressing may be due to the drying shrinkage of the concrete or to differential thermal movements between dissimilar materials or to other phenomena of a similar nature. Drying shrinkage commonly causes cracking of light weight concrete if suitable precautions are not taken. Lastly, mechanical damage can result from abrasion or impact excessive loading of flexural members. The lightest grades of light weight concrete are relatively soft so that they subject to some abrasion were they not for other reasons protected by rendering.

2.2.4 High Weight Concrete.

Concrete, a composite consisting of aggregates enclosed in a matrix of cement paste including possible pozzolans, has two major components which is cement paste and aggregates. The strength of concrete depends upon the strength of these components, their deformation properties, and the adhesion between the paste and aggregate surface. With most natural aggregates, it is possible to make concretes up to 120 MPa compressive strength by improving the strength of the cement paste, which can be controlled through the choice of water-content ratio and type and dosage of admixtures (Mehta and Aitcin, 1990).

However, with the recent advancement in concrete technology and the availability of various types of mineral and chemical admixtures, and special super plasticizer, concrete with a compressive strength of up to 100 MPa can now be produced commercially with an acceptable level of variability using ordinary 54 M.A. Rashid and M.A. Mansur / Journal of Civil Engineering (IEB), 37 (1) (2009) 53-63 aggregates (FIP/CEB, 1990).

High density concrete density differs from 3840 kg/m3 to 3360 kg/m3. However they can be produced with a density of up to 5820 kg/m3 using iron as fine and coarse aggregate. High strength concrete are using natural aggregate such as barites or magnetite or manufactured aggregates such as iron or lead shot. The density will depend on the type of aggregate used. Typically using barites the density will be in the region of 3,500kg/m^3, which is 45% greater than that of normal concrete, while with magnetite the density will be 3,900kg/m^3, or 60% greater than normal concrete. High strength concretes can be achieved with iron or lead shot as aggregate is 5,900kg/m^3 and 8,900kg/m^3 respectively.

An ideal property and high density of normal concrete are high modulus of elasticity, low thermal expansion and Creep deformation. Because of the high density concrete will have a tendency to isolation. To avoid this pre placed aggregate concreting method applied. High modulus of elasticity, low thermal expansion, low elasticity and creep deformation is an ideal property. High density of concrete used in the construction of the radiation shield. They are efficient and construction materials for the purpose of economic and permanent. Most of the aggregate of gravity is more than 3.5. They are viable and monetary development material for perpetual protecting reason. The greater part of the total particular gravity is more than 3.5.

2.3 MATERIAL

2.3.1 Cement

Cement is a binder and material having adhesive properties and cohesion, which enables fine and coarse aggregate binding to one whole. Cement clinker produced from the powder which usually contains Lime (CaO), Silica (Si02), Alumina (Al203) and Iron Oxide (Fe203). In construction, cement is used as bonding to unite aggregate, bricks, blocks and others.

The most important types of cement used as a component in the manufacture of concrete and masonry mortar a combination of cement and aggregate to form strong building material. Cements used in construction can be characterized as being either hydraulic or non-hydraulic. There are various types of cement used in construction on the properties of concrete required. The most common type of cement to make concrete has set and hardened properties of aqueous conditions through a chemical reaction between cement and water. This type of cement known as hydraulic cement. There is also a need air to cement hardened, the cement is known as non-hydraulic cement (Gambir.M.L., 1995).

Hydraulic cements such as Portland cement, set and become adhesive due to a chemical reaction between the dry ingredients and water. The chemical reaction results in mineral 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. The chemical process for hydraulic cement found by ancient Romans used volcanic ash (activated aluminum silicates) with lime (calcium oxide). For 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. There are various types of cement produced for a particular purpose and satisfaction of the particular properties required. Among the most common type of cement used was ordinary Portland cement. Cement in hardened more rapidly, lower heat and white.

2.3.1.1 Chemical Composition of Portland Cement

Compound of raw materials such as lime, silica, alumina and iron oxides will interact with each other in the Furnace to form a series of products that are more complex. This reaction produces four main compounds such as Table 2.2.3.1

Table 2.1: The main compounds of Portland cement (Ismail,M.A.K, Mohd Sam,A.R, Sumadi,S.R, Hussin,M.W, 2007).

Compounds	Chemical formulae	Basic formulae	Used (%)
Tricalcium silicate	(CaO)3 . Si02	C3s	45-60
Dicalcium silicate	(CaO)2 . Si02	C2S	*15-30*
Tricalcium aluminate	(CaO)3 . Al203	C3A	6-12
Tetracalcium Aluminoferit	(CaO)4 . A103 . Fe203	C4AF	6-8

Source: The main compounds of Portland cement, (2007).

Result of the compound C3S and C2S hydration will produce the desired characteristics of the concrete. While alumina and iron that produce C3A and C4AF will help to reduce the temperature required to produce the C3S from 2000°C to 1350°C (Ismail,M.A.K, Mohd Sam,A.R, Sumadi,S.R, Hussin,M.W, 2007). This will save energy and costs to produce Portland cement.

2.3.1.2 Types of Portland Cement

The ASTM has listed five types of Portland cement, but for the design is type IV. Physical and chemical characteristic, this cement varies primarily in their originality and C3A content them. In terms of performance, they differ primarily in the initial hydration rates and their ability to withstand attack sulfate. The General characteristics of this type are listed in Table 2.2.

Table 2.2: Types of Portland cement (ASTM)

	Classification	Characteristics	Applications
Type I	General purpose	Fairly high C_3S content for good early strength development	General construction (most buildings, bridges, pavements, precast units, etc)
Type II	Moderate sulfate resistance	Low C_3A content (<8%)	Structures exposed to soil or water containing sulfate ions
Type III	High early strength	Ground more finely, may have slightly more C_3S	Rapid construction, cold weather concreting
Type IV	Low heat of hydration (slow reacting)	Low content of C_3S (<50%) and C_3A	Massive structures such as dams. Now rare.
Type V	High sulfate resistance	Very low C_3A content (<5%)	Structures exposed to high levels of sulfate ions
White	White color	No C_4AF, low MgO	Decorative (otherwise has properties similar to Type I)

Source: ASTM (2005)

2.3.2 Aggregate

Aggregates play an important role in the concrete for strength and durability depends on the aggregates. Aggregates are usually classified into two types, fine and coarse aggregates. Fine aggregate consists of sand and crushed stones which have a maximum size not exceeding 5mm. The coarse aggregate consists of gravel whether crushed or not crushed with a size not less than 5mm (Nevelle A.M., 1995). Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material.

The aggregate is a is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, recycling concrete and that's a component of composite materials resistant to compressive stress and provide bulk composite materials. For efficient filling, aggregate should be smaller than the finished item, but have a variety of sizes. For example, particles of stone used to make concrete typically include sand and gravel. The aggregate is the materials most mined in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete which is the aggregate serves as reinforcement to add strength to the overall composite material.

Due to hydraulic conductivity values of a relatively high compared to that, the aggregate is widely used in applications such as foundation and water drainage drain, septic drain field, retaining wall drains and roadside edge drains. The aggregate is also used as base material under foundations, roads and railways. In other words, aggregates are used as a stable foundation or road/rail base with predictable, uniform properties (e.g. to help prevent differential settling under the road or building), or as a low-cost extender that binds with more expensive cement or asphalt to form concrete.

The American Society for Testing and Materials publishes an exhaustive listing of specifications including ASTM D 692 and ASTM D 1073 for various construction aggregate products, which, by their individual design, are suitable for specific construction purposes. These products include specific types of coarse and fine aggregate designed for such uses as additives to asphalt and concrete mixes, as well as other construction uses.

Sources for these basic materials can be divided into three main areas, which are mining of mineral aggregate deposits, including sand, gravel, and stone; use of waste slag from the manufacture of iron and steel, and recycling of concrete, which itself is primarily made of mineral aggregate. In addition, there are some minor materials that are used as specialty lightweight aggregates: clay, pumice, perlite, and vermiculite.

Workability concrete usually depends on the texture and shape of the aggregate. Good aggregate is rounded, angular and irregular, while the form of a flat is not a good shape and should be avoided from concrete mixture. The quality and strength of the resulting concrete depending on the size and shape of the aggregate used and then content of the mixture. The types of aggregates have different average compressive strength. Granite rocks can be used as a high compressive strength compared to other types of aggregates such as the Table 2.2.4. Although the quartzite has a higher compressive strength than granite, but granite is more readily available and cost saving.

Table 2.3: Average compressive strength of Rock-bridge (Nevelle A.M, 1995)

Types of rock.	The average compressive strength		Range, MN/m2
	MN/m2	Ib/in2	
Quartzite	252	36500	423-124
Granite	181	26200	258-115
Limestone	159	23000	241-93
Narmar	117	16900	245-51
Felsite	324	26200	258-115
Syis	170	24600	298-91

Source: Average compressive strength of Rock-bridge (1995)

2.3.3 WATER

Water in the concrete mix is to the hydration and workability of concrete. Water used should be clean and free from impurities as this will affect the hardening process, the stability of the volume, durability, discoloration and corrosion of reinforcement (Wong, Like Kee, 2001). The impurities are acids, alkalis, sulfates, chlorides, and others.

Water used in mixing concrete should also be free from impurities such as Suspended solids, organic matter and sea salt. Water containing the algae is not suitable for mixing concrete for algae to trap air and air content in concrete will reduce the strength of the concrete. Algae from the 0.09 percent (%) increase to 0.23 percent (%) would increase the air content of 10.6 percent (%) and lead to concrete strength decreased by 50 percent (%) (Kumar Mehta,R, 1991). Uses of sea water in reinforced concrete mixing are not suitable because it will cause danger due to reinforcement corrosion due to chloride content in water.

Suitable water is water containing dissolved solids less than 2000-ppm. Therefore, the water supplied in the water supply system can be used safely because it contains dissolved solids less than 2000-ppm (Kumar Mehta,R, 1991). According ASTM C1602, Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete, defines sources of mixing water as:

2.3.3.1 Batch water.

Batch water discharged into the mixer from municipal water supply, reclaimed municipal water, or water resulting from concrete production operations. This is the main source of mixing water in concrete.

2.3.3.2 Water added by the truck operator

According to ASTM C94 (AASHTO M 157) allows the addition of water on site if the slump is less than specified, provided the maximum allowable water-cement ratio is not exceeded and several other conditions are met.

2.3.3.3 Recycled Water

The recycled water are Non-potable water and water resulting from concrete production operations can be used as mixing water in concrete provided the acceptance criteria given in ASTM C1602 are met. Water recovered from processes of concrete production includes, the first one is wash water from mixers or that was a part of a concrete mixture. Second, water collected in a basin as a result of storm water runoff at a concrete production facility, or other water that contains quantities of concrete ingredients. According ASTM C1603, the solids content in recycled water generally ranges from 2½ to 10 percent. The maximum permitted solids content for water to be used in concrete is 50,000 parts per million, or 5 percent, of the total mixing water and should be tested.

2.4 CONCRETE QUALITY

Concrete is considered a quality that has a high compressive strength, durable and not easily permeable in water. While a good quality concrete structures is the vanes smooth, compact and not porous when the mold is opens. For low quality concrete will become brittle, easily cracked, and permeable in water.

Therefore, to ensure good quality of concrete, several things need to be addressed before, during and after the concrete is provided. Concrete compressive strength, density and workability of concrete are the main parameter to be determined before designing the structural members. While, the process of casting, process of compacting and process of curing operations at the construction site, must be addressed to ensure a good quality concrete. Strength and durability of concrete depends on the amount of water in the concrete mix and the degree of compaction applied. Therefore, these matters should be noted (Wong, Like Kee, 2001): Viscosity of the mixture must be appropriate to allow the concrete is mixed well. May be carried, cast, and worked easily and does not occur separation of a mixture of original material.

2.4.1 Factors Affecting the Strength of the Concrete

In designing a concrete mix, the aspect of concern is to obtain concrete with high strength levels without compromising on other features such as durability and permeability. In the previous study, there are many factors influencing the strength of concrete cutter, not least the influence of water-cement ratio, aggregate-cement ratio, degree of compaction and grading.

2.4.2 Water-Cement Ratio

Water-cement ratio can be defined as the ratio of water weight by weight of cement used in concrete mix. For fully compacted concrete, concrete strength is inversely proportional to the water-cement ratio. Water-cement ratio will determine the porosity of the cement at the level of complaints specific hydration. Addition of water-cement ratio will reduce the compressive and tensile strength and increase shrinkage of the concrete. Therefore, for a good mix of water-cement ratio should be lowered. However, if the concrete lack of water, the level of workability will be less.

2.4.3 Aggregate-Cement Ratio

Aggregate-cement ratio of concrete strength influences the level of either medium or high. There is no doubt that the aggregate-cement ratio is only a secondary factor in influencing the strength of concrete (Nevelle A.M., 1995). In a mixture of less cement or a mixture with the aggregate-cement ratio, high air voids, voids, will form and it will have adverse effect on the strength and durability of concrete.

2.4.4 Degree of Compaction

Compaction of concrete will be more convenient if the water content in the concrete mix a lot. Compaction is done is to remove the air-air trapped in the aggregate, coarse aggregate, fine and cement in concrete mixtures. Therefore, compaction is done to ensure that the concrete is at a maximum level of strength and have minimal porosity.

2.4.5 Grading

Aggregate gradation is also a determining factor on the strength and quality of concrete. One method is through the sieve analysis. Sieve analysis done by using a sieve-BS410 British Standard sieve which is the distribution of particles of granular materials among various sizes, usually expressed in terms of cumulative percentages larger or smaller than a series of sizes of sieve openings or the percentages between certain ranges of sieve openings. Results from a sieve analysis are used in three ways, which are to determine if the material meets specifications, to select the most suitable material and to detect variations in grading that are sufficient to warrant mixing select sizes or an adjustment of concrete mix proportions. In directly, this aggregate gradation direct impact on the workability of concrete and affect the workability of concrete strength.

