PERFORMANCE OF COMPRESSIVE STRENGTH WITH 5% COCONUT SHELL AS FINE AGGREGATE REPLACEMENT

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Diploma in Civil Engineering

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ABSTRAK

Penghasilan konkrit di dunia semakin pesat dari hari ke hari. Ia disebabkan oleh pembangunan manusia yang pesat dan maju. Populasi manusia juga semakin hari semakin bertambah. Oleh itu, banyak kawasan akan diterokai dan akan dibina banyak penempatan baharu. Disebabkan isu yang berlaku, permintaan terhadap konkrit juga akan meningkat dari semasa ke semasa dan juga kos untuk penghasilannya juga akan meningkat. Disebabkan pembuataan konkrit meningkat, pencemaran juga berlaku seperti pembebasan gas hijau dan juga membawa kepada pemanasan global. Ia juga akan membawa kepada pengurangan bahan semula jadi seperti agregat dan sebagainya. Oleh hal yang demikian, bahan lain perlu digunakan sebagai penganti untuk menghasilkan konkrit. Bahan yang digunakan perlulah dalam kuantiti banyak sebagai contoh menggunakan bahan buangan pertanian seperti tempurung kelapa. Masyarakat di Malaysia tidak lari dari penggunaan kelapa dalam kehidupan seharian. Penggunaan ini menghasilkan bahan buangan seperti tempurung kelapa. Dari masalah diatas iaitu berkaitan konkrit dan sisa buangan tempurung kelapa, ia dapat ditangani dengan cara menggunakan tempurung kelapa sebagai penganti untuk bahan membuat konkrit seperti menggantikan bahan asas membuat konkrit. Dengan membuat kajian, ia boleh dilakukan sekiranya banyak kajian dilakukan bagi menghasilkan konkrit yang mengandungi bahan buangan sehingga boleh mengurangkan sisa pertanian. Secara keseluruhannya, penggantian bahan asas memnghasilkan konkrit dapat mengatasi isu global, menjimatkan kos dan juga menjadikan alam sekitar menjadi bersih dan selamat.

ABSTRACT

The production of concrete in the world is increasing rapidly day by day. It is caused by rapid and advanced human development. The human population is also increasing day by day. Therefore, many areas will be explored and many new settlements will be built. Due to the issues that occur, the demand for concrete will also increase from time to time and also the cost for its production will also increase. Due to the increase in concrete manufacturing, pollution also occurs such as the release of green gases and also leads to global warming. It will also lead to the reduction of natural materials such as aggregates and so on. Therefore, other materials need to be used as substitutes to produce concrete. The materials used must be in large quantities, for example using agricultural waste such as coconut shells. Society in Malaysia does not run away from the use of coconut in daily life. This use produces waste materials such as coconut shells. From the above problem which is related to concrete and coconut shell waste, it can be dealt with by using coconut shell as a substitute for concrete making material such as replacing the basic material for making concrete. By doing research, it can be done if a lot of research is done to produce concrete that contains waste materials so as to reduce agricultural waste. Overall, the replacement of basic materials producing concrete can overcome global issues, save costs and also make the environment clean and safe.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Concrete can be defined as the composite material composed of the binding medium such as the mixture of cement, water, and the different fine and coarse aggregates. Nowadays, the demand for concrete increases from time to time. Concrete has been the most common building material for many years. It is expected to remain so in the coming decades. Concreting is widely used in domestic, rural, commercial, recreational and educational constructions. Communities around the world rely on concrete as a safe, strong and simple building material.

Due to the higher demand of concrete, this will lead to environmental issues such as global warming, contamination, and reduction of natural materials. The major issues for the study are about the materials that use for mixing concrete such as cement, coarse and fine aggregate. The concrete production requires the use of large amount of raw materials. Over 27 billion tonnes of raw materials are consumed each year (Nicoara et al. 2020). Concrete's mass demand results in annual aggregate consumption of up to 48.3 billion tonnes (Silva et al. 2014). This high consumption is depleting natural resources.

The efficient way to reduce the consumption of raw material for mixing concrete is the agricultural waste need to be used in the concrete mixing which is coconut shell. According to Department of Agriculture Malaysia 2012, there are 114, 000 hectares of coconut plantation in Peninsular Malaysia and the area is more or less static. Agricultural waste was disposed of in large amount in most of the tropical countries particularly in Asia for countries like Philippine, Thailand, and Malaysia (Olanipekun et al. 2006). Most abandon agriculture wastes in Malaysia are oil palm shell, coconut shell, risk husk and corn cob. Coconut shell may offer itself as a coarse or fine aggregate and this would solve the environmental dilemma of reducing the solid wastes simultaneously. Coconut shell concrete is lighter in weight than natural aggregate. In conclusion, some researchers have concluded that coconut shell can be used for lightweight concrete at different proportion for required concrete strength (Azunna et al. 2018). At the same time, this will lead to good benefits such as the uses of natural resources will reduce and also the agricultural waste will reduce.

1.2 Problem Statement

In recent decades, the environmental impact of the concrete industry has attracted much attention as awareness of environmental protection and potential negative consequences have increased at every stage of the concrete industry (Lima et al. 2021). Today, the average production of concrete worldwide is about 3.8 tonnes per person per year (Gursel et al. 2014). Concrete production and consumption are expected to be four times higher by 2050 than in 1990 (Nicoara et al. 2022). The high annual production of concrete means that the consumption of cement and aggregates is also high.

Concrete now is affecting the environment due to civilization. The unfavourable consequences of the increase in demand for concrete include depletion of naturally occurring aggregate, degradation of the environment and ecological inequality. As a result of the constant rise in construction cost and the need reduce environmental. Due to the issues, the other materials need to be use in concrete mixing. The material must be in larger amount, easy to get, low cost and almost used by human routines activities (Azunna et al. 2018). This material should not only contribute to reduction in construction cost and accelerate infrastructural but also to reduce stress on the environment. The efficient way to reduce is the agricultural waste need to be used in the concrete mixing which is coconut shell. Hence, the study on concrete with 5% replacement of coconut shell as fine aggregate is to reduce the uses of natural raw material and agricultural waste.

1.3 Objectives of Study

This study is mainly focused on characteristics of modified concrete properties which replacement 5% coconut shell as fine aggregate.

i. To determine the compressive strength of concrete by replacing 5% of coconut shell in dry state.

ii. To determine the compressive strength of concrete by replacing 5% of coconut shell in wet state.

1.4 Scope of Study

The scope of study is limited to compressive strength test according BS 1881 Part 116:1983. The concrete is casting into cube mould with dimension of 150 x 150 x 150 in mm. The experimental was carried out at Concrete and Structure Laboratory, Faculty of Civil Engineering Technology, Universiti Malaysia Pahang. The evaluation of the concrete is limited to the strength of the concrete only. The observation will be conducted on 7 and 28days. The cube will have to type which is normal and modified. For normal cube are contain a common ingredient for mix concrete but for modified cube are come with replacement of 5% coconut shell as fine aggregate. The two types of cubes will be compared for the compressive strength.

1.5 Significance of Study

The green concrete provides good benefits for the environment while reducing the uses of natural materials. In addition, the implementation of the agricultural waste in the concrete able to reduce the agricultural waste and the basic ingredients for mixing concrete such as fine aggregate.

The outcome of this study able to determine the characteristics strength of concrete at 7 and 28 days and fulfil the requirement of Sustainable Development Goals 11 (SDG 11) for better quality environment. The study also contributes in fulfilling the guideline and policy of building construction for achieving the green building status under the Green Building Index (GBI), Malaysian Carbon Reduction and Environmental Sustainability Tool (My CREST). This is to support the objective of Ministry of Energy, Green Technology and Water – Kementerian Tenaga, Teknologi Hijau dan Air (KeTTHA) and Green Technology Master Plan (GTMP) 2017-2030 to reduce the uses of current materials and replace it with waste and improve the environment quality.

