INFLUENCE OF 5% COCONUT SHELL AS PARTIAL REPLACEMENT OF FINE AGGREGATE ADDED IN CONCRETE TOWARDS WORKABILITY

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ABSTRAK

Kebanyakan negara menghadapi masalah untuk melupuskan sisa tumbuhan termasuk Malaysia. Selain itu, peningkatan pembuangan tempurung kelapa semakin meningkat dan penting untuk mencari alternatif untuk menyelesaikan kemelut ini. Salah satu penyelesaiannya ialah, menggunakan sisa tempurung kelapa sebagai bahan binaan. Pembinaan adalah sektor yang mengekalkan pertumbuhan pembangunan sambil menggunakan sejumlah besar bahan. Oleh itu, ia bertindak sebagai laluan berpotensi untuk mengitar semula sisa tempurung kelapa walaupun penggunaan dan penggunaan sisa tempurung kelapa pada masa ini adalah rendah di Malaysia. Kajian ini mencari percubaan untuk menggunakan sisa tempurung kelapa (sisa tumbuhan) untuk menggantikan sejumlah agregat halus dalam campuran konkrit dengan pengurangan berat. Untuk kajian ini, dua komposisi campuran berbeza digabungkan dengan sisa tempurung kelapa 5% telah disediakan dan diuji dalam dua keadaan, terutamanya ujian kebolehkerjaan dalam keadaan segar, dan ujian kekuatan mampatan dalam keadaan mengeras. Tambahan pula, konkrit biasa yang dituang tanpa kemasukan sisa tempurung kelapa bertindak sebagai parameter untuk perbandingan perubahan sifat antara campuran. Keputusan menunjukkan bahawa konkrit yang menggabungkan agregat halus mempunyai kebolehkerjaan yang lebih rendah dan mempamerkan pengurangan ketara dalam kebolehkerjaan konkrit. Ketepatan data kurang tepat dalam ujian slump akibat kuantiti bahan yang digunakan tidak mencukupi sebanyak 20% semasa membuat pengiraan CMD. Akhir sekali, ujian faktor pemadatan menunjukkan peningkatan sebanyak 30% dalam ujian kon merosot. Malah, perbezaan dalam penyediaan bahan terutamanya adalah tempurung kelapa.

ABSTRACT

Most countries face problems to dispose of plant waste including Malaysia. In addition, the increase in discarded coconut shells is increasing and it is important to find alternatives to solve this problem. One of the solution is to use coconut shell waste as a building material. Construction is a sector that sustains development growth while consuming large amounts of materials. Therefore, it acts as a potential route to recycle coconut shell waste even though the use and consumption of coconut shell waste is currently low in Malaysia. This study seeks to attempt to use coconut shell waste (plant waste) to replace a certain amount of fine aggregate in the concrete mix with weight reduction. For this, two mixture compositions of varying conditions according to suitability with 5% coconut shell waste were prepared and tested in two conditions, mainly the fresh workability test, and the fresh compression test. Furthermore, normal concrete poured without the inclusion of residual shell acts as a parameter for the comparison of property changes between mixes. The results show that concrete incorporating fine aggregates has lower workability and exhibits a significant reduction in concrete workability. The accuracy of the data is less accurate in the slump test due to the quantity of material used being insufficient by 20% when making the CMD calculation. Finally, the compaction factor test showed a 30% increase in the slump cone test. In fact, the difference in the preparation of ingredients is mainly the coconut shell.

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LIST OF SYMBOLS

%	Percentage
m^2	Metre square
m^3	Metre cube
N/mm^2	Newton per millimetre square
mm	Millimetres
kg/m^2	Kilogram per metre square

LIST OF ABBREVIATIONS

MSW	Municipal Solid Waste
CSAC	Coconut shell aggregate concrete
LS-SVR	Used to predict true values of condition indicators
CSC	Coconut shell concrete
NWC	Normal weight concrete
SEM	Scanning electron microscopy
EDS/EDX	Energy dispersive X-ray spectroscopy
FTIR	Fourier transform infrared spectroscopy
LWC	Lightweight aggregate concrete
CMD	Concrete Mix Design

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The most critical issue in environmental protection and natural resource conservation is waste management. Changes in the environment and improvements in population is the main cause of many processes of degradation that has changed our ecosystem planet, including municipal solid waste generation (MSW). Therefore, there is a need to reuse waste for creating a greener and healthier place on earth usage of agricultural waste will be emphasized. Being renewable, low cost, light, has high a certain strength and rigidity has made agriculture waste suitable for use as building materials such as, coconut shells, palm oil shells, palm oil clinker, corn cob ash, and rice husk ash are all by-products of agriculture. Although some of these materials can be used as fuel for biomass power plants, animal feed, or multiple boilers in the industrial sector to produce steam, most of these materials are still burned or disposed of in landfills this caused significant environmental issues.

One of the solid waste materials from agricultural activities is coconut shells. Problems regarding solid waste disposal have led to the utilization of coconut shells as one composite material in the creation of concrete (Tomas, 2013). Due to their high strength and modulus values, coconut shell is a promising choice for novel development composite materials in the concrete mix design. As a result, using coconut shells instead of other materials to make concrete will have greater advantages. In addition to being good for the environment, using coconut shells for structural purposes benefits low-income families, especially those who live in areas where coconut palms are farmed.