The ASTM C 33, Standard Specification for Concrete Aggregates, grading requirements for coarse and fine aggregates and there are several reasons for specifying grading limits and maximum aggregate size, most importantly, workability and cost. For instance, very coarse sands produce harsh and unworkable concrete mixtures, and very fine sands increase water and cement requirements, and are uneconomical. Aggregates that do not have a large deficiency or excess of any particular size produce the most workable and economical concrete mixtures.

Coarse aggregates used in concrete making contain aggregates of various sizes. This particle size distribution of the coarse aggregates is termed as “Gradation”. The sieve analysis is conducted to determine this particle size distribution.

Grading pattern is assessed by sieving a sample successively through all the sieves mounted one over the other in order of size, with larger sieve on the top. The material retained on each sieve after shaking represents the fraction of aggregate coarser than the sieve in question and finer than the sieve above.

Proper gradation of coarse aggregates is one of the most important factors in producing workable concrete. Proper gradation ensures that a sample of aggregates contains all standard fractions of aggregate in required proportion such that the sample contains minimum voids. A sample of the well graded aggregate containing minimum voids will require minimum paste to fill up the voids in the aggregates. Minimum paste means less quantity of cement and less quantity of water; leading to increased economy, higher strength, lower shrinkage & greater durability. The workability is improved when there is an excess of paste above that required to fill the voids in the sand, and also an excess of mortar (sand plus cement) above that required to fill the voids in the coarse aggregate because the fine material lubricates the larger particles.

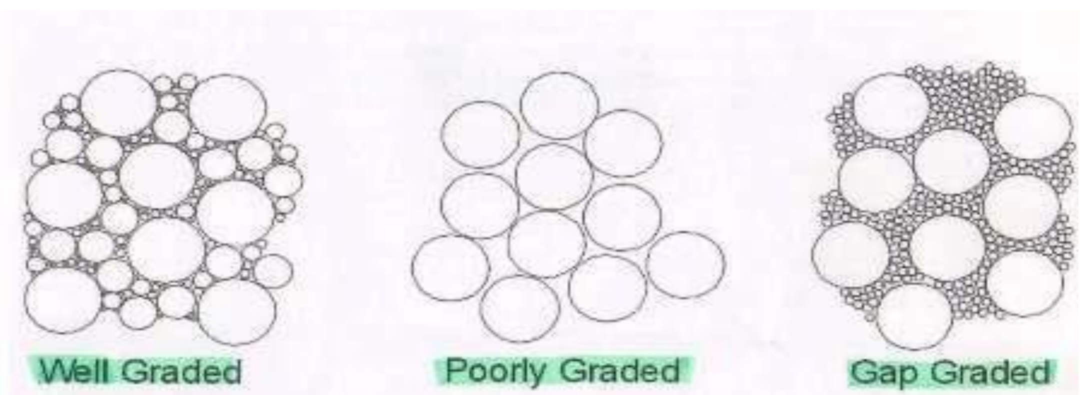

Figure 2.2: There are three categories of aggregate grading

Source: ASTM C 33, (2005)

(a) **Well graded**: Well-graded aggregate has a gradation of particle size that fairly evenly spans the size from the finest to the coarsest. A slice of a core of well-graded aggregate concrete shows a packed field of many different particle sizes. It is characterized by the S- shaped in gradation curve.

(b) **Poor graded**: Poor-graded aggregate is characterized by small variation in size. It contains aggregate particles that are almost of the same size. This means that the particles pack together, leaving relatively large voids in the concrete. It is also called "uniform-graded". It is characterized by steep curve.

(c) **Gap graded**: Gap-graded aggregate consists of aggregate particles in which some intermediate size particles are missing. A core slice of gap-graded, or skip grade, concrete shows a field of small sized- aggregate interspersed with slightly isolated, large aggregate pieces embedded in a small sized aggregate. It is characterized by a gradation curve with a hump in between.

2.5 OIL PALM SHELLS

In Malaysia, oil palm shell (OPS) is an agricultural solid waste originating from the palm oil industry and are not basic materials in the development business. The Palm Oil Industry is a significant industry in the Malaysian economy. This country currently accounts for 51% of world palm oil production and 62% of world exports. This is either in light of the fact that they are not accessible in vast amounts as sand or rock, or on the grounds that their utilization for such has not been empowered. For quite a while, the Nigerian government has been clamoring for the utilization of neighborhood materials in the development business to point of confinement expenses of development.

2.5.1 Properties of oil palm shell (OPS)

According to journal lightweight concrete made from crushed oil palm shell, which means the Oil palm shell (OPS) is a waste lightweight aggregate originating from the palm oil industry, which is approximately 50% lighter than conventional aggregate. In this study, crushed old OPS were used as coarse aggregate. Compressive strength under different curing conditions and the splitting tensile and flexural strengths were compared with those of the normal weight granite concrete. The test results showed that OPS concrete with a compressive strength in the range of 34–53 MPa has a splitting tensile strength range of 2.8–3.5 MPa and flexural strength range of 4.4–7.0 MPa.

According this study is another effort to show the potential engineering performance of (OPS) concrete. Compared to the other previous studies, oil palm shell (OPS) of different shapes was used as a coarse aggregate in this study. Oil palm shell (OPS) were obtained by crushing large sizes of old oil palm shell (OPS). The use of crushed oil palm shell (OPS) is new and this shape of oil palm shell (OPS) was not used in previous studies. Compressive strength, splitting tensile strength and flexural strength of light weight concrete (LWC) containing crushed oil palm shell (OPS) were evaluated.

2.6 PREVIOUS STUDY

2.6.1 TESTING

2.6.1.1 COMPRESSIVE STRENGTH

In the previous study, the 28-day compressive strength of Oil Palm Shell (OPS) and normal weight concrete in dry and moist skin conditions, in continuously moist curing, no curing regime and initial water curing regimes 3 week, 5 week, and 7 week are summarized in Table 2.4.

Table 2.4: Compressive Strength for 28 days

Table 5
28-day compressive strength (MPa) under different curing conditions.

Mix No.	28-day compressive strength (MPa)					
	Continuously moist curing		No curing	Initial water curing		
	Saturate skin	Dry skin	(AC)	(3 W)	(5 W)	(7 W)
P1	41.38	44.96	36.66	39.53	40.44	40.64
P2	53.05	54.31	48.01	51.82	52.29	52.96
P3	43.25	44.25	40.67	42.84	42.86	42.81
P4	34.29	36.67	34.61	36.47	36.42	37.29
N	84.45	–	79.23	81.16	81.10	82.85

Source: Compressive Strength for 28 days, (2003)

The compressive strength ratio of Oil Palm Shell (OPS) concrete is lower than normal concrete. However, it is comparable with LWAC made with artificial LWA of an equivalent grade.

I. Continuously Moist Curing

The 28-day compressive strength and the oven dry concrete density of Oil Palm Shell (OPS) concrete varied from 34 to 53 MPa and from 1790 to 1922 kg/m3, respectively. (Yasar et al.) reported that light weight aggregate concrete (LWAC) made with crushed Scoria aggregate as a natural lightweight aggregate had air-dry density of 1860 kg/m3 and 28-day compressive strength of 28 MPa for a standard concrete cylinder.

In these studies, the Oil Palm Shell (OPS) concretes have strength in the normal range of structural lightweight concrete (17–35 MPa). Therefore, it can be seen that the difference between Oil Palm Shell (OPS) concrete and conventional coarse aggregate concretes reduces for high strength Oil Palm Shell (OPS) concrete.

II. Effect of Curing Conditions on 28-Day Compressive Strength.

(Haque) reported that to negate skin effects, all specimens in his study were placed outside the fog room (23 ± 2 _C and RH of 95 ± 5%) 24 h prior to testing. It has been reported that air dried specimens have 20–25% higher strength than specimens in a saturated condition.

Water curing is the best method than air curing (AC) because the strength by water curing is higher than air curing. Therefore, the cost of curing can significantly be reduced. (Shafigh P, Jumaat MZ, Mahmud H.) was reported that under air curing (AC), OPS concrete made with uncrushed OPS aggregate with 9.5 mm maximum size and with 28-day compressive strength of 42–48 MPa, has strength loss in the range of 14–26%. In the present study the strength loss for OPS concrete with 28-day compressive strength of 41–53 MPa was 6–11%. It can be seen that the sensitivity of OPS concretes made with crushed OPS in poor curing conditions (AC) is lower than that of uncrushed OPS concrete.

2.6.1.2 FLEXURAL STRENGTH

The 28-day flexural strength of the OPS concrete in this study ranged from 4.42 to 6.99 MPa. In the previous studies revealed that OPS concretes have flexural strength in the range of 2.13–4.93 MPa. The 28-day flexural strength was, on average, 13.7% of the 28-day compressive strength, ranging from 12.9% to 14.8%. It was reported that the flexural strength of normal weight concrete with a compressive strength of 34–55 MPa is in the range of 5–6 MPa and a flexural or compressive strength ratio is in the range of 11.6–13.5%. (Alengaram et al) Reported, that this ratio for OPS concrete is between 60% and 70%.

Therefore, it can be concluded that Oil Palm Shell (OPS) concretes tested in this study have a similar or higher flexural strength and flexural strength ratio than normal weight concrete of the same compressive strength. The 28-day flexural strength ranges from 4.4 to 7.0 MPa, which is 12.9–14.8% of the 28-day compressive strength. This ratio increases with increasing OPS content in the mixture. These ratios are comparable or even higher than normal weight concrete.

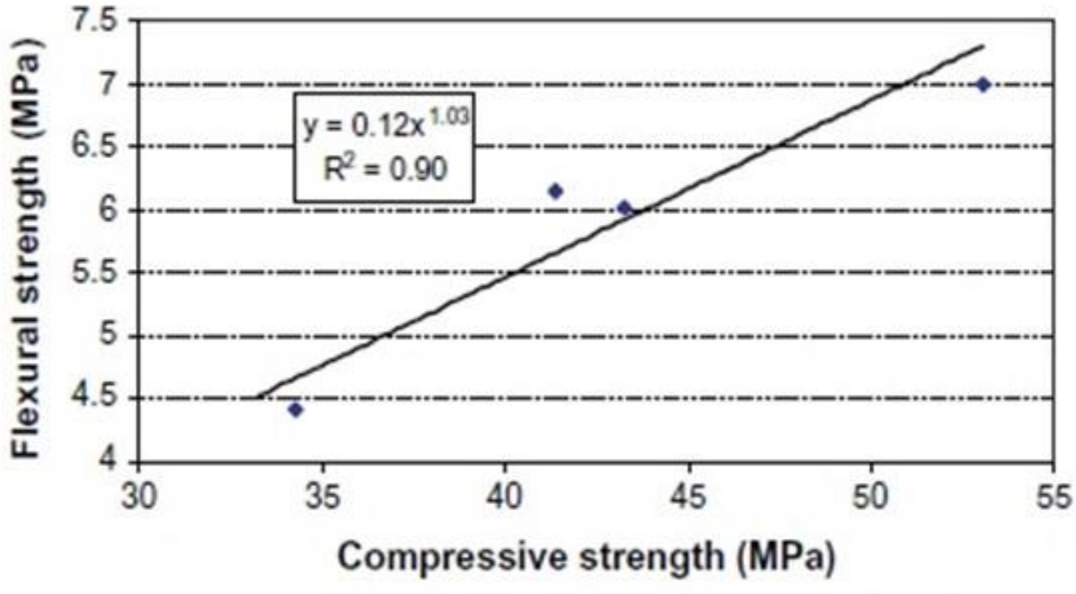

Figure 2.3: Relationship between 28-days compressive and flexural strength of crush OPS concrete.

Source: Alengaram et al (2008)

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter discussed on the methodology used for this research. To get the objectives of study, a good and accurate assessment should be obtained. Thus, the methodology implemented in the study is very important matter. The methodology should be carefully planned and arranged so as to yield result that are accurate and covers all the aspects either of the theory or practical.

In reviewing, the effectiveness of using oil palm shell to replaced coarse aggregate in the concrete mix. There are several tests, that are carried out in this researched. The laboratory testing is performed to obtain the data and concrete compressive strength, slump test and flexural strength. The test are conducted to investigate the mechanical properties of oil palm shell concrete by using various water to cement ratio, and compared to plain concrete. Data obtained from these tests and analyzed to obtain a decision that achieve the goals and objective of this study. Figure 3.0 shows the flowchart of the study. This flowchart is to ensure the flow of the study can be done smoothly.