CHAPTER 2

LITERATURE REVIEW

2.1 Global Warming

The environmental impact of concrete, its manufacture and applications, are complex, driven in part by direct impacts of construction and infrastructure, as well as by CO_2 emissions; between 4-8% of total global CO2 emissions come from concrete (Anon (a), 2022). A major component is cement, which has its own environmental and social impacts and contributes largely to those of concrete. The cement industry is one of the two largest producers of carbon dioxide (CO_2), creating up to 5% of worldwide man-made emissions of this gas, of which 50% is from the chemical process and 40% from burning fuel. (Lehne et al. 2018). The CO_2 produced for the manufacture of structural concrete (using ~14% cement) is estimated at 410 kg/m3 (~180 kg/ton @ density of 2.3 g/cm^3) (reduced to 290 kg/m^3 with 30% fly ash replacement of cement). (Samarin et al. 2018). The CO_2 emission from the concrete production is directly proportional to the cement content used in the concrete mix; 900 kg of CO2 are emitted for the fabrication of every ton of cement, accounting for 88% of the emissions associated with the average concrete mix. (Mahasenan et al. 2003; Nisbet et al., 2002). Cement manufacture contributes greenhouse gases both directly through the production of carbon dioxide when calcium carbonate is thermally decomposed, producing lime and carbon dioxide, and also through the use of energy, particularly from the combustion of fossil fuels (Anon (b), 2011).

One area of the concrete life cycle worth noting is the fact that concrete has a very low embodied energy per unit mass. This is primarily the result of the fact that the materials used in concrete construction, such as aggregates, pozzolans, and water, are relatively plentiful and can often be drawn from local sources (Anon (c), 2015). This means that transportation only accounts for 7% of the embodied energy of concrete, while the cement production accounts for 70%. With a total embodied energy of 1.69 GJ/ton concrete has a lower embodied energy per unit mass than most common building material besides wood. However, concrete structures have high mass, so this comparison is not always directly relevant to decision making. It is worth noting that this value is based on mix proportions for concrete of no more than 20% fly ash. It is estimated that one percent replacement of cement with fly ash represents a 0.7% reduction in energy consumption. With some proposed mixes containing as much as 80% fly ash, this would represent a considerable energy saving (Nisbet et al. 2002).

Moreover, cement production emits Nitrogen Oxide (NO_2). It is produced by thermal oxidation in a rotary kiln (Isaiah et al. 2021). Most (NO_2) is released in the form of (NO_2) (about 90%) and the rest in the form of (NO_2) (Innovative energy policies, vol. 1, pp. 1-9, 2011). When nitric oxide (NO) comes into contact with oxygen (O_2), it oxidizes to nitrogen dioxide (NO_2), causing NO_2 compounds to rise in water and lead to serious environmental problems such as acid rain (Biotechnology advances, vol. 30, no. 6, pp. 1405-1424, 2012). In addition, according to Kim and Chae (Sustainability, vol. 8, no. 6, p. 578, 2016), nitric oxide is an important substance that influences the phenomenon of eutrophication. The cement sector in China accounts for 12% of the country's NO_2 emissions (Chen et al. 2015). In addition, the cement industry releases (PM) such as (PM_{10}) and ($PM_{2.5}$), with (PM) generated during clinker production accounting for the largest share of total emissions (approximately 37%), followed by fugitive emissions from cement grinding (32%). The amount of (PM) released during clinker production ranges from 0.68-1 kg/ton (Tang et al. 2018). Particulate matter has a negative impact on air quality, leading to many human health problems (Khaniabadi et al. 2018). In addition, particulate matter is particularly harmful to health because it can interact with hazardous substances such as Cd, As, Cr, Mn, Pb, Ni, Cu, and Zn, which are associated with human-induced activities (Rovira et al. 2015). It is worth noting that the cement sector in China is a major source of (PM) pollution, representing 30% of total industrial particulate matter emissions (Hua et al. 2016). In addition, PM10 and PM2.5 levels were found to be much higher than permissible around cement plants in a local government district in Nigeria (Ogedengbe et al. 2011). In 2017, it was also reported that the number of infant deaths due to $PM_{2.5}$ in the Nigerian atmosphere was 49,100, with children under 5 years of age being the most vulnerable (Lelia et al. 2020). Volatile Organic Compounds (VOCs) are also released into the environment by the cement industry (Devi et al. 2017). Incomplete combustion of various fuels contributes significantly to VOCs emissions into the environment (Zimwara et al. 2012). VOCs are caused by ozone formation and can pollute soil and groundwater. Moreover, VOCs have a negative effect on plant growth (Moretti et al. 2017). In addition, the European cement industry emits 334 - 4670 tonnes of NO_2, up to 11125 tonnes of SO2, 2.17 - 267 tonnes of VOCs and 460 - 11500 tonnes of CO annually (Dunuweera et al. 2018).

Table 2.1 Impact of cement industry in different environmental categories

Impact categories	Unit	Authors		
		L. Moretti et al., 2017	F. N. Stafford et al., 2016	W. Chen et al., 2015
Global warming	kg CO_2 eq	964	2160	734.12
Ozone layer depletion	kg CFC-11 eq	$5.4*10^{-5}$	$2.54*10^{-4}$	$1.28*10^{-6}$
Aquatic acidification	kg SO_2 eq	-	-	0.89
Terrestrial acid	kg SO_2 eq	-	7.86	5.58
Aquatic eutrophication	kg PO_4 P-lim	-	-	0.0102
Freshwater eutrophication	kg P eq	0.32	0.138	-
Formation of tropospheric ozone	kg C_2H_4 eq	0.51	-	-
Respiratory inorganics	kg $PM_{2.5}$ eq	-	L. Moretti et al., 2017	0.23
Respiratory organics	kg C_2H_4 eq	-	-	$3.30 * 10^{-2}$
Particulate matter formation	kg PM_{10} eq	-	3.32	-

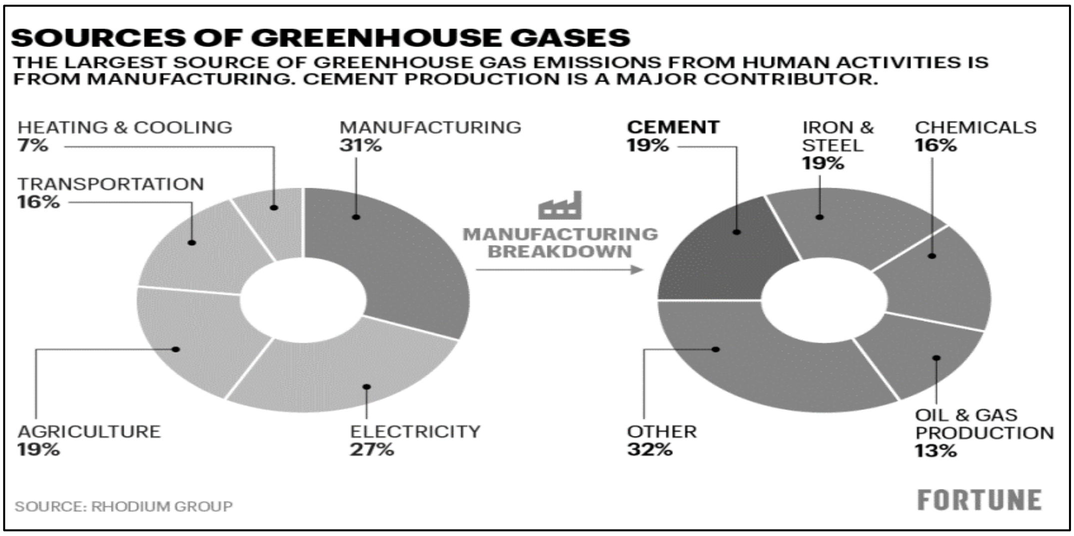

Figure 2.1 Sources of Greenhouse Gases

2.2 Concrete

Concrete is the most used building material in the world. People use more concrete than wood, aluminium, steel and plastic put together. It's used in projects that range from dams to tunnels, from roadways to runways, driveways to patios, and increasingly in the home. Although concrete is a popular building material, many people are unfamiliar with the production of concrete, as well as how concrete is delivered and poured. By considering using concrete for a construction project, knowing more about how concrete works can help choose the right mixture for the project. Read on to learn more about how concrete is produced and the easiest ordering and delivery process for concrete. Concrete offers many benefits: It's easy to have concrete delivered to building sites. It's also strong, fire resistant and durable. However, these four reasons are key to its popularity.

1. Low-Maintenance Building Material

Unlike most other building materials, concrete needs very little maintenance. Its low-maintenance nature means it's commonly used in dams, bridges and tunnels. It's also made it an increasingly sought-after choice for homeowners. Concrete won't rust like steel or attract mould like wood. When used for flooring, it also has lower maintenance needs than stone or porcelain.

2. Versatile and Easy to Shape

For most people, the biggest benefit to using concrete is its versatility. It's easy to mould, stain, shape and paint. There are a variety of possible finishes and textures. This means concrete often looks like expensive, high-maintenance building materials. But unlike these materials, it doesn't have the high price tag or maintenance.