3.2 FLOW CHART OF METHODOLOGY

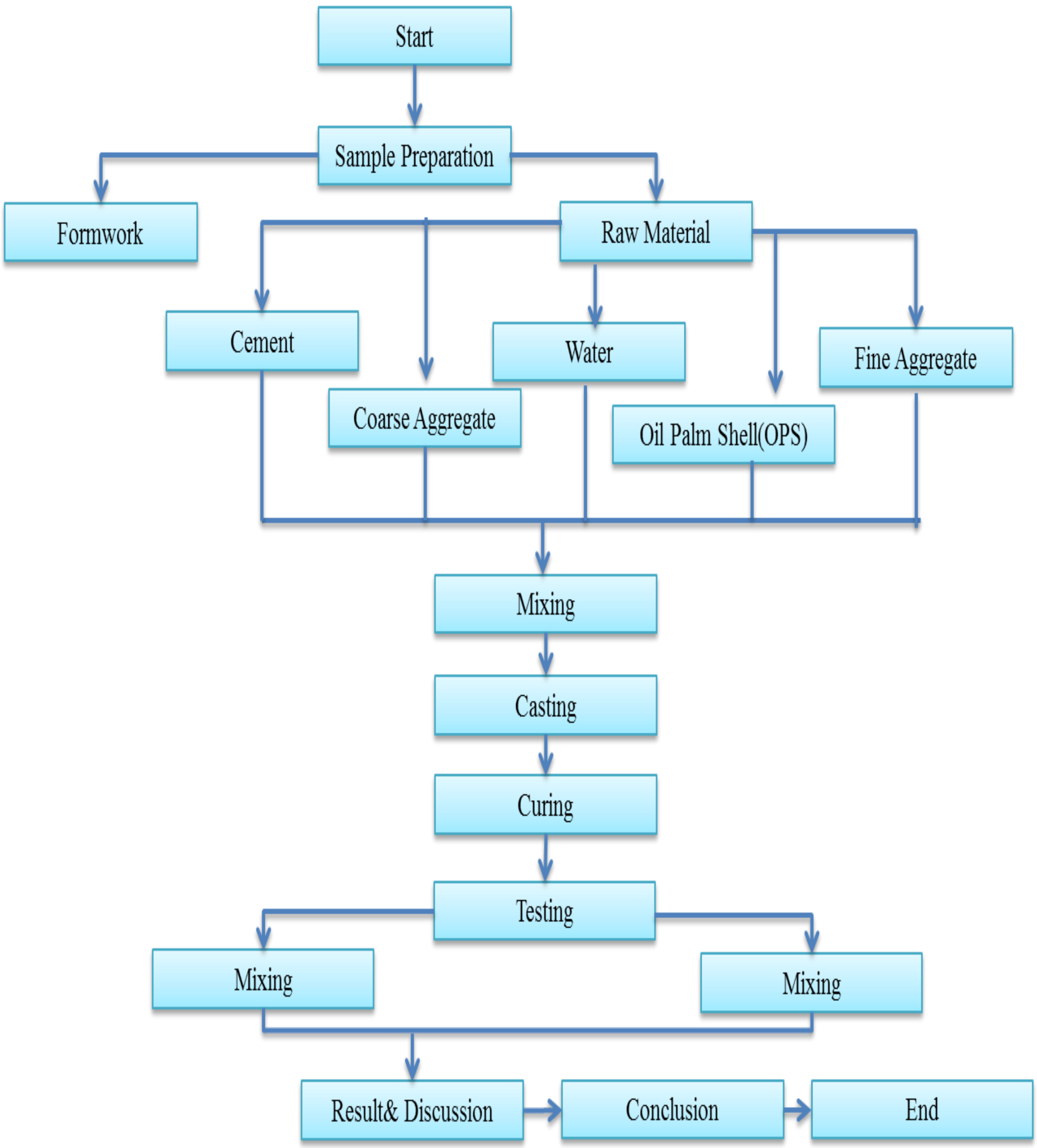

Figure 3.1: Represented the Flow Chart of the Process of This Research

First, the research is started. Then, trial and mix is done to get the mix proportion of the concrete that achieved the target strength. Next, using the mix proportion, casting is carried out and after it is done, the specimen is cured by wet gunny for 7, 14 and 28 days. After 7, 14 and 28 days, testing is conducted for the specimen. The analysis is done using the results that was obtained from the testing conducted.

Each work carried out must have careful planning in order to achieve the goals and objectives. For this study work plan was made as shown in Figure 3.2

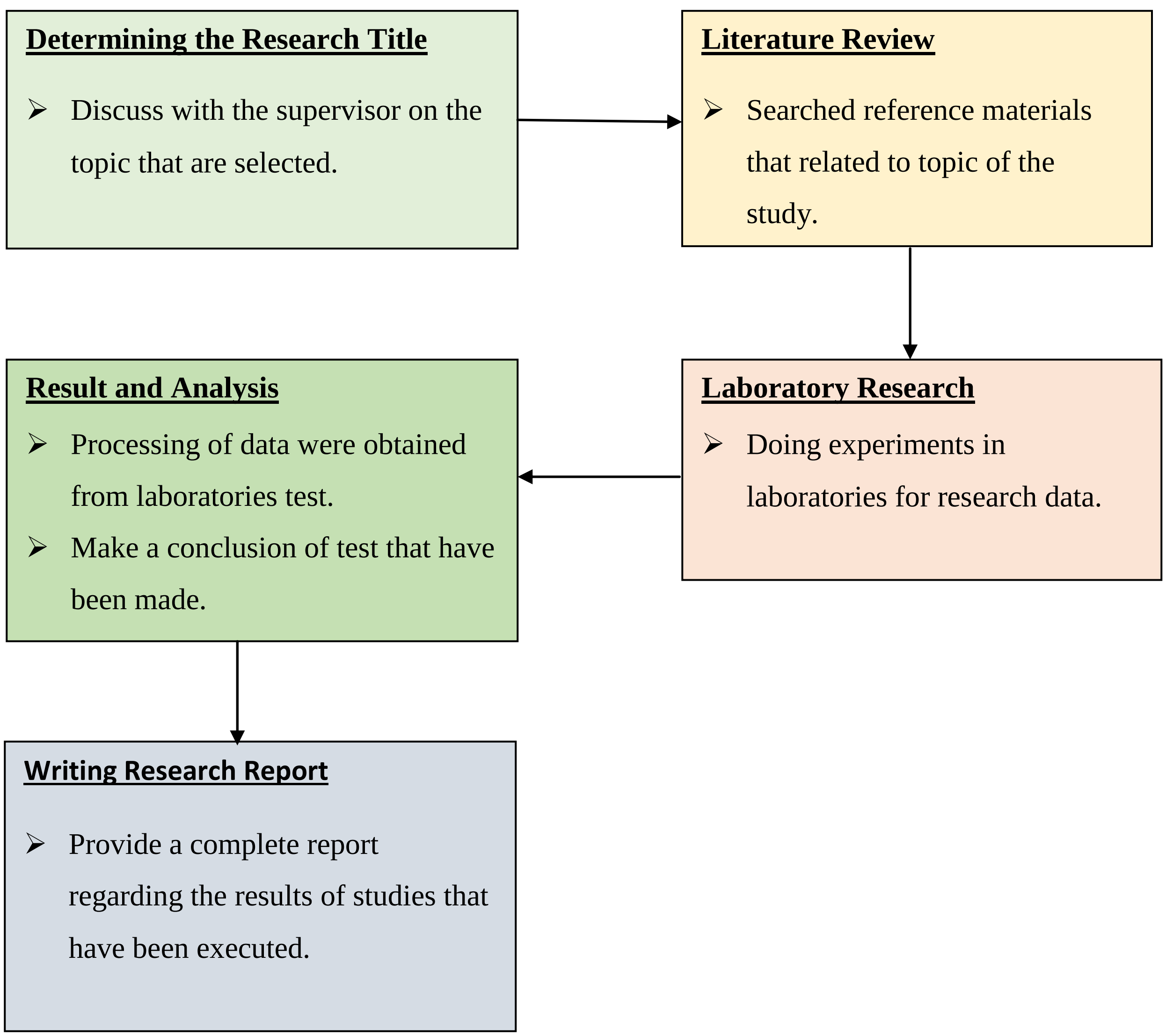

Figure 3.2: Study Work Plan

3.3 MATERIAL USED

3.3.1 OIL PALM SHELL

Oil palm shell (OPS) was used as a lightweight aggregate as the replacement for coarse aggregate in this research. A crushed oil palm shell that was obtained from the factory was used for the conducted test. The crushed oil palm shells (OPS) are located at Maran and Lepar Hilir.

Figure 3.3: Shown an Example of Oil Palm Shell Used

3.3.2 CEMENT

Cement is one of the main materials used in this research. Cement is a soft grey powder that was mixed with water and other substance to make concrete. It can define as the binding element that was used to bind others materials together. The type of the cement that used in this research was Portland Composite Cement (PCC) because it was basic ingredient of concrete, mortar, and most non-specialty grout. This is the most common type of cement use around the world. It is a fine powder produced by grinding Portland cement clinker (more than 90%), usually contains of calcium sulfate with the ability of setting, hardening and remains stable under water. The PCC was used according to BS 12:1958, Specification for Portland Cement. This Figure 3.3 was shown the type of cement used.

Figure 3.4: Type of cement used

3.3.3 COARSE AGGREGATE

Aggregate is a collective term for the mineral materials such as sand, gravel and crushed stone that were used with a binding medium (such as water, bitumen, Portland cement, lime, etc.) to form compound materials (such as asphalt concrete and Portland cement concrete). Aggregate is also used for base and sub base courses for both flexible and rigid pavements. Aggregates can either be natural or manufactured. Natural aggregates are generally extracted from larger rock formations through an open excavation (quarry). Extracted rock is typically reduced to usable sizes by mechanical crushing. Manufactured aggregate is often the byproduct of other manufacturing industries.

Coarse aggregates were used in concrete making contain aggregates of various sizes. This particle size distribution of the coarse aggregates is termed as “Gradation”. The sieve analysis is conducted to determine this particle size distribution. Grading pattern is assessed by sieving a sample successively through the entire sieves mounted one over the other in order of size, with larger sieve on the top. The material retained on each sieve after shaking represents the fraction of aggregate coarser than the sieve in question and finer than the sieve above.

Proper gradation of coarse aggregates is one of the most important factors in producing workable concrete. Proper gradation ensures that a sample of aggregates contains all standard fractions of aggregate in required proportion such that the sample contains minimum voids. A sample of the well graded aggregate containing minimum voids will require minimum paste to fill up the voids in the aggregates. Minimum paste means less quantity of cement and less quantity of water; leading to increased economy, higher strength, lower shrinkage & greater durability. The workability is improved when there is an excess of paste above that required to fill the voids in the sand, and also an excess of mortar (sand plus cement) above that required to fill the voids in the coarse aggregate because the fine material lubricates the larger particles.

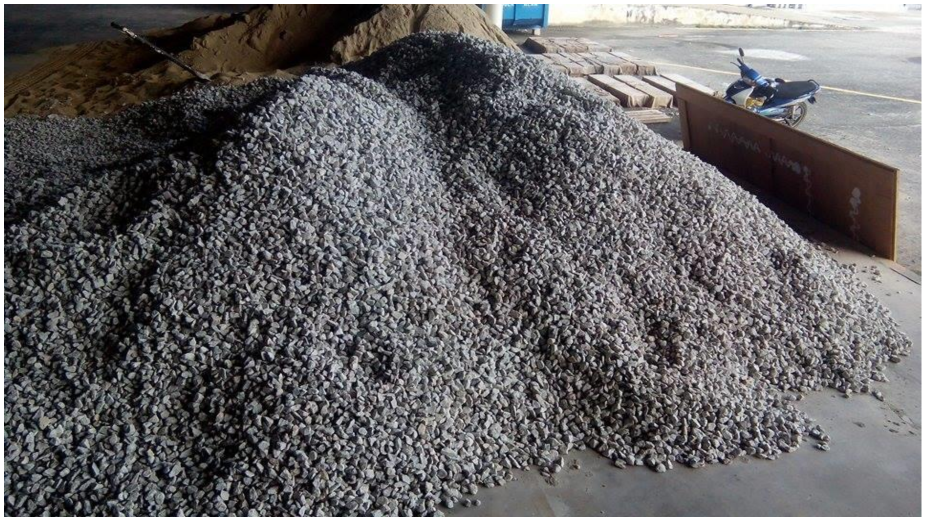

Figure 3.5: Coarse aggregate

3.3.4 FINE AGGREGATE

Fine aggregate is natural sand which has been washed and sieved to remove particles larger than 5 mm and coarse aggregate is gravel which has been crushed, washed and sieved so that the particles vary from 5 up to 50 mm in size. The fine and coarse aggregate are delivered separately. Because they have to be sieved, a prepared mixture of fine and coarse aggregate is more expensive than natural all-in aggregate. The reason for using a mixture of fine and coarse aggregate is that by combining them in the correct proportions, a concrete with very few voids or spaces in it can be made and this reduces the quantity of comparatively expensive cement required to produce a strong concrete.

Figure 3.6: Close-up of fine aggregate or sand

3.3.5 WATER

Water used in mixing concrete shall be from sources that are clean and approved. In addition, water used shall be free from contaminants such as suspended solid, organic matter and so on. Therefore, the amount of water in concrete controls many fresh and hardened properties of concrete including workability, compressive strengths, permeability and water tightness, durability and weathering, drying shrinkage and potential for cracking. For these reasons, limiting and controlling the amount of water in concrete is important for both constructability and service life.

3.3.5.1 Water Cement Materials Ratio (w/cm)

The w/cm ratio is a modification of the historical water-cement ratio (w/c ratio) that was used to describe the amount of water, excluding what was absorbed by the aggregates, to the amount of the Portland cement by weight in concrete.

Figure 3.7: Water Cement Ratio

3.4 CONCRETE MIX DESIGN

Mix designed is based on experimental samples of the mix samples are using oil palm shell (OPS) as coarse aggregate. Mix designed for all sample were same, but different ratio of partial replacement of oil palm shell (OPS). Oil palm shell will be substituted into the mix by using unit weight method based on percentage.

Based on the trial mixed, the concrete mixed was also design and casting the cube. Concrete mix will be designed to achieve the compressive strength of 30 N/mm^2 on 28days and for the cylindrical was 25 N/mm^2 on 28days and has total collapse of the slump test from 10-30 mm. the result of this designed are as in the table 3.4

Table 3.1: Concrete Mix Design

Type of Beam	Control	5% of OPS	10% of OPS	15% of OPS
Material	Weight (kg/m3)	Weight (kg/m3)	Weight (kg/m3)	Weight (kg/m3)
Cement	335	335	335	335
Water	192	192	192	192
Fine aggregate	1033	1033	1033	1033
Course aggregate	852	836	792	748
OPS	0%	5%	10%	15%
w/c ratio	0.58	0.58	0.58	0.58

3.5 PREPARATION OF SAMPLE

Samples for this experiment are provided based on the mix designs were prepared. Concrete mix made for the one samples base on experimental sample using oil palm shell (OPS) with the ratio was (5, 10, and 25 percent). The result for all samples will be compared with the normal concrete. Therefore, all experimental results can be determined whether it is better or not. Figure 3.6 also shows the sample of concrete mix.