3. Affordable Choice

Compared to other building materials, concrete is a low-cost choice. It's significantly less expensive than materials like steel, aluminium or wood. It's usually produced locally, so there aren't high transportation expenses. And its low-maintenance needs and long lifespan also contribute to its ongoing affordability.

4. Energy Efficient Building Material

Compared to other building products, concrete has a high thermal mass. This means it helps maintain steady air temperatures inside. One study found that concrete walls reduced heating and cooling needs in a home by more than 17 percent.

2.2.1 Ordinary Portland Cement (OPC)

Ordinary Portland cement is one of the most widely used type of Cement. Types, properties, constituents, manufacture, uses and advantages of Ordinary Portland Cement is discussed. In 1824 Joseph Aspdin gave the name as Portland cement as it has similarity in colour and quality found in Portland stone, which is a white grey limestone in island of Portland, Dorset.

Figure 2.2 Ordinary Portland Cement

Cement is a hydraulic mineral binding material. Blended with water, the pulverous cement can generate the plastic paste which will turn into hard cement block and bind granulated or block materials together after a series of physical and chemical effects. The hardening of cement paste will happen not only in the air but also in water and also can maintain and increase its strength. Cement is one of the important materials for the construction of national economy. Also, it is the basic component for concrete, reinforced concrete, and prestressed concrete, commonly used in construction, transportation, water conservancy, electric power, national defense, and other construction projects. According to the national cement naming standard, cement can be named based on its main hydraulic minerals as: Portland cement, aluminate cement, sulphate cement and sulpho-aluminate cement, and phosphate cement. The principal raw materials used in the manufacture of Ordinary Portland Cement are:

1. Argillaceous or silicates of alumina in the form of clays and shales.
2. Calcareous or calcium carbonate, in the form of limestone, chalk and marl which is a mixture of clay and calcium carbonate.

The ingredients are mixed in the proportion of about two parts of calcareous materials to one part of argillaceous materials and then crushed and ground in ball mills in a dry state or mixed in wet state. The dry powder or the wet slurry is then burnt in a rotary kiln at a temperature between 1400 degree C to 1500-degree C. the clinker obtained from the kiln is first cooled and then passed on to ball mills where gypsum is added and it is ground to the requisite fineness according to the class of product.

Table 2.2 The chief chemical constituents of Portland Cement

Lime (CaO)	60 to 67%
Silica (SiO2)	17 to 25%
Alumina (Al2O3)	3 to 8%
Iron oxide (Fe2O3)	0.5 to 6%
Magnesia (MgO)	0.1 to 4%
Sulphur trioxide (SO3)	1 to 3%
Soda and/or Potash (Na2O+K2O)	0.5 to 1.3%

Table 2.3 The properties of Ordinary Portland Cement

Properties	Values
Specific Gravity	3.12
Normal Consistency	29%
Initial Setting time	65min
Final Setting time	275 min
Fineness	330 kg/m^2
Soundness	2.5mm
Bulk Density	830-1650 kg/m^3

2.2.2 Coarse Aggregate

Coarse aggregates refer to irregular and granular materials such as sand, gravel, or crushed stone, and are used for making concrete. In most cases, Coarse is naturally occurring and can be obtained by blasting quarries or crushing them by hand or crushers. It is imperative to wash them before using them for producing concrete. Their angularity and strength affect the concrete in numerous ways. Needless to say, the selection of these aggregates is a very important process.

1. Size of Coarse Aggregate

Materials that are large enough to be retained on the 4.7mm sieve size usually constitute coarse aggregates and can reach a maximum size of 63mm. The size of coarse aggregates affects several aspects of the concrete, mainly strength and workability, and the amount of water needed for the concrete mix. It also helps determine how much fine aggregate is needed to produce a concrete batch. The bigger the size, the smaller is its bondable surface area for cement, sand and water; the less water and fine aggregate is needed with concrete mixes.

2. Grading of Coarse Aggregate

The grading of aggregate is its classification according to the average size of the particles. It is important that the grading is kept constant for concrete batches. The aggregate particles need to be of a consistent size for an even grading. Similar shaped coarse aggregates make the concrete more cohesive and uniform.

3. Shape of Coarse Aggregate

The characteristic of the parent rock from which coarse aggregates is produced and also the type of crusher used to influence the shape of the aggregates. They may be round, angular or completely irregular. Rounded aggregates, such as gravel, have the lowest water demand due to their lower surface area. They also have the lowest cement requirement. This makes rounded aggregates more economical; however, the bonds they form are not as strong as those of angular aggregate. Angular ones require more water and cement because they have a higher surface area. This can make a concrete batch more expensive, but it is also stronger and more durable. Irregularly-shaped aggregates have similar properties to angular aggregates, but if the particles are too flaky or elongated, it can result in segregation in the concrete.

4. Strength of Coarse Aggregate

The strength of the actual material will determine the final strength of the concrete mix. Some rocks and stones are stronger than others thus, giving higher resistance to cracking and crushing. Granite, for example, is far stronger than limestone. Therefore, it is a common aggregate used by contractors.

5. Water Absorption of Coarse Aggregate

Aggregate absorption is the water it soaks up in the concrete batch. Dry aggregates suck up any water in the concrete, which can lead to a dry and brittle mix. That is why contractors keep their aggregates damp before mixing a batch of concrete. Coarse aggregates can absorb water up to five percent of their weight. This means that contractors need to add extra water to a concrete mix if the aggregate is dry. These properties determine the final quality and strength of a concrete batch. The size, grading, shape, strength and water absorption of the aggregate all influence the final concrete mix in various ways, so contractors need to keep an eye on these variables. The properties of coarse aggregate will determine the final quality and strength of a concrete batch. The size, grading, shape, strength and water absorption of the aggregate all influence the final concrete mix in various ways, so contractors need to keep an eye on these variables.

Figure 2.3 Coarse Aggregate

2.2.3 Fine Aggregate

Fine aggregate, which may be granular material or crushed stone, is a fundamental component of concrete. The quality of the fine aggregate and the density of the fine aggregate both have a significant impact on the hardened qualities of the concrete. If the fine aggregate is chosen for its grading zone, particle geometry and surface characteristics, wear and skid resistance, soaking and surface moisture, then the concrete mixture will last longer, become sturdier, and cost less.

Characteristics of fine aggregates:

1. Void Content

The proportion of cementitious material needed for the mixture is determined by the size of the voids between the fine aggregates. Remember that angular aggregates raise void content while well-graded aggregate and better grading lower it.

2. Shape and texture

Size and pattern have a significant impact on how well concrete mixes. You should realize that coarse-textured, jagged, and longitudinal particles demand excess moisture for the formula while preparing an inexpensive concrete mix. But if the components are smooth, spherical, and compact, you'll need little water to make usable concrete.

3. Absorption and surface moisture

To determine how much water will be needed in the concrete mixture, the absorption rate must be measured. The density of fine aggregate is determined by the interior bulk phase and void content.

4. Abrasion and skid resistance

When designing heavy-duty floors and pavements, it is important to account for the relative measure of wear caused by the rotation of the fine aggregate in a cylinder with an abrasive charge.

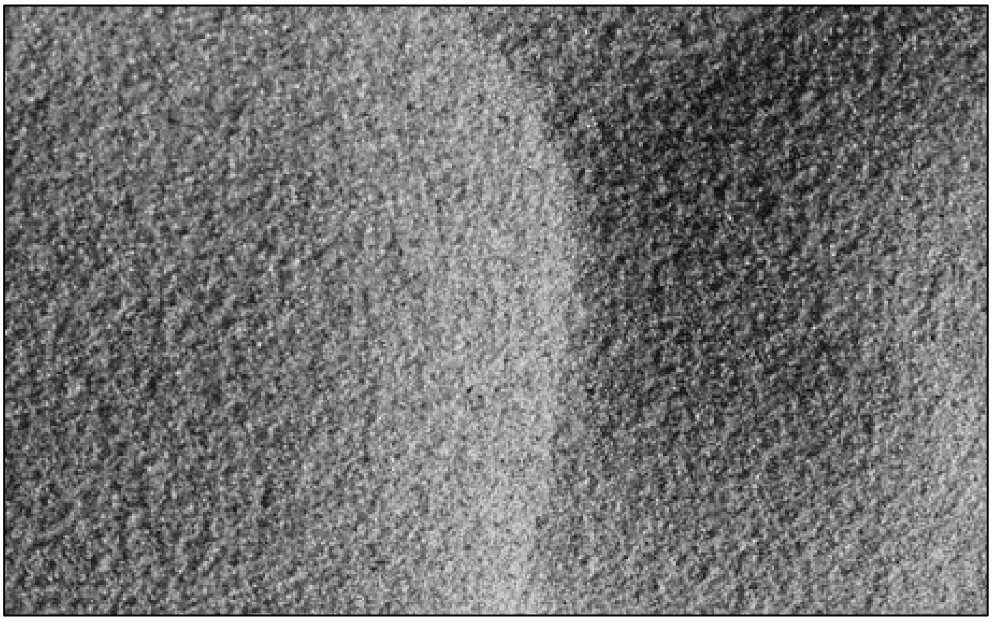

Figure 2.4 Fine Aggregate (sand)

2.2.4 Water

The amount of water in concrete controls many fresh and hardened properties in concrete including workability, compressive strengths, permeability and watertightness, 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.

1. Water-cementitious materials ratio

The ratio of the amount of water, minus the amount of water absorbed by the aggregates, to the amount of cementitious ratio and commonly referred to as the w/cm ratio. The w/cm is a modification of the historical water-cement ratio (w/c ratio) that was used to describe the amount of the Portland cement by in concrete. Because most concretes today contain supplementary cementitious materials such as fly ash, slag cement, silica fume, or natural pozzolans, the w/cm ratio is more appropriate. To avoid confusion between the w/cm ratios, use the w/cm ratio for concretes wit and without supplementary cementitious materials. The w/cm ratio equation is w/cm ratio = weight of water – weight of water absorbed in the aggregates) divided by the weight of cementitious materials.

Upon hardening, the paste or glue consisting of the cementitious materials and water binds the aggregates together. Hardening occurs because of the chemical reaction, called hydration, between the cementitious materials and water. Obviously, increasing the w/cm ratio or the amount of water in the paste dilutes or weakens the hardened paste and decreases the strength of the concrete. Decreasing the w/cm ratio also improves other hardened concrete properties by increasing the density of the paste which lowers the permeability and increases watertightness, improves durability and resistance to freeze-thaw cycles, winter scaling and chemical attack.

In general, less water produces better concrete. However, concrete needs enough water to lubricate and provide a workable mixture that can be mixed, placed, consolidated and finished without problems

2. Code requirements

Because w/cm ratio controls both strength and durability, building codes have set upper limits or maximum w/cm ratios and corresponding minimum compressive strengths as shown in Table 1. For example, concrete exposed to freezing and thawing in a moist condition or to deicing chemicals shall have a maximum 0.45 w/cm ratio and a minimum 4,500 psi compressive strength to ensure durability. Designers select maximum w/cm ratios and minimum strengths primarily based on exposure conditions and durability concerns not load-carrying capacity requirements. For different exposure conditions, use the code required maximum w/cm ratios and minimum strengths to reduce the permeability of the concrete. Doing so will increase the concrete’s resistance to weathering.

3. Water content and drying shrinkage

The most important factor affecting the amount of drying shrinkage and the subsequent potential for cracking is the water content or the amount of water per cubic yard of concrete. Fundamentally, concrete shrinkage increases with higher water contents. About half of the water in concrete is consumed in the chemical reaction of hydration and the other half provides the concrete's workability. Except for the water lost to bleeding and absorbed by the base material or forms, the remaining water that is not consumed by the hydration process contributes to drying shrinkage. By keeping the water content as low as possible, drying shrinkage and the potential for cracking can be minimized.

4. Workability

The ease of mixing, placing, consolidating and finishing concrete is called workability. The water content of the mixture is the single most important factor that affects workability. Other important factors that affect workability include: mix proportions, characteristics of the coarse and fine aggregates, quantity and characteristics of the cementitious materials, entrained air, admixtures, slump (consistency), time, air and concrete temperatures. Adding more water to the concrete increases workability but more water also increases the potential for segregation (settling of coarse aggregate particles), increased bleeding, drying shrinkage and cracking in addition to decreasing the strength and durability.

5. Adding water onsite

If measured slumps are less than allowed by the specifications, slumps may be adjusted by a one-time addition of water. However, there are requirements associated with adding water onsite:

1. Do not exceed the maximum water content for the batch as established by the accepted concrete mixture proportions.
2. No concrete has been discharged from the mixer except for slump testing.

3. All water additions shall be completed within 15 minutes from the start of the first water addition.

4. Water shall be injected into the mixer with such pressure and direction of flow to allow for proper distribution within the mixer.

Before adding water onsite, the allowable amount of water that can be added must be known. This amount should be printed on the delivery ticket or be determined during the pre-construction meeting and be agreed upon by all parties. Water is a key component in concrete. However, too much water can be detrimental to both the fresh and hardened concrete properties, especially strength, long term durability and potential for cracking.

2.3 Coconut Shell

Utilization of concrete is increasing at a very high rate due to infrastructural development activities in the world. Concrete is one of the world's most widely used construction material. In addition, Concrete is the second most consumed substance in the world after water. Approximately ten billion tons of concrete is produced every year. Annual production represents one ton for every individual on the planet (Amarnath et al. 2012). There are some negative impacts of more production of concrete like continuous extensive extraction of aggregate from natural resources will lead to its depletion and ecological imbalance (Kinniburgh, nd). So many researchers are in search of replacing coarse aggregate to make the concrete economical and to extend sustainable development (Daniel, 2013). This environmental reason has generated a lot of concern in the infrastructural development world. The role of sugarcane bagasse, wood chips, plastic waste, fabric waste, polyethylene, rice husk ash, rubber tires, vegetable fibres, paper and pulp industry waste, vegetable fibres, paper and pulp industry waste, peanut shell, waste glass, broken bricks are some cases of replacing aggregates in concrete (Maninder et al. 2012). Therefore, there is a need to explore and to find out suitable replacement material to substitute the natural stone. Coconut shell as Figure 2.6 has high strength and modulus properties. Coconuts are being naturally available in nature and since its shells are nonbiodegradable; they can be used readily in concrete, which may fulfil almost all the qualities of the original form of concrete. In developed nations, the construction industries have identified many artificial and natural lightweight aggregates (LWA) that have replaced conventional aggregates thereby reducing the size of structural members. Coconut shell is categorized as light weight aggregate. The coconut shell when dried contains cellulose, lignin and ash in varying percentage (Kulkarni et al. 2013). The purpose of this research is to determine whether the coconut shell is suitable use for replacement of fine aggregate in concrete.

According to a Department of Agriculture Malaysia 2012, there are about 114, 000 hectares of coconut plantation in Peninsular Malaysia and the area is more or less static. Agricultural waste was disposed of in large amount in most of the tropical countries particularly in Asia for countries like Philippine, Thailand, and Malaysia (Olanipekun et al. 2006). If not disposed of in properly, it will lead to environmental problems. Most abandon agriculture wastes in Malaysia are oil palm shell, coconut shell, rice husk and corn cob. Coconut shell may offer itself as a coarse or fine aggregate and this would solve the environmental dilemma of reducing the solid wastes simultaneously.

The demand for concrete has increased since it became an unavoidable construction material worldwide. Coarse aggregate is one of the main ingredients of concrete. Depletion of aggregate deposits occurs due to continuous extraction of aggregates, which leads to environmental degradation and thus ecological imbalance. Therefore, trends in concrete technology are currently directed toward searching for alternative sustainable materials for aggregate in order to minimize over reliance on natural resources. Many substitute materials such as aggregates from industrial wastes and by products are used for production of concrete. Coconut shell is a waste material from agricultural industries and available in plenty throughout the tropical regions worldwide. Coconut shells are used for many useful purposes, but most of the coconut shell wastes are yet to be utilized commercially. A promising solution to the challenges in coconut waste management involves coconut shell as aggregate in concrete. Many researches were conducted on coconut shell aggregate concrete in the last decade. This paper presents an overview of physical, mechanical and chemical properties of coconut shells, followed by a discussion on the physical, mechanical, bond and durability properties of coconut shell aggregate concrete. Structural behaviours such as shear, flexure and torsion of coconut shell aggregate concrete are also discussed. Some applications of the coconut shell aggregate concrete are also highlighted. The current understanding of coconut shell aggregate concrete provides basis for further research in this field.