3.5.1 Oil Palm Shell Concrete (OPSC)

Materials used in the concrete mix are Portland cement, oil palm shell, coarse aggregate, fine aggregate, and water. Oil palm shell derived from the plant shall be clean and contain no impurities in it. After all materials are provided, the concrete mix can be done with concrete mixer machine. Mixes which have been mixed with the distribution will be entered into a mold made of steel or cast iron according to the dimensions of the mold to be used based on the test conducted on concrete.

Figure 3.8: Oil Palm Shell Concrete

3.6 CURING CONCRETE SAMPLE

Curing is done to control the moisture content of concrete during the hardening process of concrete. This stage is important because it can minimize dehydration and heat stress in the concrete which can cause crack on the surface of the sample surface after the fully harden. In addition, it will allow the concrete to build and achieve the required strength.

Sample preserved in this experiment using immersion in tank of water. It is also preserved by the different time period according to the test to be conducted. In this experiment, the curing is 7, 14, and 28 days. Wet gunny method and immersion method were the curing method used in the research. Figure 3.6 also shows the type of curing.

Figure 3.9: Type of Curing.

3.7 TEST CONDUCTED

Each sample or cube test made in accordance with the test specified. The test are performed in the materials and structures laboratory FKASA in accordance with the established procedures. Among the test conducted in this study are as sieve analysis, slump test, compression test and flexural strength.

3.7.1 Sieve Analysis

A sieve analysis or gradation test is a procedure used commonly used in civil engineering to assess the particle size distribution also called gradation of a granular material. The grain size characteristics of soils that are predominantly coarse grained are evaluated by a sieve analysis.

A sieve analysis can be performed on any type of non-organic or organic granular materials including sands, crushed rock, clays, granite, feldspars, coal, and soil, a wide range of manufactured powders, grain and seeds, down to a minimum size depending on the exact method. Being such a simple technique of particle sizing, it is probably the most common. A nest of sieves is prepared by stacking test sieves one above the other with the largest opening at the top followed by sieves of successively smaller openings and a catch pan at the bottom.

Percent passing formula:

$$\%Passing = \frac{W_{Below}}{W_{Total}} x100\%$$

Where:

W_{Below} - The total mass of the aggregate within the sieves below the current sieve, not including the current Sieve's aggregate.

W_{Total} - The total mass of all of the aggregate in the sample.

3.7.1.1 Apparatus

i. Sample splitter, quartering machine, quartering cloth, or shovel and a smooth surface.
ii. Set of standard U. S. sieves, meeting the requirements of Tex-907-K.
iii. Mechanical sieve shaker.
iv. Balance, Class G2 in accordance with Tex-901-K, minimum capacity of 10,000 g.
v. Drying oven, capable of attaining a temperature of at least 200 ± 9°F (93 ± 5°C).
vi. Various pans.
vii. Scoop.
viii. Brass wire brush.
ix. Bristle brush.

3.7.1.2 Procedure

i) Write down the weight of each sieve as well as the bottom pan to be used in the analysis.
ii) Record the weight of the given dry soil sample.
iii) Make sure that all the sieves are clean, and assemble them in the ascending order of sieve numbers (#4 sieve at top and #200 sieve at bottom). Place the pan below #200 sieves. Carefully pour the soil sample into the top sieve and place the cap over it.
iv) Place the sieve stack in the mechanical shaker and shake for 10 minutes.
v) Remove the stack from the shaker and carefully weigh and record the weight of each sieve with its retained soil. In addition, remember to weigh and record the weight of the bottom pan with its retained fine soil.

3.7.2 WORKABILITY TEST

Workability may be defined as the property of the concrete which determines as ability to be placed compacted, and finished. It is the most term relating to fresh concrete of these three operations, the greatest emphasis should be placed on compaction to eliminate of air voids, since the consequences of inadequate compaction are serious. It also can be independent characteristic as follows:

a) Consistency; is the firmness of form of a substance or the ease with which it will flow. It is measure of wetness and fluidity.
b) Mobility; the ease which concrete mix can flow into and completely fill the formwork or mold.
c) Compatibility; the ease which a given concrete mix can be fully compacted to remove all trap water and to achieve maximum possible density. Next is the increase in compressive strength with an increase density.

3.7.2.1 SLUMP TEST

The workability of a concrete mix is defined as the case with which it can be mixed, transported, placed and compacted in position. Slump test is carried out to measure the consistency of plastic concrete. It is sustainable for detecting changes in workability. This test is being used extensively on site. There are three types of slump which is true slump, shear slump and collapse slump as shown in figure 3.7.2.

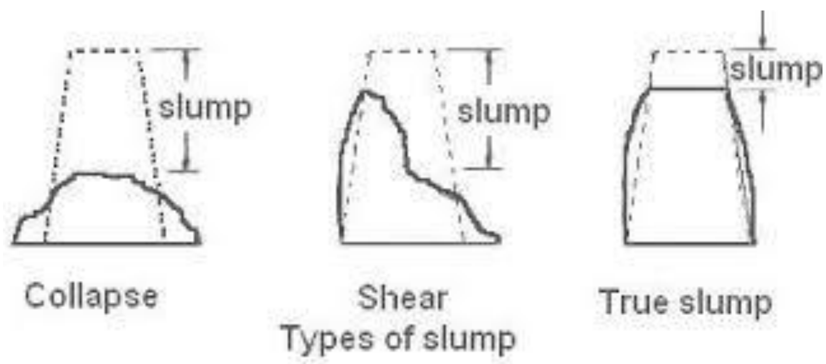

Figure 3.10: Types of slump

Source: M.L. Gambhir, (2009)

3.7.2.2 APPARATUS

Apparatus	Description
Cone mould	Has a diameter of 100 mm and 200 mm below and height 300mm
Steel rods	Has a diameter of 16 mm and the length is 600 mm with both ends shaped hemisphere
Sampling tray	This tray mould is used to cover the cone
spatula	Used for mixing concrete and put into the mould
Ruler	Used to measure the debris

3.7.2.3 PROCEDURE

i) The mold for the slump test is a frustum of a cone, 300 mm (12 in) of height. The base is 200 mm (8in) in diameter and it has a smaller opening at the top of 100 mm (4 in).

ii) The base is placed on a smooth surface and the container is filled with concrete in three layers, whose workability is to be tested.

iii) Each layer is temped 25 times with a standard 16 mm (5/8 in) diameter steel rod, rounded at the end.

iv) When the mold is completely filled with concrete, the top surface is struck off (leveled with mould top opening) by means of screening and rolling motion of the temping rod.

v) The mould must be firmly held against its base during the entire operation so that it could not move due to the pouring of concrete and this can be done by means of handles or foot - rests brazed to the mould.

vi) Immediately after filling is completed and the concrete is leveled, the cone is slowly and carefully lifted vertically, an unsupported concrete will now slump.

vii) The decrease in the height of the center of the slumped concrete is called slump.

viii) The slump is measured by placing the cone just besides the slump concrete and the temping rod is placed over the cone so that it should also come over the area of slumped concrete.

ix) The decrease in height of concrete to that of mould is noted with scale. (Usually measured to the nearest 5 mm (1/4 in).

3.7.3 COMPRESSIVE TEST

Compressive strength test are test that are widely used worldwide to measure the strength of the concrete, where concrete grades and different age will give the different strength. This test is one of the damage concrete tests based on specification of BS 1881: part 116: 1983 (British Standard Institution 1983). Compressive strength of the concrete can be calculated using the following formulae.

These specimens are tested by compression testing machine after 7 days, 14 days and 28 days curing. Load should be applied gradually at the rate of 140 kg/cm^2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete. The size of cube that used is 150mm x 150mm x 150mm.

Compressive strength, fcu =P/A (N/mm^2)/Pascal

Where:

P = Ultimate Load (N)

A = Surface Area of a Cube (mm^2)

The instrument used in this test is the concrete compressive strength testing machine (ADR 2000) as shown in figure 3.7.3 below item such as the size of the cube will be recorded, so that the results of test carried out in accordance with the size of the test cube.

Figure 3.11: Compression Machine

3.7.3.1 APPARATUS

I. Compression machine
II. Broom

3.7.3.2 PROCEDURE

I. Remove the specimen from water after specified curing time and wipe out excess water from the surface.
II. Take the dimension of the specimen to the nearest 0.2m
III. Clean the bearing surface of the testing machine
IV. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
V. Align the specimen centrally on the base plate of the machine.
VI. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.

VII. Apply the load gradually without shock and continuously at the rate of 140kg/cm2/minute till the specimen fails

VIII. Record the maximum load and note any unusual features in the type of failure.

3.7.4 TEST

Flexural testing is used to determine the flex or bending properties of a material. Sometimes referred to as a transverse beam test, it involves placing a sample between two points or supports and initiating a load using a third point or with two points which are respectively call 3-Point Bend and 4-Point Bend testing.

Maximum stress and strain are calculated on the incremental load applied. Results are shown in a graphical format with tabular results including the flexural strength (for fractured samples) and the yield strength (samples that did not fracture). Typical materials tested are plastics, composites, metals, ceramics and wood.

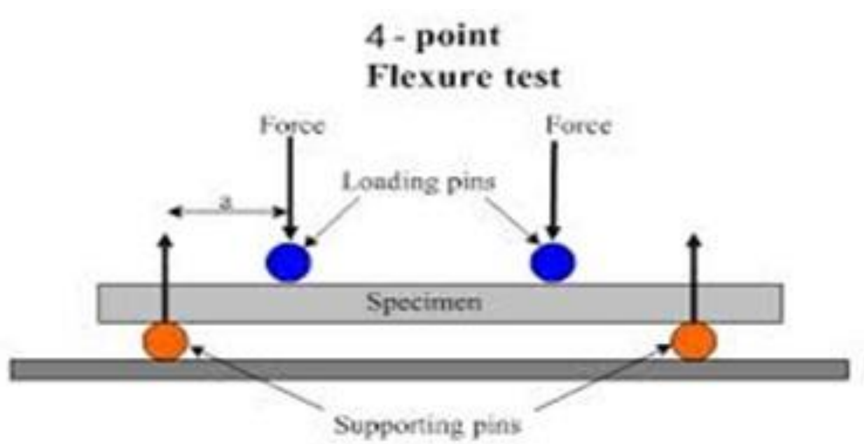

Figure 3.12: Example of flexural strength 4-point

Source: ASTM C78 (2005)

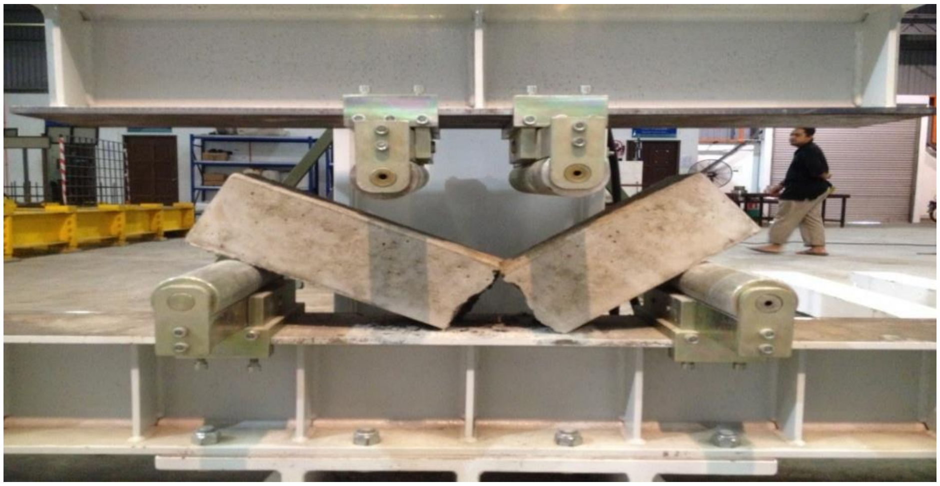

Figure 3.13: Example of flexural strength test

3.7.4.1 APPARATUS

Apparatus	Description
Prism mold	Size are 150 x 150 x 750 mm (when size of aggregate is less than 38 mm). so that's the aggregate is 20 mm
Tamping bar	The size is (40 cm long, weighing 2 kg and tamping section having size of 25 mm x 25 mm)
Flexural test machine	The bed of the testing machine shall be provided with two steel rollers, 38 mm in diameter, on which the specimen is to be supported, and these rollers shall be so mounted that the distance from center to center is 60 cm for 15.0 cm specimens or 40 cm for 10.0 cm specimens. The load shall be applied through two similar rollers mounted at the third points of the supporting span that is, spaced at 20 or 13.3 cm center to center. The load shall be divided equally between the two loading rollers, and all rollers shall be mounted in such a manner that the load is applied axially and without subjecting the specimen to any torsion stresses or restraints.

3.7.4.2 PROCEDURE

- Prepare the test specimen by filling the concrete into the mold in 3 layers of approximately equal thickness. Tamp each layer 35 times using the tamping bar as specified above. Tamping should be distributed uniformly over the entire cross section of the beam mold and throughout the depth of each layer.
- Clean the bearing surfaces of the supporting and loading rollers, and remove any loose sand or other material from the surfaces of the specimen where they are to make contact with the rollers.
- Circular rollers manufactured out of steel having cross section with diameter 38 mm will be used for providing support and loading points to the specimens. The length of the rollers shall be at least 10 mm more than the width of the test specimen. A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes. The distance between the outer rollers (i.e. span) shall be **3d** and the distance between the inner rollers shall be **1d**. The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic.
- The specimen stored in water shall be tested immediately on removal from water; whilst they are still wet. The test specimen shall be placed in the machine correctly centered with the longitudinal axis of the specimen at right angles to the rollers. For molded specimens, the mold filling direction shall be normal to the direction of loading.
- The load shall be applied at a rate of loading of 400 kg/min for the 150.00 mm specimens and at a rate of 180 kg/min for the 100.00mm specimens.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

Based on test conducted, result and data have been collected. These data were used in the analysis and conclusions related to the study as well as to achieve the goals and objectives. Therefore, this chapter describe the results of the experiments have been performed.