Coconut shell concrete is lighter in weight than the natural aggregate. Some researchers have concluded that coconut shell can be used for lightweight concrete at different proportion for required concrete strength. In an investigation conducted by (Kakade, 2015), the 28-days compressive strength of concrete contained 25% volume replacement by coconut shell aggregate is 21.3 MPa, which is ideal for non-structural and structural applications. The density of coconut ranges between 550- 650 kg/m3, which are within the specified limits for lightweight aggregate. In addition, better workability is expected because of the shape and surface texture of the coconut shells (Maninder et al. 2012).

Figure 2.5 Coconut shell

2.4 Compressive Strength Test

Strength of concrete is considered as one of the important factors in the determination of concrete quality. It is an eminent element in structural design and consistently used as the compliance purposes. Concrete is designed to achieve certain strength at a certain age, which is traditionally characterized by 28-day value. There are numerous factors that contribute to the strength development f concrete material over time for example water/ cement ratio (w/cm ratios), cement characteristic, aggregate properties, curing condition and others. Therefore, information on the strength-time relation is considered important for a structure that will be subjected into certain loading characteristic at various ages like early removal of formwork, lifting of precast concrete panel or distribution of full loading.

Principles

One of the principal concerns of an engineer is the analysis of material used in structural applications. The term structure refers to any design that utilizes materials that support loads and keeps deformation within acceptable limits. The compressive strength is a measure of the concrete's ability to resist loads which tend to crush it. Many tests are used to evaluate the hardened concrete properties, either in the laboratory or in the field. Some of these tests are destructive, while other are non-destructive. The most common test performed on hardened concrete is the compressive strength test. Compressive strength is one of the main structural design requirements to ensure that the structure will be able to carry the intended load. The compressive strength is measured by breaking a cylindrical or cubical concrete specimen of known dimensions in a compression testing machine. The compressive strength is calculated from the failure load divided by the cross-sectional area resisting the load and reported in MPa (SI unit).

Figure 2.6 Compressive Strength Test Machine

The compressive strength of the concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. Concrete compressive strength for general construction varies from 25 MPa (2200 psi) to 30 MPa (4400 psi) and higher in commercial and industrial structures. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during the production of concrete, etc. The types of failure for specimen in compressive strength test is satisfactory and unsatisfactory failure.

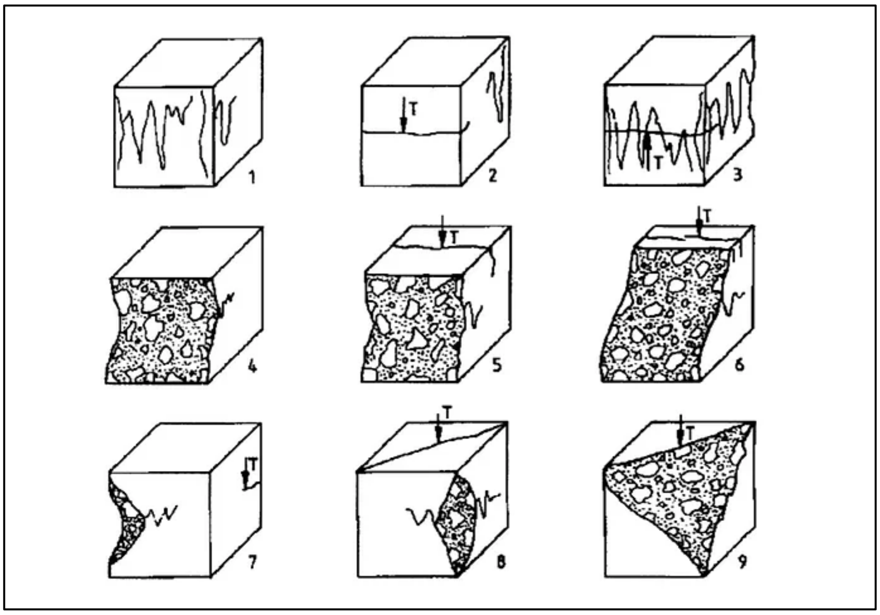

Figure 2.7 Unsatisfactory Failure

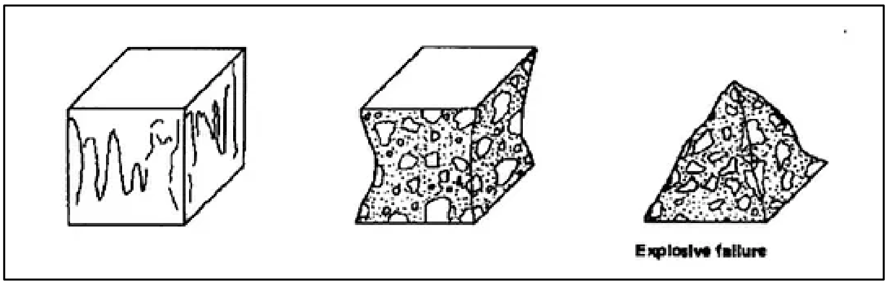

Figure 2.8 Satisfactory Failure

2.5 Previous Findings

In the previous findings or journal, its conclude that the compressive strength of concrete reduces with respect to the percentages of replacement. The reduction varies from 25-50% of the control specimen. Similar behaviour was observed on flexural and split tensile strength of the coconut shell mixes. The optimum replacement accepted is with 10% where the reduction in all strength is less than 30% (Azunna et al. 2018). The average compressive strengths for all batches are summarized in Table 2.4 and presented in Figure 2.10. From Figure 2.10, it can be generalised that the compressive strength of all mixes increased steadily with respect to curing age. At 28 days, the compressive strength of concrete specimen with natural fine and coarse aggregate (control specimen) is 50.56 MPa. From Table 2.4, it shows that the strength reduction increases as the percentage of replacement increased until almost half of the control strength (25.21MPa) when 30% replacement was made. As reported by Yerramala and Ramachandrudu (2012) surface texture determines bond between the particles, smooth surface on the concave side of coconut shell aggregate and coupled with the continuous presence of water will prevent good bond between the aggregate, which contributed to the lower bond strength. Hence, to overcome this, more cement required for proper bonding and to maintain strength but it is not economical.

Table 2.4 Compressive strength of concrete with coconut shell replacement

	Compressive strength of concrete with CS replacement (MPa)				
CS fine and coarse Aggregate replacement	Compressive strength at 7th day	Compressive strength at 14th day	Compressive strength at 21th day	Compressive strength at 28th day	Percentages of final difference
0%	36.16	42.11	47.12	50.56	-
10%	23.30	29.50	34.82	38.37	-24.11
20%	18.47	25.07	28.48	30.54	-39.60
30%	12.09	17.37	23.29	25.21	-50.14

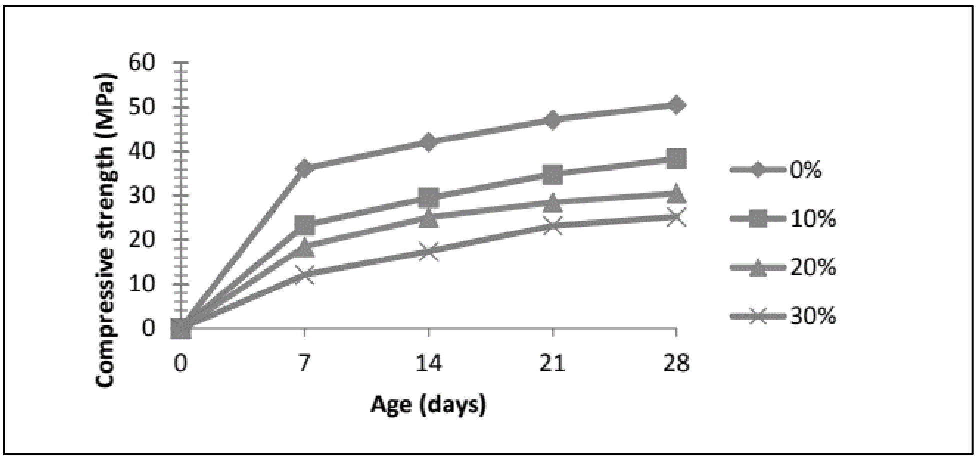

Figure 2.9 Development of strength with age

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter outlines the methodology of the study is to determine the characteristics strength of concrete by replacing 5% of fine aggregate and to investigate whether the coconut shell is suitable for concrete mixing. The test is conducted at Concrete and Structure Laboratory, Universiti Malaysia Pahang at Gambang, Pahang.

3.2 Methodology of Study

Figure 3.1 shows the flow chart from start to end of the study which consists four item which is preparation of raw material, mixing, testing and analysis.