4.2 SLUMP TEST

Consequently, after conducting laboratory tests based on particular standard methods, the results below were obtained.

The workability of concrete batches for different percentages of OPS using slump test is shown in the Table 4.1 and Figure 4.1. The mix samples with constant water/cement (W/C) ratio of 0.58 exhibited medium to high workability. It is obvious that workability of concrete reduces as the amount percentage of OPS increase except for 5% OPS where it shows a spike in workability, to which from that point, as the percentage of OPS increases, the workability of the concrete was increased. This can be attributed to the fact that since the control aggregate is denser than the OPS aggregate. This implies that more cement paste is required for the lubrication of the aggregate, hence reducing the entire fluidity of the mix, thereby reducing the height of the slump.

Similarity, the decrease of the slump height in 5%, 10%, and 15% OPS as percentage of OPS aggregate was increased and was equally be attributed to w/c ratio. With w/c ratio of 0.58 used for all the mixes, the hydrated cement paste became less watery and more viscous because the OPS is absorb the water. This process permits the penetration of cement into the OPS aggregate. Furthermore, it reduces the amount of cement paste available for lubrication and hydration. Therefore, it can leads to a decrease in the free movement of cement paste in the mixed and consistently leads to a decrease in slump.

Table 4.1 Slump Test Result (mm)

Sample	**W/C Ratio**	**Slump (mm)**	**Slump Type**
Control	0.58	64	True Slump
R1-5%	0.58	55	True Slump
R2-10%	0.58	47	True Slump
R3-15%	0.58	43	True Slump

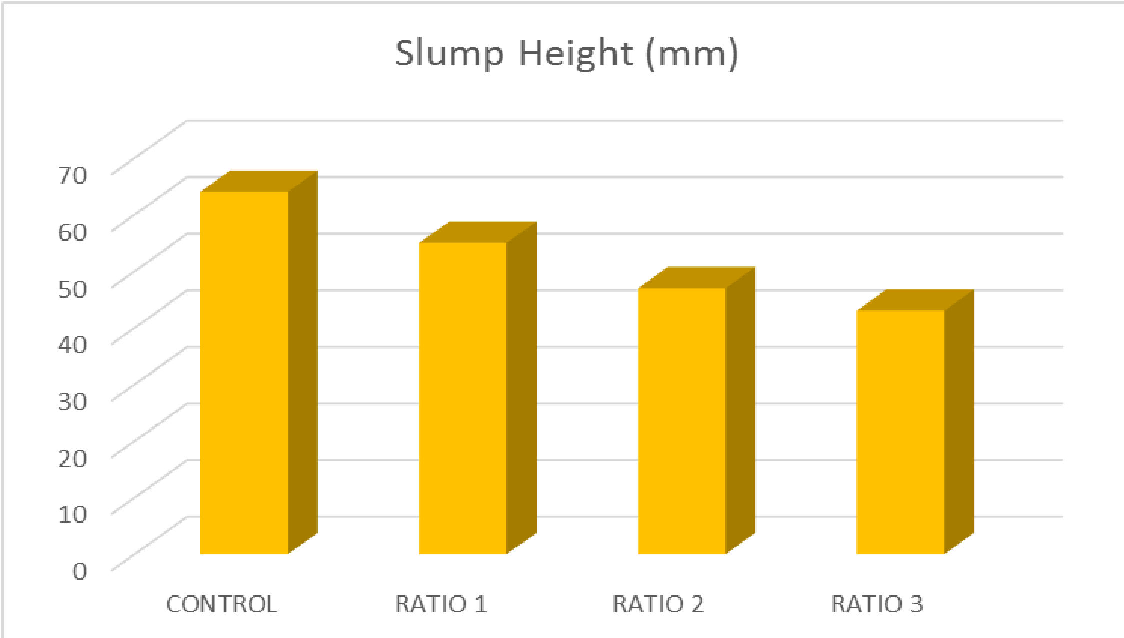

Figure 4.1: Slump Height for OPS Concrete

4.3 COMPRESSION TEST

Table 4.2: Maximum Load for Compressive Strength Test

Sample	7 days kN	14 days kN	28 days kN
Control	542.023	677.482	746.589
5%	370.608	400.584	546.492
10%	324.639	460.547	576.449
15%	264.731	394.472	491.661

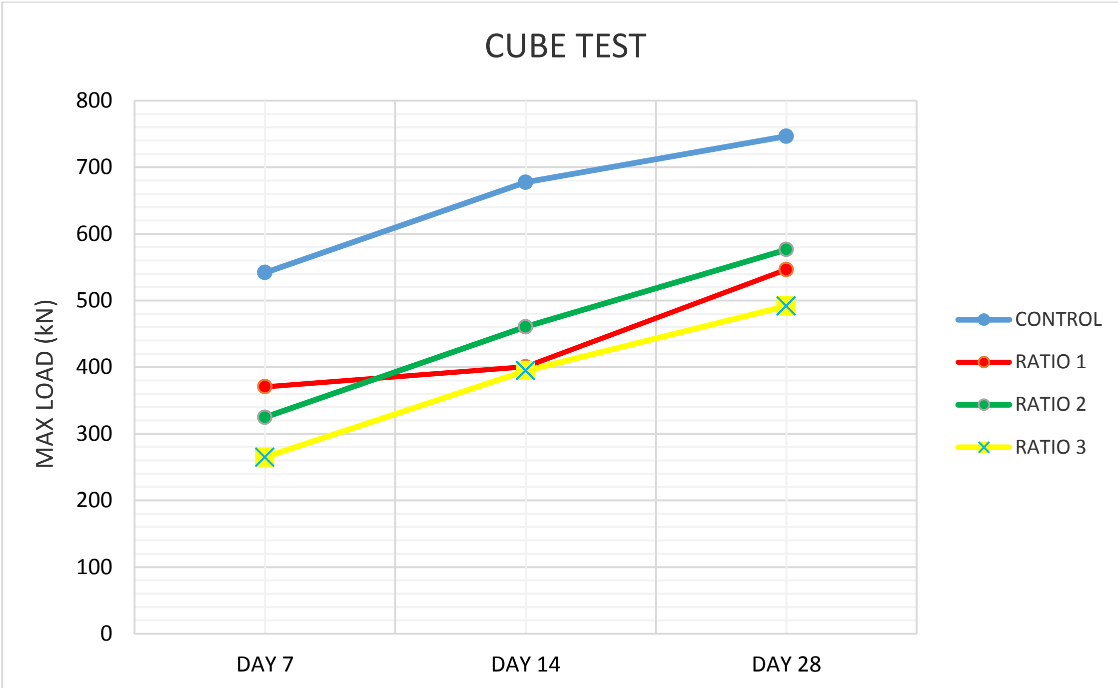

Figure 4.2: Maximum Load of the Cubes

Table 4.3: Maximum Strength for Compressive Strength Test

Sample	7 days MPa	14 days MPa	28 days MPa
Control	24.090	30.110	33.182
5%	16.472	17.804	24.289
10%	14.429	20.468	25.620
15%	17.532	17.532	21.851

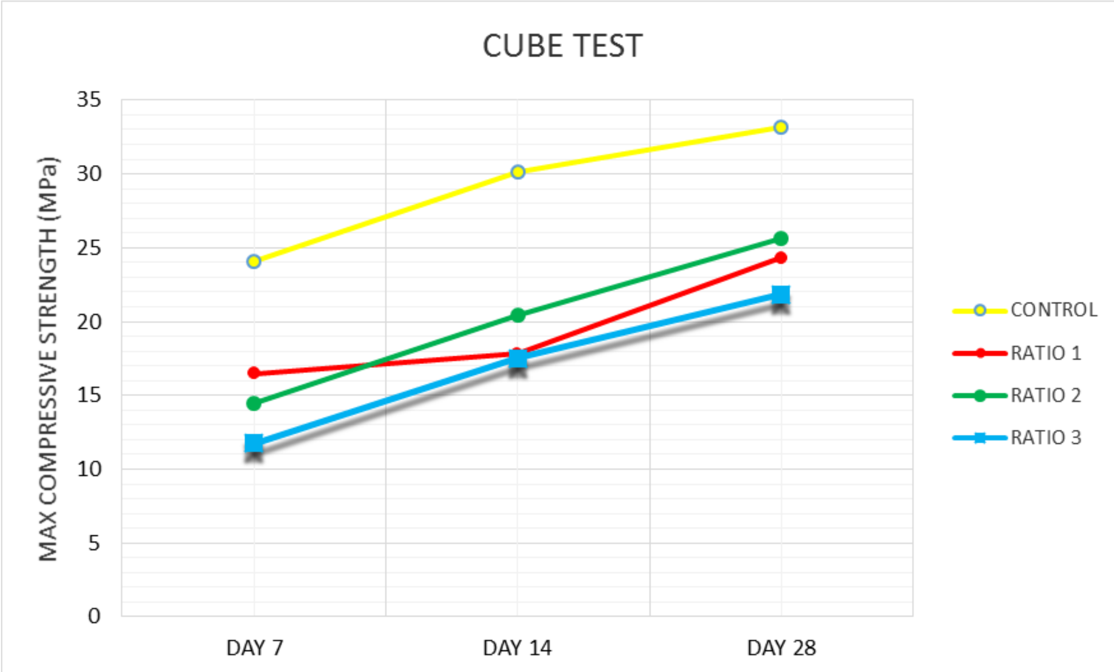

Figure 4.3: Compressive Strength of the Cubes

Figure 4.2 and Table 4.2 shows the development of maximum load compressive strength of concrete with age. Figure 4.3 and Table 4.3 showed the result of compressive strength. It indicates the different amount of OPS that were added, as it affects the strength of the concrete. The rate of strength gained was substantial as the curing days increase; on the other hand, the strength of the concrete specimens is reciprocal to the percentage of OPS added. As the percentage of OPS increase, the compressive strength of the concrete decreases, vice versa.

As it is clear, 0% OPS attained the maximum strength at 7 to 28 days, as OPS gradually replaces the coarse aggregate, so the concrete the concrete strength was dropped when replace the OPS with 15% ratio. These phenomena could be explained from the fact that OPS are the organic materials that happen to be lighter and less strong than granite.

Furthermore, the reduction in strength of concrete strength as a result of increment in the added percentage of OPS as coarse aggregate could be attributed as a result of the highly irregular shapes of the OPS, which prevent full compaction with usual coarse aggregate, there by affecting the strength of the concrete.

In addition, the bonding between OPS and cement paste are not as strong as that of control concrete because the surface of OPS are smooth compare to granite that cause the normal concrete more strength compare to OPS concrete. However, for OPS concrete, 10% as partial replacement of OPS was increased modestly at 14 and 28 days of curing age. The results of this age curing were 20.468 MPa and 25.620 MPa.

As a conclusion, with respect to the general strength of all samples, it can be noted that 0% and 10% are highest strength of compression test. Taking 28 days as the reference of curing age, 0% and 10% are certified as the highest condition of strength for concrete.

Table 4.4: Cube Test for 7 days curing period

Sample of Percentage Replacement, (%)	Load, (kN)	Compressive Strength, (MPa)
Control	542.023	24.090
5	370.608	16.472
10	324.639	14.429
15	264.731	11.766

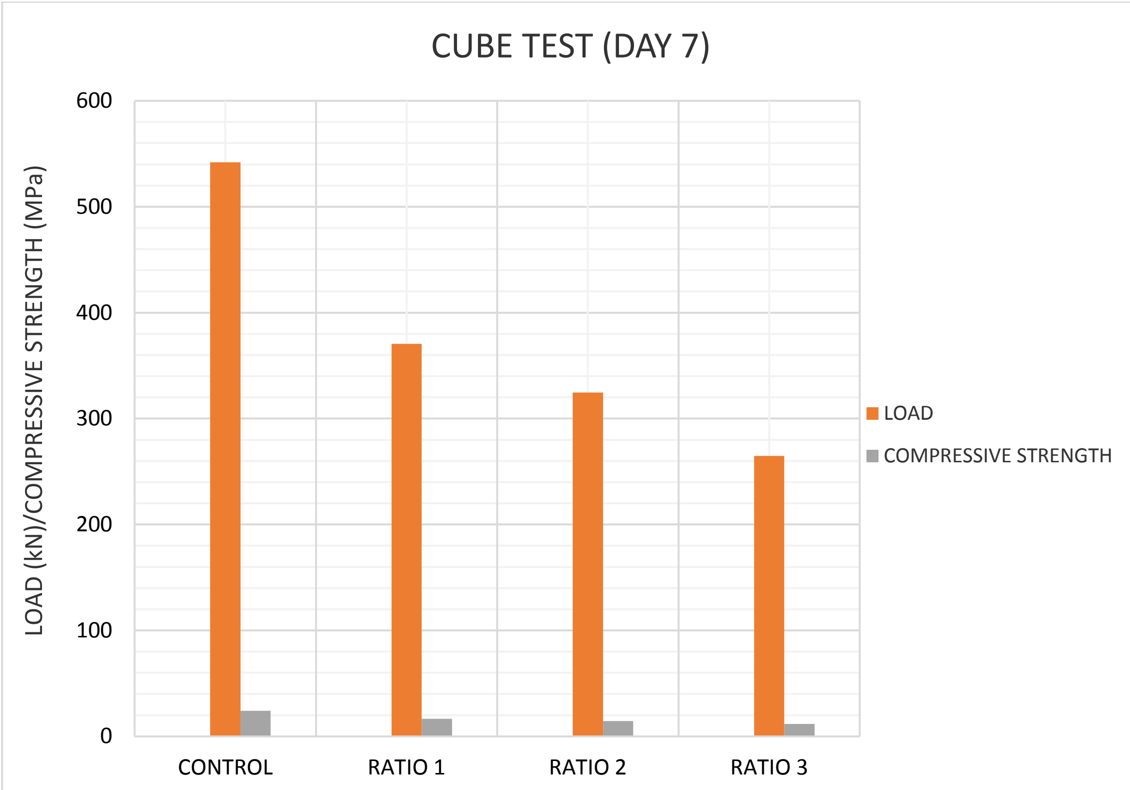

Figure 4.4: Cube Test for 7 days curing period

The test results indicate that Oil Palm Shell (OPS) addition caused a decrease in load and compressive strength of the concrete depending upon the OPS content. Figure 4.4 and table 4.4 shows the cube test for 7 days curing age with different percentages of OPS as partial replacement coarse aggregate in concrete mixes. This compression test is conducted to check the durability of the concrete mixes.