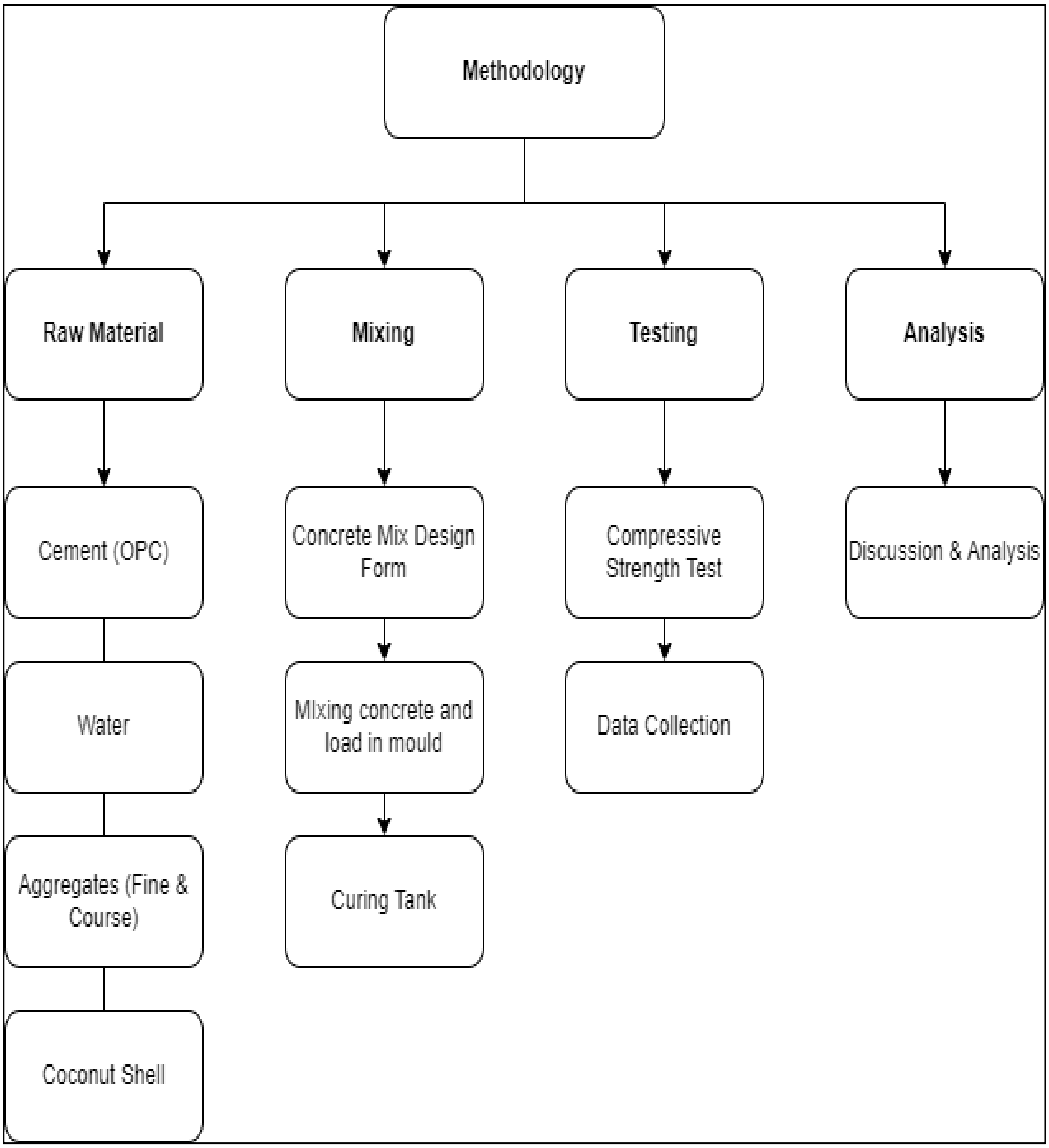

Figure 3.1 Flow Chart of Methodology

3.2.1 Preparation of Raw Material

1. Ordinary Portland Cement (OPC)

Ordinary Portland Cement was selected as the binder for concrete mixing because it's the most common type of cement in general use around the world as a basic ingredient of concrete and mortar.

Figure 3.2 Ordinary Portland Cement

2. Coconut Shell as Fine Aggregate

For this study, the coconut shell was used as replacement of fine aggregate which is 5%. The size for the coconut shell to be crushed is 5mm below. The process to crush the coconut shell are many equipment or method be used such as using Aggregate Impact Value Test Machine (AIV), using hammer and also other hardness material.

Figure 3.3 Coconut Shell crushed below 5 x 5mm

3. Coarse Aggregate

For the coarse aggregate, size 20mm and 10mm used for casting concrete. Coarse aggregate has been sieved to separate the unwanted size and the right sizes will be selected for casting concrete

Figure 3.4 Coarse aggregate with different sizes

4. Fine Aggregate

For the fine aggregate, size below 4.75mm is consider fine aggregate and used for mixing concrete

Figure 3.5 Fine aggregate size below 4.75mm

5. Water

For binder mix, clean water used for casting concrete which no other particle matter inside it

Table 3. 1 Types of Concrete Cube

Type	Normal Concrete	Modified Concrete
Cement (kg)	9.05	9.05
Water (kg)	6.41	6.41
Fine Aggregate (kg)	27.98	26.58
Coarse Aggregate (kg)	41.95	41.95
Coconut Shell (kg)	-	1.4

Figure 3.6 Concrete mix put into the mould size 150 x 150 x 150mm

Figure 3.7 Specimen at curing tank

After all proportions of concrete ingredients has been mixed, the concrete mix will put into the mould with size 150 x 150 x 150mm which is in the Figure 15. After that, at the next day the cube will be put into curing tank and tested on 7 and 28 days which is in Figure 3.7.

3.3 Testing

To determine the strength of concrete, the compressive strength test according to BS 1881 Part 116 1983 has conducted which to determine the compressive strength. The target strength for the compressive strength is 20MPa which standard for lightweight concrete which have replacement coconut shell as fine aggregate. The machine use for test the compressive strength is Matest Concrete Compression machine 2000kN high Stability Motorized which is in Figure 3.8

Figure 3.8 Compressive Strength Test Machine

The result obtained from compression machine are the maximum load and maximum strength in unit MPa. Before conduct the test, the dimension of specimen and weight of specimen were recorded. The value will use to calculate the Ultimate Strength using equation maximum load in N divided with cross-sectional area of specimen in mm^2.

Figure 3.9 Data obtained from compression strength test machine

3.4 Analysis

From the testing, data that will used to analysis the specimen are the area of specimen, maximum load from compression strength machine and weight of specimen. From the result, the ultimate strength can be calculated by using equation maximum load divided with cross sectional area of specimen which will get in N/mm^2. From the calculation, the specimen will be analysis based on the average of the total specimen and analysis hypothesis whether the specimen is achieving the target strength or can fulfil the objective of the study.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the evaluation of compressive strength of concrete cube specimen that have replacement with 5% of coconut shell and compare with the control mix of concrete specimen. All the data were obtained from compressive strength test machine from the Material and Structure Laboratory Universiti Malaysia Pahang at Gambang Pahang.

4.2 Compressive Strength Test Data

Testing at 7 days

Table 4.1 Control Concrete at 7 days

Characteristic	Specimen				
	1	2	3	4	5
Weight (kg)	7.858	7.860	7.930	8.015	8.060
Area (mm^2)	22500	22500	22500	22500	22500
Maximum Load (kN)	295.662	347.162	346.285	344.116	336.641
Ultimate Strength, f_c (N/ mm^2)	13.14	15.43	15.39	15.29	14.96
Average Ultimate Strength, f_c (N/ mm^2)	14.84				

Table 4.2 Modified Concrete at 7 days (wet state)

Characteristic	Specimen				
	1	2	3	4	5
Weight (kg)	7.435	7.480	7.495	7.885	7.680
Area (mm^2)	22500	22500	22500	22500	22500
Maximum Load (kN)	241.117	226.027	254.222	253.346	251.684
Ultimate Strength, f_c (N/ mm^2)	10.72	10.05	11.30	11.26	11.19
Average Ultimate Strength, f_c (N/ mm^2)	10.90				

Table 4.3 Modified Concrete at 7 days (dry state)

Characteristic	Specimen				
	1	2	3	4	5
Weight (kg)	6.640	6.350	6.695	6.470	6.380
Area (mm^2)	22500	22500	22500	22500	22500
Maximum Load (kN)	312.559	328.929	352.552	374.424	383.407
Ultimate Strength, f_c (N/ mm^2)	13.89	14.62	15.67	16.64	17.04
Average Ultimate Strength, f_c (N/ mm^2)	15.57				