From the compression test with 7 days curing age, it is indicated that 0% OPS sample with load at 542.023 kN and strength at 24.090 MPa. Besides that, for the partial replacement of OPS as coarse aggregate was Ratio 1 which is 5% indicated of the highest load and strength. The load of 5% OPS was 370.608 kN and the strength was 16.472 MPa.

Table 4.5: Cube Test for 14 days curing period

Sample of Percentage Replacement, (%)	Load, (KN)	Compressive Strength, (MPa)
Control	677.482	30.110
5	400.584	17.804
10	460.547	20.468
15	394.472	17.532

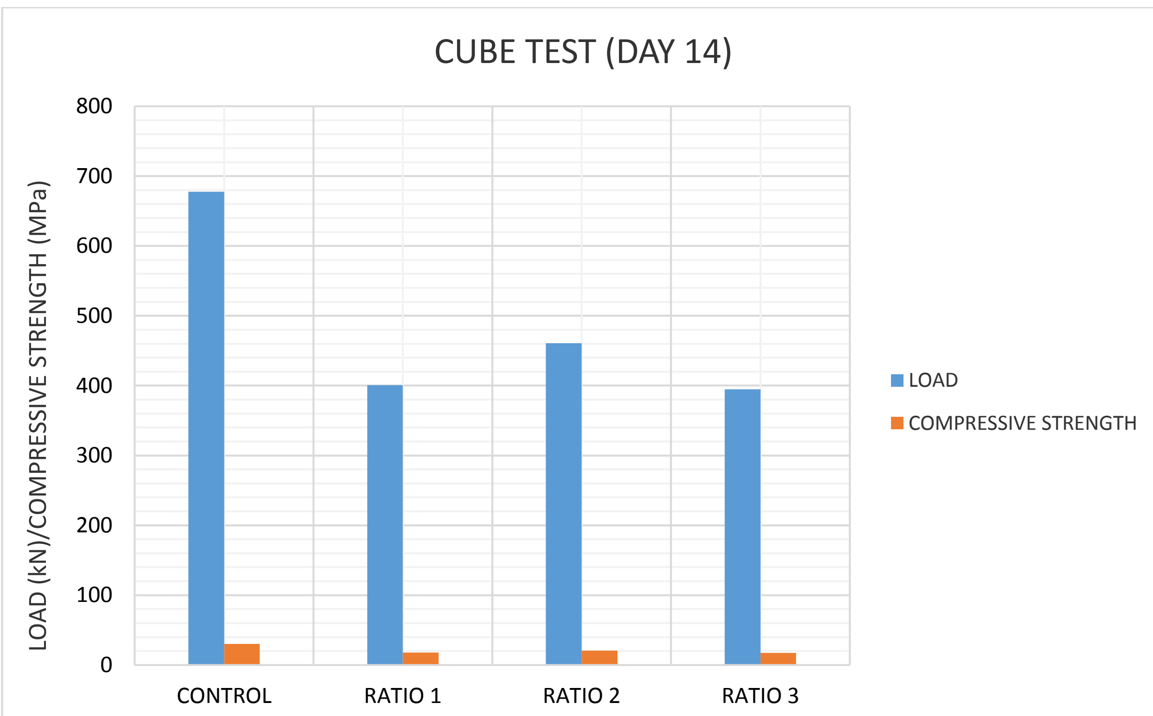

Figure 4.5: Cube Test for 14 days curing period

Figure 4.5 and Table 4.6 shows the development of compressive strength of different ratio concrete with age of curing. It indicates the different amount of OPS that were added, as it affects the strength of concrete when cured the sample at 14 days. The rate of strength gained was substantial as the curing age, while on the other hand, the strength of concrete of control concrete are highest strength but for 10% partial replacement of OPS was increased steadily at 400.584 kN for load and 17.804 MPa for strength.

Based on the bar charts when the curing age at 14 days, the result shows the lowest strength of the concrete which is for 15% partial replacement of OPS as coarse aggregate at 394.472 kN for load and 17.532 MPa for strength.

Table 4.6: Cube Test for 28 days curing period

Sample of Percentage Replacement, (%)	Load, (KN)	Compressive Strength, (MPa)
Control	746.589	33.182
5	546.492	24.289
10	576.449	25.620
15	491.661	21.851

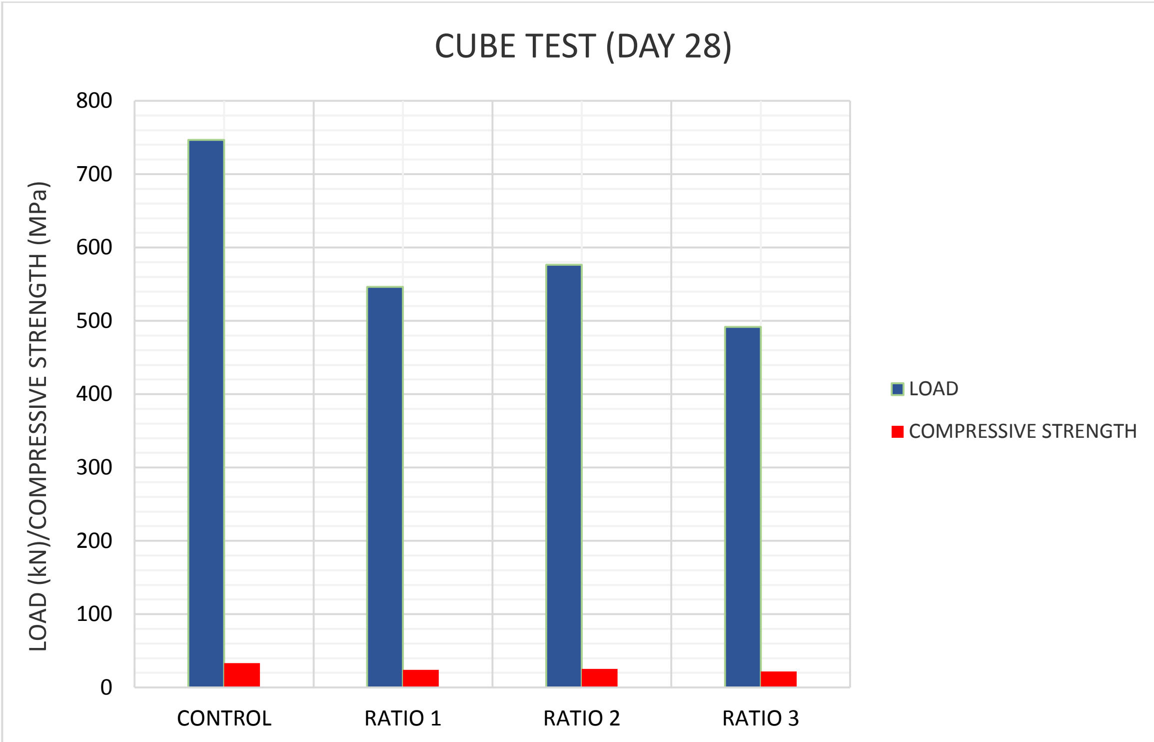

Figure 4.6: Cube Test for 28 days curing period

Figure 4.6 and Table 4.7 shows the development of compressive strength of different ratio concrete with age of curing. It indicates the different amount of OPS that were added, as it affects the strength of concrete when cured the sample at 28 days. Then, for 28 days curing period presented the highest value of load and compressive strength, 746.589 kN and 33.182 Mpa, respectively at 0% replacement of sand with Oil Palm Shell concrete. Besides that, the second highest value for OPS concrete was 10% partial replacement, the value of load at 576.449 kN and the strength at 25.620MPa. So, the optimum percentage of partial replacement oil palm shell (OPS) as coarse aggregate was 10%. Conversely, the lowest value of load, 491.661 kN and compressive strength, 21.851Mpa goes to 15% replacement of coarse aggregate with OPS concrete at 28 days curing period.

4.4 FLEXURAL 4 POINT TEST

Table 4.7: Maximum Load with days

Sample	7 days MPa	14 days MPa	28 days MPa
Control	24.53	28.12	26.19
5%	22.21	28.26	34.71
10%	18.23	23.02	28.42
15%	17.93	21.20	21.57

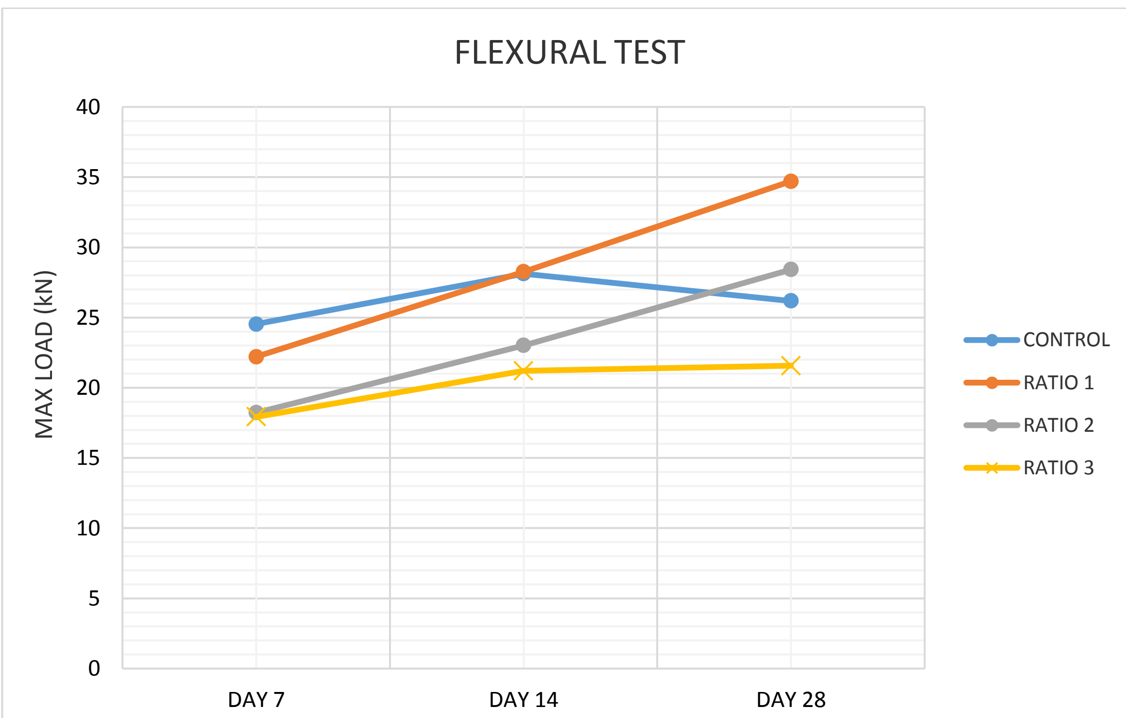

Figure 4.7: Maximum Load of the Prisms

Table 4.8: Flexural Strength with days

Sample	7 days MPa	14 days MPa	28 days MPa
Control	5.452	6.249	5.820
5%	4.936	6.279	7.714
10%	4.052	5.116	6.315
15%	3.985	4.710	4.794

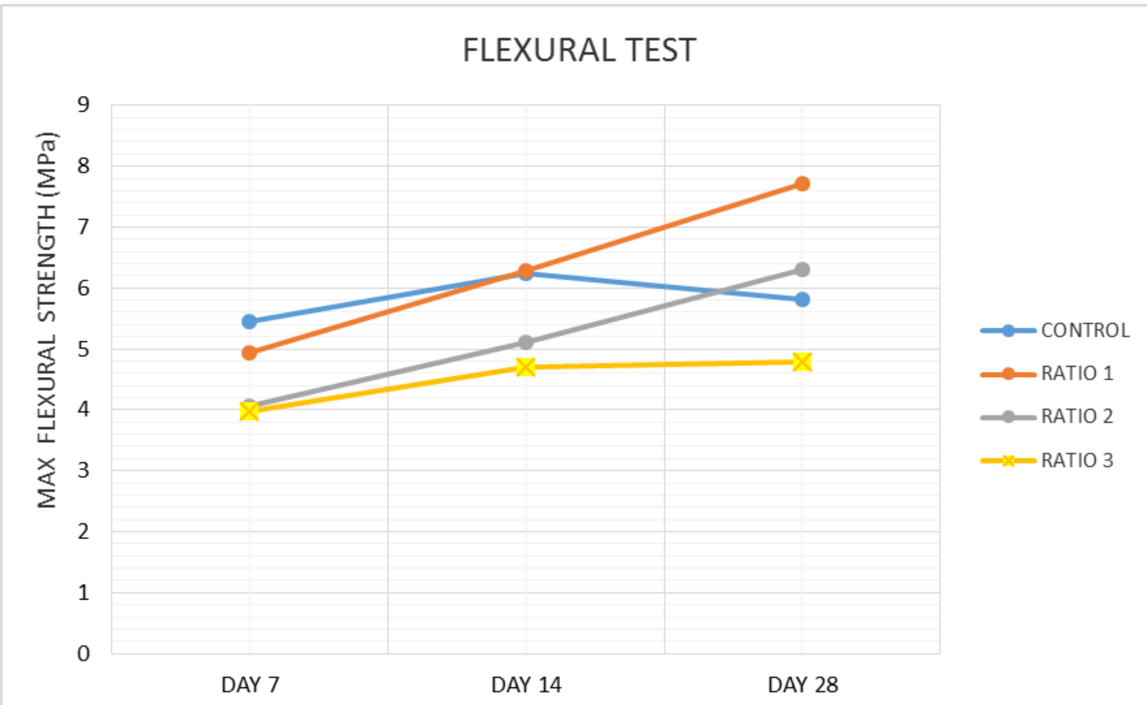

Figure 4.8: Flexural Strength of the Prisms

Based on the Figure 4.7 and Table 4.7 was shows the maximum loads of the prims. From that, the highest load of flexural strength is ratio 1 which is 5% OPS at 34.71 kN of 28 days age curing and the lowest load is ratio 3 which is 15% of OPS at 21.57 kN of 28 days curing. The control concrete went down from 28.12 kN to 26.19 kN at 28 days of age curing. This is due to the cement used is old and can cause the concrete strength decreased.