Testing at 28 days

Table 4.4 Control Concrete at 28 days

Characteristic	Specimen				
	1	2	3	4	5
Weight (kg)	7.740	7.418	7.310	7.750	7.505
Area (mm^2)	22500	22500	22500	22500	22500
Maximum Load (kN)	553.702	542.272	580.312	531.668	582.694
Ultimate Strength, f_c (N/ mm^2)	24.61	24.10	25.79	23.63	25.90
Average Ultimate Strength, f_c (N/ mm^2)	24.81				

Table 4.5 Modified Concrete at 28 days (wet state)

Characteristic	Specimen				
	1	2	3	4	5
Weight (kg)	7.365	7.390	7.075	7.310	7.295
Area (mm^2)	22500	22500	22500	22500	22500
Maximum Load (kN)	378.175	462.400	380.771	256.99	326.990
Ultimate Strength, f_c (N/ mm^2)	16.81	20.55	16.92	11.42	14.53
Average Ultimate Strength, f_c (N/ mm^2)	16.05				

Table 4.6 Modified Concrete at 28 days (dry state)

Characteristic	Specimen				
	1	2	3	4	5
Weight (kg)	5.916	6.590	6.410	5.200	6.515
Area (mm^2)	22500	22500	22500	22500	22500
Maximum Load (kN)	72.784	158.054	5.846	153.139	153.771
Ultimate Strength, f_c (N/ mm^2)	72.784	158.054	5.846	153.139	153.771
Average Ultimate Strength, f_c (N/ mm^2)	4.83				

4.3 Analysis & Discussion

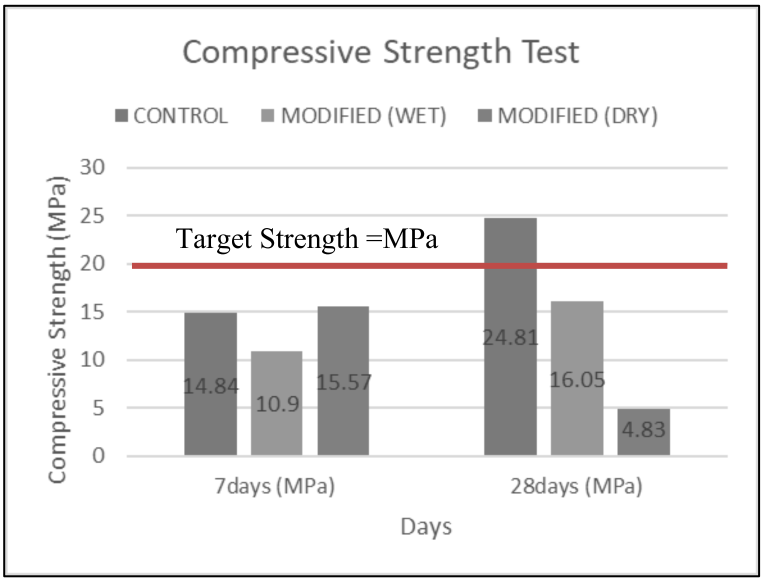

Figure 4.1 Compressive Strength Test Histogram

From the Figure 4.1, for 7 days result, the strength of control cube is satisfied because at 7 days the strength should be half of the strength target strength at 28 days. It seems that at 7 days for control cube is half and quarter of the target strength which is 14.84MPa. Same goes to modified, the strength at 7 days is 10.90MPa which is half of the target strength which 20MPa. At 28 days, for the control cube is pass the target strength which is 24.81MPa and satisfied the concrete mix design form. For the modified cube, the strength at 28 days is 16.05MPa which is not passing the target strength. The percentage different between target and modified cube is 19.75% which is closes to the target. But it will consider as unsatisfied. The percentage different between control and modified cube is 35.31% which is a bit far to approach the control cube. But for the dry state condition its seem shows bad performance. For the 28 days performance its 4.83MPa and its lower than its 7 days performance.

In conclusion, 3 types of mix concrete cube have been tested at 7 and 28 days. It seems that for the control mix is satisfied the concrete mix design form and target strength but for the modified mix it’s not satisfied for the dry state and the wet state are shows the good performance. Figure below are the evidence of the test were conducted.

CHAPTER 5

CONCLUSION

5.1 Introduction

This study focused on the performance of the concrete with 5% coconut shell replacement of fine aggregate. The main findings of this study have been determine which is the compressive strength of the concrete with replacement 5% coconut shell at 7 and 28 days.

The results obtained from this study is that the coconut shell can be a part of ingredients for casting concrete if the proportion or ratio for coconut shell as replacement is correct. From the results, the compressive strength for cube with replacement coconut shell is really closes to the target strength. From the pattern of the strength, the target strength can be achieved by some improvement. Due to limitations, there are several issue need to be taken. If there are any chances to make more testing or improvements, may be the target strength can be achieved if there are no limitations. From the previous findings also, the research conclude that the performance of concrete will drop with respect to the percentages of the replacement coconut shell as fine aggregate and the reduction varies from 25-50% of the control specimen. The researcher also conclude that the optimum replacement accepted is with 10% where the reduction in all strength are less than 30% (Azunna et al. 2018).

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APPENDICES

Appendix A: Concrete Mix Design Form

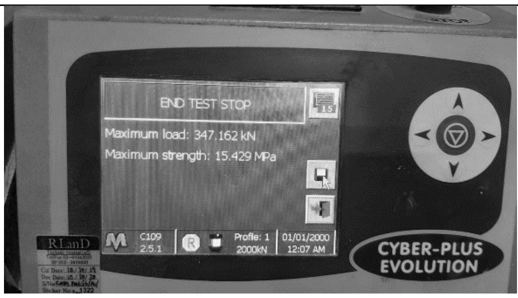
Stage	Item	Reference or Calculation	Values
1	1.1 Characteristic strength	Specified	20 N/mm2 at 28 days Proportion Defective 5 %
	1.2 Standard Deviation	Table 1.1	1.64 N/mm² or no data ____ N/mm²
	1.3 Margin	C1 or Specified	(k = 1.64) 5 x 1.64 = 8.2 N/mm²
	1.4 Target mean Strength	C2	20 + 8.2 = 28 N/mm²
	1.5 Cement type	Specified	OPC/SRPC/RHPC
	1.6 Aggregate type : coarse Aggregate type : fine		Crushed/uncrushed Crushed/uncrushed
	1.7 Free – water/cement ratio	Table 1.3, Figure 2	0.71
	1.8 Maximum free-water/cement ratio	Specified	____ Use the lower value [0.71]
2	2.1 Slump or Vebe Time	Specified	Slump 30 - 60 mm or Vebe time 3 - 6 s
	2.2 Maximum aggregate size	Specified	20 mm
	2.3 Free water content	Table 2.1	190 kg/m³ [190 kg/m³]
3	3.1 Cement Content	C3	190 / 0.71 = 268 kg/m³
	3.2 Maximum cement content	Specified	____ kg/m³
	3.3 Minimum cement content	Specified	____ kg/m³
	3.4 Modified free-water/cement ratio		use 3.1 if < 3.2 use 3.3 if > 3.1 [268 kg/m³]
4	4.1 Relative density of aggregate (SSD)		2.65 known/assumed
	4.2 Concrete density	Figure 3	2530 kg/m³
	4.3 Total Aggregate content	C4	2530 - 190 - 268 = 2072 kg/m³ [2072 kg/m³]
5	5.1 Grading of fine aggregate	Percentage passing 600 µm sieve	50 %
	5.2 Proportion of fine aggregate	Figure 4	40 %
	5.3 Fine aggregate content	} C5	0.40 x 2072 = [829 kg/m³]
	5.4 Coarse aggregate content	} C5	0.60 x 2072 = [1243 kg/m³]