Figure 4.8 and table 4.8 was shown the flexural strength test results of the prisms. From the results, at 7 days the controlled concrete only can resist the highest strength compare to others ratio. Namely at 14 and 28 days, the ratio 1 was went up compared to ratio for controlled, ratio 1, and ratio 3. At 7 days the controlled concrete had a highest strength at 5.452 MPa. But at 14 days, ratio 1 was slightly increased than control concrete at 6.279 MPa. Besides that, at 28 days the concrete for controlled went down but for concrete of ratio 1was increased at 7.714 MPa compare to ratio 2 and ratio 3. That's mean ratio 1 or the 5% ops as partial replacement as coarse aggregate was highest maximum strength among the others ratio.

Table 4.9: Flexural Test for Control of Oil Palm Shell Concrete

Curing Age (Day)	Load, (KN)	Flexural Strength, (MPa)
7	24.53	5.452
14	28.12	6.249
28	26.19	5.820

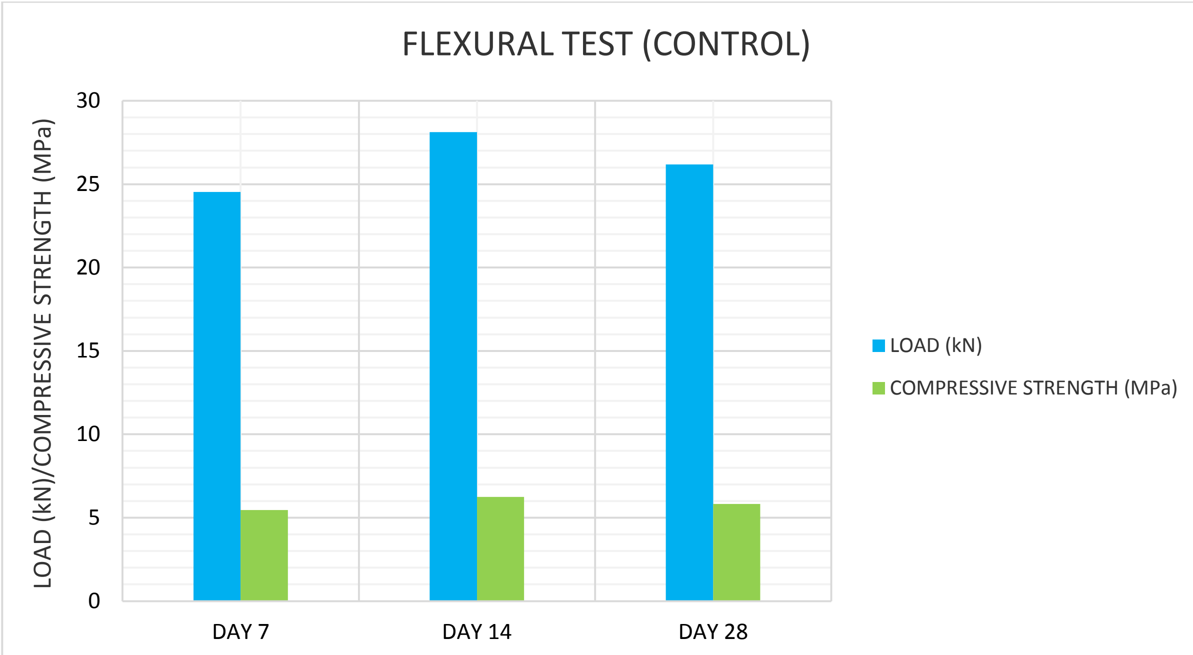

Figure 4.9: Flexural Test for Control of Oil Palm Shell Concrete

Table 4.10: Flexural Test for 5% of Oil Palm Shell Concrete

Curing Age (Day)	Load, (KN)	Flexural Strength, (MPa)
7	22.21	4.936
14	28.26	6.279
28	34.71	7.714

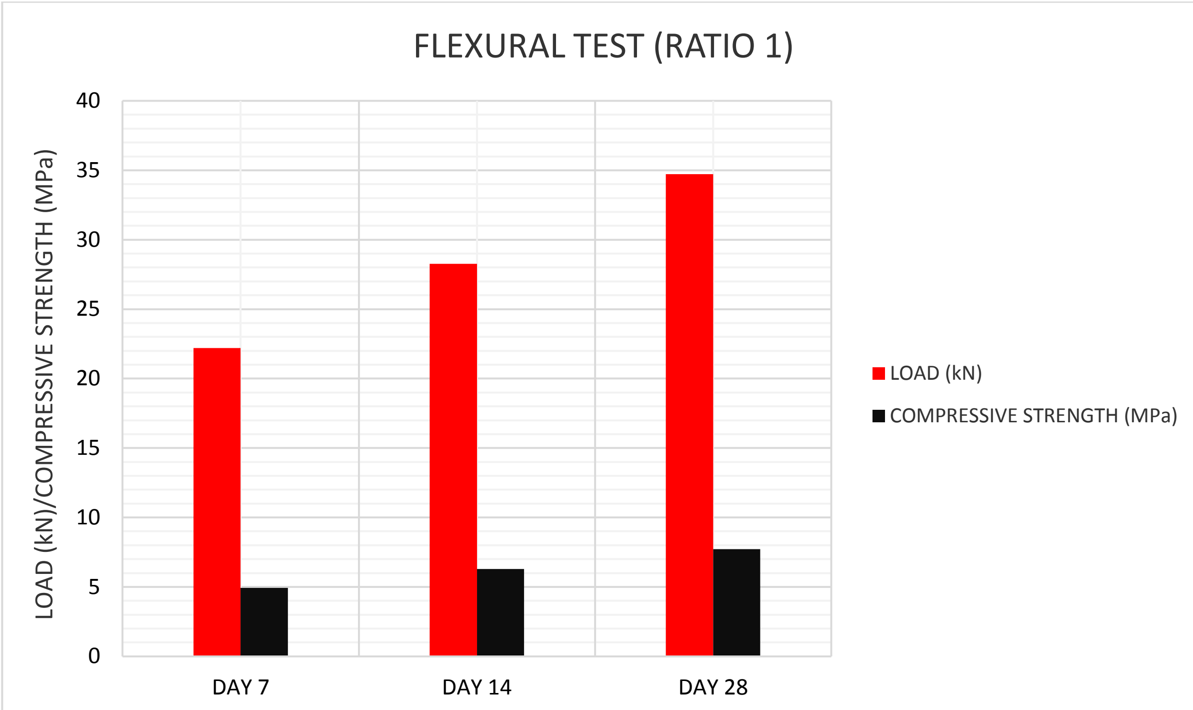

Figure 4.10: Flexural Test for 5% of Oil Palm Shell Concrete

Table 4.11: Flexural Test for 10% of Oil Palm Shell Concrete

Curing Age (Day)	Load, (KN)	Flexural Strength, (MPa)
7	18.23	4.052
14	23.02	5.116
28	28.42	6.315

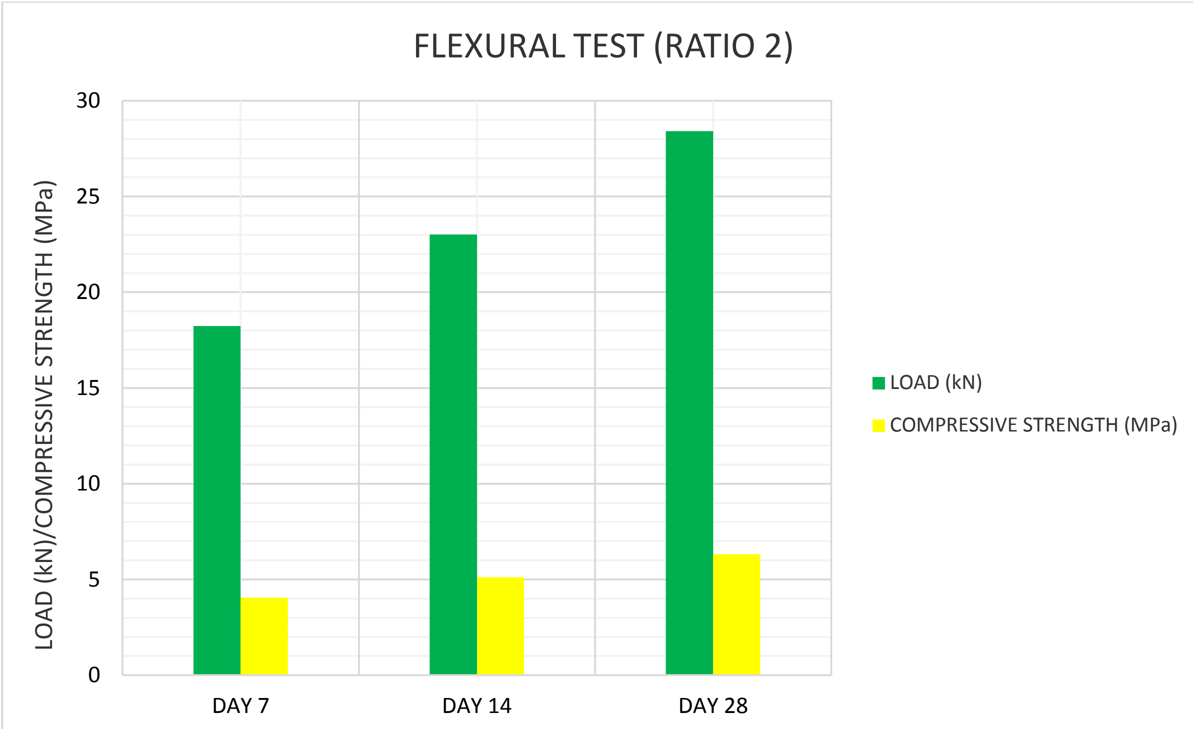

Figure 4.11: Flexural Test for 10% of Oil Palm Shell Concrete

Table 4.12: Flexural Test for 15% of Oil Palm Shell Concrete

Curing Age (Day)	Load, (KN)	Flexural Strength, (MPa)
7	17.93	3.985
14	21.20	4.710
28	21.57	4.794

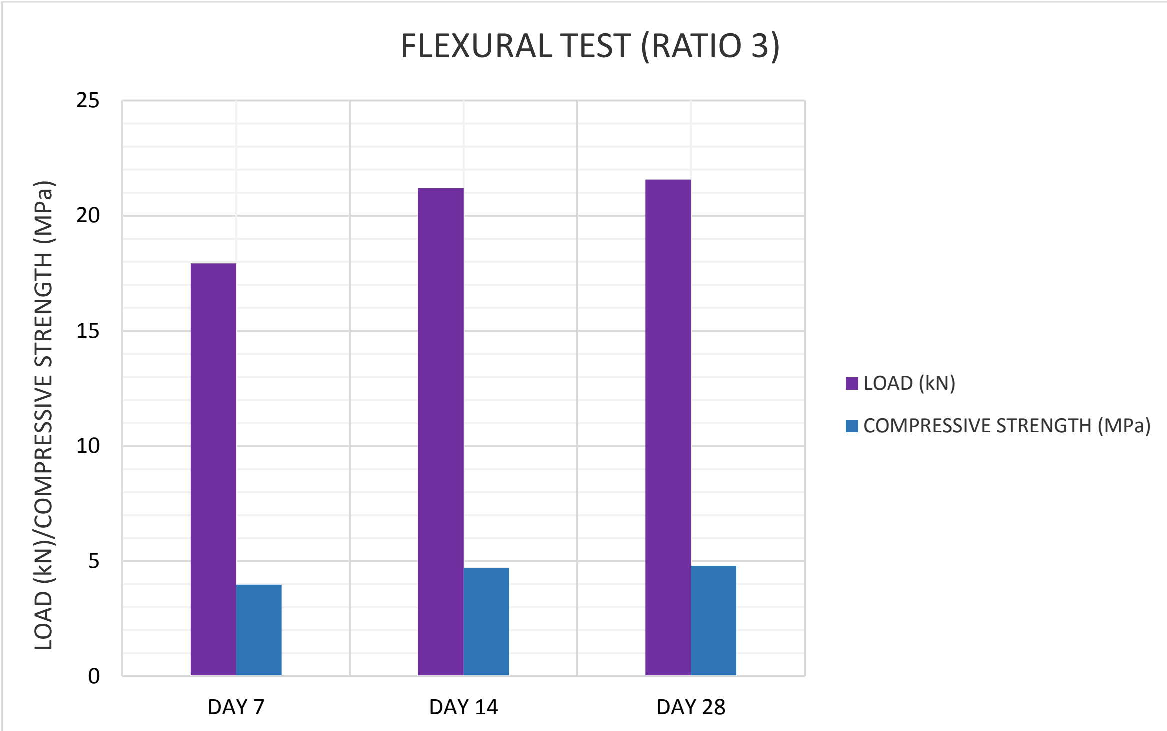

Figure 4.12: Flexural Test for 15% of Oil Palm Shell Concrete

The result has shown that the flexural strength of concrete decreased as the percentage of OPS increased in the mix proportions. Figures 4.9 and Table 4.9 shows these strength and loads for control concrete at 7, 14, and 28 days curing periods, respectively. For the mix proportion C25/30, the strengths obtained at 7 days and 14 days were 5.452 MPa and 6.249 MPa and for the load were 24.53 kN and 28.12 kN. The strength and load of control concrete were decreased at 28 days. The result of load was 26.19 kN and the strength was 5.820 MPa.

Next, based on the Figure 4.10 and Table 4.10 shows the strength and loads of ratio 1 or 5% of OPS as partial replacement of coarse aggregate with age curing. All the specimens with water curing increased steadily. The result at 7 days of curing periods was 22.21 kN for loads and 4.936 MPa for strength. Then, for the 14 days curing age the results were 28.26 kN and 6.279 MPa. Besides that, the highest results of 5% replacement of OPS at 28 days curing age, the results were 34.71 kN and 7.714 MPa. This mean, the flexural strength for 28 days curing age were suitable for oil palm shell partial replacement.

Table 4.11 shows the results of flexural strength for 7, 14, and 28 days with concrete grade 25 and figure 4.11 shows the strength with increasing steadily of ratio 2 with 10% of OPS as partial replacement of coarse aggregate with age curing. For the curing age at 7 days, the result shows the load was 18.23kN and 4.052 MPa for strength. For curing age at 14 days, the result was increased at 23.02 kN and 5.116 MPa compared to the curing age at 7 days. Next was the result of curing age at 28 days, the strength was 6.315 MPa and for the load was 28.42 kN.

Lastly, the Table 4.12 was shows the result for ratio 3 with 15% partial replacement of OPS and Figure 4.12 shows the strength and load with curing age at 7, 14, and 28days. The corresponding value at 15% replacement of OPS was 17.93kN for load and 3.985 MPa for strength. The next specimen with curing age at 14 day, the result was increased with 21.20 kN for load and 4.710 MPa for strength. For 28 days curing age, the result shown the same trend for the strength which is slightly increased of OPS percentage in concrete. The result was 21.57 kN for load and 4.794 MPa for strength. In all cases, the 15% replacement of OPS gave a satisfactory strength for the flexural strength of concrete.

CHAPTER 5

CONCLUSION AND RECOMENDATION

5.1 INTRODUCTION

In general, OPS aggregate was founded to be a good replacer of coarse aggregate in concrete production from strength and workability but for a small replacement point of view and according to recycle of waste material.

5.2 CONCLUSION

Based on this study, the following conclusion can be drawn:

a) SLUMP TEST (WORKABILITY)

- From the slump test done, result shown the sample of ratio 3 was the highest of workability at 43mm compared to other specimen which are 47 mm for ratio 1, 55 mm for ratio 2, and 64 mm control concrete.

b) COMPRESSION TEST

- Based on the result of compressive strength test of the cube, the ratio 2 with 10% was the optimum percentage of compressive strength.

- On 28 days, 10% OPS was get 25.62 MPa for the compressive strength and for the ordinary concrete got 33.18 MPa. So, both samples were almost getting the same strength of the concrete in range of (20 – 30) MPa.

c) FLEXURAL TEST

- Based on the result of flexural strength test of the prism, the ratio 1 with 5% was the optimum percentage of flexural strength.
- On 28 days, 5% OPS was get 7.714 MPa for the compressive strength and for the ordinary concrete got 5.820 MPa. So, both samples were almost getting the same strength of the concrete.

Overall, it can be concluded that the use of oil palm shell will slightly lower the strength of the concrete due to density compared to fine aggregate. It can considered as normal class for strength of concrete due to the compressive strength was above 20 to 30 MPa, but this type of concrete can be applied to build a structure that does not bear the burden of building such as walls and barriers, concrete blocks, stiffness column and so on.

5.2 RECOMMENDATIONS FOR FUTURE STUDY

Upon completion of the study of oil palm shell concrete, some suggestion can be submitted for the concrete improvements that can be produce a better engineering materials as well as economical. This is the list of the suggestion are as follows:

a. Using the correct density of the aggregate mix designs, when the density of oil palm shell to be used when the concrete mix design carried out so that the total weight of materials used will be more accurate.

b. Reduce the water cement ratio in concrete is to improve the mix. Water ratio will affect the strength of cement concrete.

c. Make a more detailed study of the concrete because oil palm shell concrete offers as a potential construction material and simultaneously solving the environment problem of reduction is solid waste.

d. Make sure the material is good condition such as cement, because for control concrete quality, the cement should be fresh to manage achieve required properly

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APPENDIX A

CONCRETE MIX DESIGN			
Stage	Item	Reference & calculation	Value
1	1.1 Characteristic Strength	Specified	**G30** N/mm^2 at **28** days Proportion Defective **5 %**
	1.2 Standard Deviation	Figure 3	**5** N/mm^2
	1.3 Margin	C1 or Specified	(k=1.64) 1.64 x **5** = **8.2**N/mm^2
	1.4 Target mean strength	C2	**30** + **8.20** = **38.20** N/mm^2
	1.5 Cement type	Specified	**PCC**
	1.6 Aggregate type: Coarse		**Crushed**
	Aggregate type: Fine		**Crushed**
	1.7 Free water/cement ratio	Table 2, Fig 4	**0.58** use the lower value
	1.8 Max. free-water cement ratio	Specified	**0.65**
2	2.1 Slump or V-B	Specified	Slump **10-30 mm**
	2.2 Maximum aggregate size	Specified	**20 mm**
	2.3 Free-water content	Table 3	**190 kg/m^2**
3	3.1 Cement content	C3	**190** ÷ **0.58** = **327.59 kg/m^2**
	3.2 Maximum cement content	Specified	______**Kg/m^2**
	3.3 Minimum cement content	Specified	**275 kg/m^2** – use if greater than item 3.1 and calculate 3.4
	3.4 Modified free-water/cement ratio		______
4	4.1 Relative density of aggregate (SSD)	Fig 5	**2.7** known/assumed
	4.2 Concrete density	C4	**2435 kg/m^2**
	4.3 Total aggregate content		**2435** – **327.52** = **1917.41** kg/m^2
5	5.1 Grading of fine aggregate	BS 882	Zoom ______ - ______ -
	5.2 Proportion of fine aggregate	Fig 6	______**Per cent**
	5.3 Fine aggregate content	C5	**1917.41** X **0.53** = **1016.23kg/m^2**
	5.4 Coarse aggregate content	C5	**1917.41**- **1016.23**= **901.18kg/m^2**

Quantities	Cement (Kg)	Water (Kg)	Fine aggregate (Kg)	coarse aggregate (Kg)
Per m^3 (to nearest 5 kg)	**330**	**190**	**1020**	**905**
Per trial mix of **0.18225** m^3	**61**	**35**	**188.14**	**165**

APPENDIX B

COMPRESSIVE STRENGTH OF CONTROL CONCRETE

RATIO	DAYS	SAMPLE 1		SAMPLE 2		SAMPLE 3		AVG. LOAD, kN	AVG. STRENGTH, MPa
		LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa		
Standard Ratio C25/30	7	568.045	25.246	541.696	24.075	516.328	22.948	542.023	24.09
	14	683.077	30.359	651.375	28.95	697.995	31.022	677.482	30.11
	28	797.016	35.423	723.590	32.160	719.161	31.963	746.589	33.182

APPENDIX C

COMPRESSIVE STRENGTH OF 5% OIL PALM SHELL

RATIO	DAYS	SAMPLE 1		SAMPLE 2		SAMPLE 3		AVG. LOAD, kN	AVG. STRENGTH, MPa
		LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa		
5% OPS	7	383.704	17.054	366.284	16.279	361.836	16.082	370.608	16.472
	14	396.816	17.636	432.376	19.217	372.559	16.558	400.584	17.804
	28	557.206	24.765	509.414	22.641	572.857	25.46	546.492	24.289

APPENDIX D

COMPRESSIVE STRENGTH OF 10% OIL PALM SHELL

RATIO	DAYS	SAMPLE 1		SAMPLE 2		SAMPLE 3		AVG. LOAD, kN	AVG. STRENGTH, MPa
		LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa		
10% OPS	7	305.362	13.572	342.402	15.218	326.153	14.496	324.639	14.429
	14	471.946	20.975	436.534	19.401	473.160	21.029	460.547	20.468
	28	553.469	24.599	568.886	25.284	606.993	26.977	576.449	25.62

APPENDIX E

COMPRESSIVE STRENGTH OF 15% OIL PALM SHELL

	DAYS	SAMPLE 1		SAMPLE 2		SAMPLE 3		AVG. LOAD, kN	AVG. STRENGTH, MPa
		LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa		
15% OPS	7	246.5	10.956	297.635	13.228	250.059	11.114	264.731	11.766
	14	398.595	17.715	402.663	17.896	382.159	16.985	394.472	17.532
	28	500.444	22.242	486.055	21.602	488.484	21.71	491.661	21.851

APPENDIX F

FLEXURAL STRENGTH OF CONTROL CONCRETE

RATIO	DAYS	SAMPLE 1		SAMPLE 2		SAMPLE 3		AVG. LOAD, kN	AVG. STRENGTH, MPa
		LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa		
Standard Ratio C25/30	7	23.61	5.247	24.94	5.542	25.05	5.567	24.53	5.452
	14	29.35	6.522	26.37	5.86	28.64	6.364	28.12	6.249
	28	25.4	5.644	24.93	5.54	28.24	6.276	26.19	5.82

APPENDIX G

FLEXURAL STRENGTH OF 5% OIL PALM SHELL

RATIO	DAYS	SAMPLE 1		SAMPLE 2		SAMPLE 3		AVG. LOAD, kN	AVG. STRENGTH, MPa
		LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa		
5% OPS	7	25.18	5.596	22.36	4.969	19.09	4.242	22.21	4.936
	14	28.42	6.316	31.43	6.984	24.92	5.538	28.26	6.279
	28	32.48	7.218	38.41	8.536	33.25	7.389	34.71	7.714

APPENDIX H

FLEXURAL STRENGTH OF 10% OIL PALM SHELL

RATIO	DAYS	SAMPLE 1		SAMPLE 2		SAMPLE 3		AVG. LOAD, kN	AVG. STRENGTH, MPa
		LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa		
10% OPS	7	18.45	4.1	17.97	3.993	18.28	4.062	18.23	4.052
	14	24.98	5.551	24.75	5.5	19.34	4.298	23.02	5.116
	28	29.94	6.653	30.78	6.84	24.53	5.451	28.42	6.315

APPENDIX I

FLEXURAL STRENGTH OF 15% OIL PALM SHELL

RATIO	DAYS	SAMPLE 1		SAMPLE 2		SAMPLE 3		AVG. LOAD, kN	AVG. STRENGTH, MPa
		LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa	LOAD, kN	STRENGTH, MPa		
15% OPS	7	18.72	4.16	17.47	3.882	17.61	3.913	17.93	3.985
	14	21.3	4.733	21.84	4.853	20.45	4.544	21.2	4.71
	28	23.82	5.293	19.86	4.413	21.04	4.676	21.57	4.794

APPENDIX J

PICTURES OF THIS RESEARCH

PREPARATION OF SAMPLE (OPS)

Sample Collected

Washed and dried the oil palm shell (OPS)

Sieve analysis

Materials collected

Concreting work

Oil sealed in formwork

Concrete poured & vibrated

APPENDIX K

Slump Test

Filled up the mixture

Compact the mixture

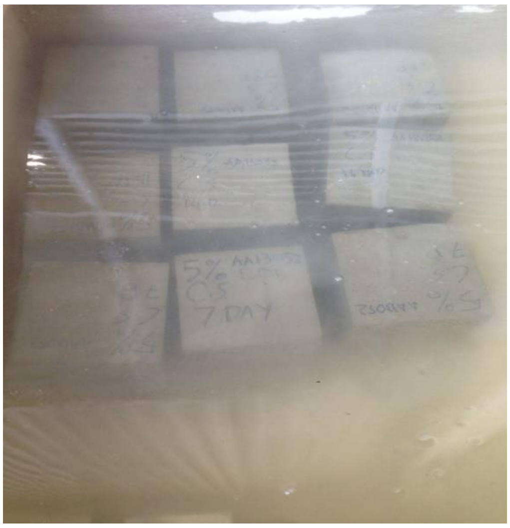
Pull up the cone

Measured the slump height

APPENDIX L

Compressive Strength Test

Filled & vibrated the concrete



Curing the cube

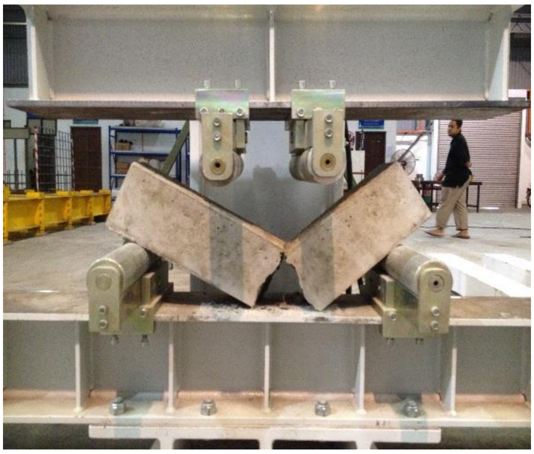
Compression test

Result for compressive

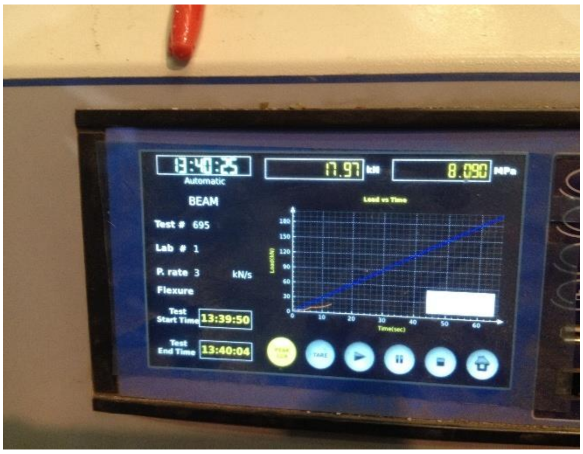
APPENDIX M

Flexural Strength Test

Setup the sample



Test the sample



Result of the load