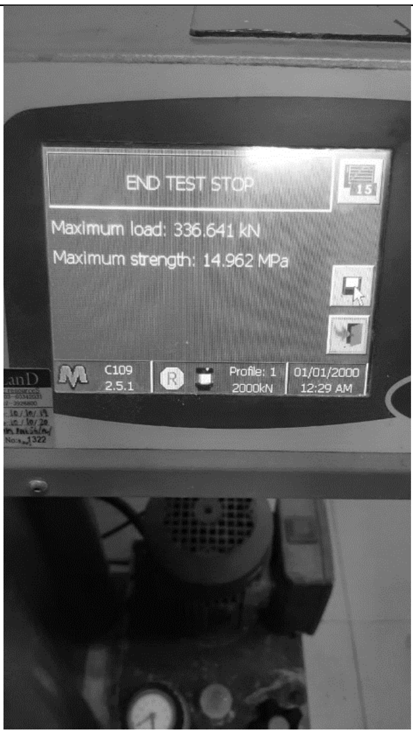
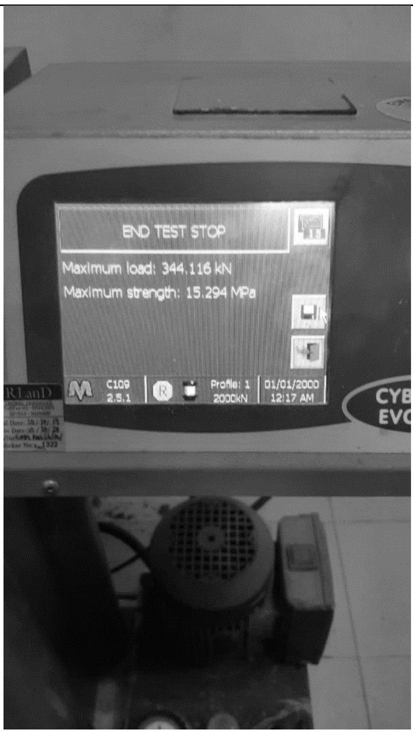
Quantities	Cement (kg)	Water (kg or L)	Fine Aggregate (kg)	Coarse Aggregate (kg) 10 mm	20 mm	40mm
Per m³ (to nearest 5 kg)	268	190	829	414	829	
Per trial mix of 0.03375 m³	9.05	6.41	27.98	13.97	27.98	

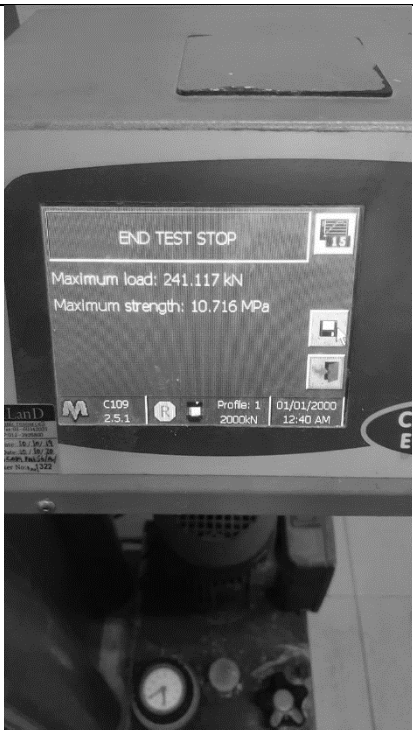
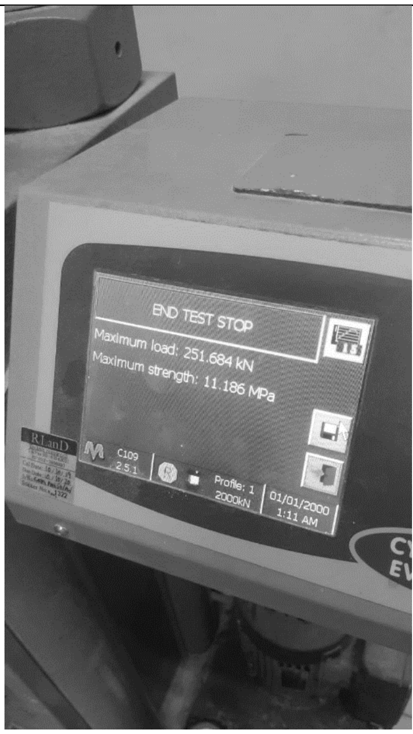
Appendix B: Data Collection

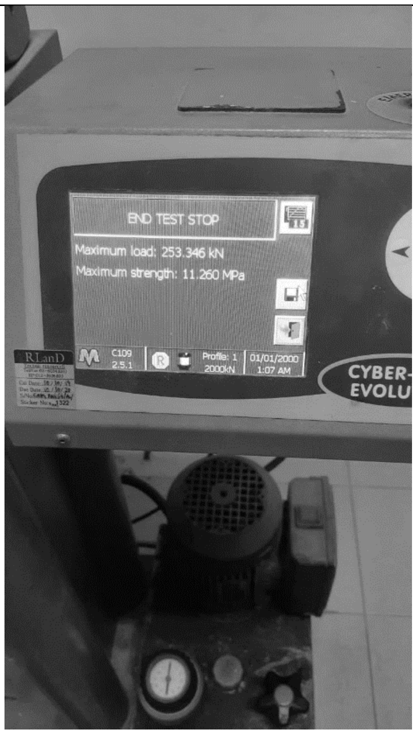
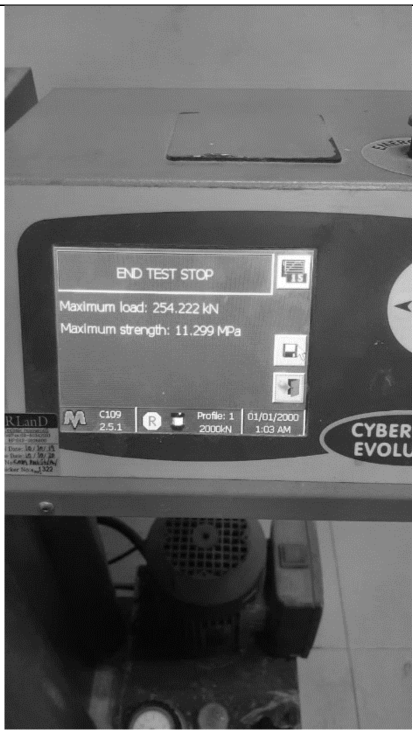
	


END TEST STOP
Maximum load: 346.285 kN
Maximum strength: 15.390 MPa
C109
2.5.1
Profile: 1
2000kN
01/01/2000
12:12 AM


END TEST STOP
Maximum load: 347.162 kN
Maximum strength: 15.429 MPa
C109
2.5.1
Profile: 1
2000kN
01/01/2000
12:07 AM
CYBER-PLUS
EVOLUTION

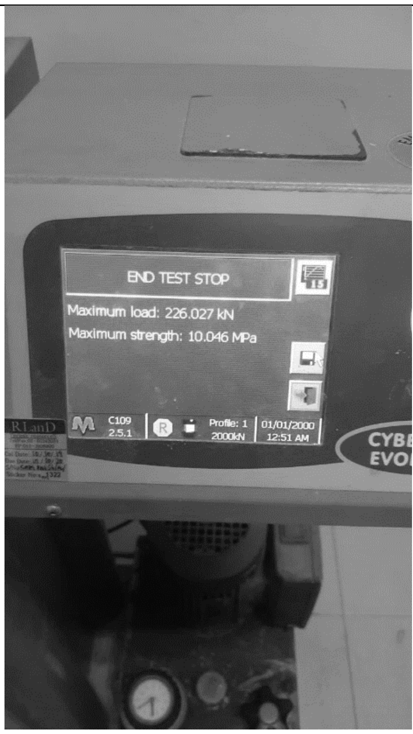
END TEST STOP
Maximum load: 336.641 kN
Maximum strength: 14.962 MPa
C109
2.5.1
Profile: 1
2000kN
01/01/2000
12:29 AM	
END TEST STOP
Maximum load: 344.116 kN
Maximum strength: 15.294 MPa
C109
2.5.1
Profile: 1
2000kN
01/01/2000
12:17 AM	

 END TEST STOP Maximum load: 241.117 kN Maximum strength: 10.716 MPa C109 2.5.1 Profile: 1 2000kN 01/01/2000 12:40 AM	
 END TEST STOP Maximum load: 251.684 kN Maximum strength: 11.186 MPa C109 2.5.1 Profile: 1 2000kN 01/01/2000 1:11 AM	

END TEST STOP
Maximum load: 253.346 kN
Maximum strength: 11.260 MPa
C109 2.5.1
Profile: 1 2000kN
01/01/2000 1:07 AM

END TEST STOP
Maximum load: 254.222 kN
Maximum strength: 11.299 MPa
C109 2.5.1
Profile: 1 2000kN
01/01/2000 1:03 AM


END TEST STOP
Maximum load: 226.027 kN
Maximum strength: 10.046 MPa
C109
2.5.1
Profile: 1
2000kN
01/01/2000
12:51 AM