Coconut shells disposal has emerged as a fresh environmental issue for many nations as a result of the worldwide vehicle industry's explosive growth. As a result, after their performance and strength have been examined and approved, incorporating natural plant-based components into the concrete mix according to the proportions may become a new use. The ability of the shell to withstand significant deformations is one of its physical characteristics. As a result, this property makes the coconut shells adaptable to a wide range of applications and prevents damage to their own particle structure even when subjected to high forces. Investigating this substance will help to mitigate or solve the harp waste issue.

Workability is one of the characteristics of coconut to ensure the quality of concrete. The main consideration in this study was to look at the potential of coconut shells in concrete mix toward a concrete slump.

1.2 Problem Statement

Coconut shells pose a serious disposal problem for the local environment. However, this waste can use as a potential material or substitute material in the construction industry. Next, the use of coconut shells in concrete demonstrates how the waste from coconuts is used after proper management as additives to improve life on the streets before addressing the problem. Thus, coconut shells are simple biodegradable material and the analysis found that the material can remain on earth for a long time without corruption. Some investigations have shown well-being hazards caused by inappropriate coconut shell removal wasted (Shahidan, 2017).

Concrete is a widely used material in civil engineering, as the main element in the field of construction. Through innovative methods, using coconut shell waste in concrete can reduce the amount of aggregate used and further reduce the cost required when solving the problem of coconut shell waste disposal. Until now there are many successful examples involving coconut shells in civil engineering applications such as the manufacture of shell charcoal as a fuel for coal substitutes and so on. Using waste coconut shells can definitely reduce the amount of additional coconut shell waste produced every year that causes problems for our environment.

Coconut shell has beneficial properties such as low density, hard physical properties, low thermal conductivity and high shear strength at large strains. Then the different properties of coconut shells from soil materials such as sand and gravel must be taken into account in the design such as impervious properties. By integrating the unique characteristics between coconut shell and standard concrete admixture, concrete structures with good workability, durability, strength and other advantages may be found. The cohesion or bond between the hard shell and the components in the concrete must be monitored throughout the study to ensure that the concrete produced is well mixed and good in strength.

1.3 Objectives

The objectives are mainly focused on two aspects of the slump test:

1. To modify the concrete mix design by adjusting with 5% fine coconut replacement.
2. To investigate the workability characteristics of concrete added with 5% refined coconut shell.

1.4 Scope of Study

1. 5% of coconut shell by weight of sand replacement.
2. Standard used in performing lab work were (BS 1881-102:1983) for slump test and (BS 1881: part 103:1983) for compacting factor test.
3. Size of mould limited to 150 mm x 150 mm x 150 mm for producing 20 cubes.

1.5 Significance of Study

This study is more based on tests to see whether adding 5% waste coconut shell to concrete will increase its workability. This study is anticipated to aid in the process of creating more sustainable and economical building materials that will have a better impact, be able to utilize coconut shell trash in the industry, and reduce the amount of coconut shell waste disposed of. In order to strengthen employability in the industry, this study intends to better understand the relationship between employability and the capacity of concrete in socioeconomic groups. It may also result in a more effective approach to material preparation and a reduction in production costs.

In addition, this study contributes to SDG 11, which is the use of plant waste, namely coconut shells, and helps to preserve the environment by using waste materials. The use of recycled waste or natural materials can promote a sustainable environment. Several materials have been studied to replace materials in concrete mix design to reduce the use of commercial materials. Recycled materials such as coconut shells and wood can replace and reduce commercial substrate in the substrate layer while coconut shells show a positive effect as a concrete mix design such as, slump test (Azahar, 2021).

Recent studies show the use of recycled non-organic waste materials which are crushed wood, and crushed concrete and recycled organic parts which are sawdust. In terms of materials felt in the study, crushed concrete improves aeration and root drainage due to its coarser structure but fails to comply with the desired water retention and weight constraints (Eksi et al, 2020). In addition, the use of coconut shells has been implemented in the concrete mix for the slump test (CMD) and was chosen because it is light and easy to manage. The results of the study show that the performance of coconut shells surpasses the use of commercial substrate materials for coconut shells (Nurain, 2020).

Residual coconut shells with recycled waste materials help improve the workability of the slump test and compacting test. Substitutes for fine aggregate must have characteristics to allow workability and strength while preventing the movement of small particles into the concrete mix. In addition, the coconut shells material element must be durable which will have the ability to withstand the pressure of concrete cement and be durable over time.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Concrete may require to have low density, high elasticity, low stiffness, high drainage capacity, high thermal insulation capacity, high toughness, and high impact resistance in certain applications. Although concrete is the most widely used building material today, it is not the best or ideal material for all construction projects. As a result, the new technology and application are studied to increase the elastic qualities of concrete by blending waste materials and further resolving the addition of waste materials created. The use of leftover coconut shell waste to replace some of the aggregates is one of these applications.

The maximum size, form, texture, and aggregate grading are the primary factors that determine how easily concrete may be worked. There is one coarse/fine ratio number for a specific material that offers the maximum workability for a given water-cement ratio value. created a small-scale slump test for cement pastes that takes less time to test and needs less repair. However, due to the production of hydrates, the workability of high slump test concrete vanishes within the first 30 minutes.

2.2 Component of Coconut Shell

Coconuts are produced in 92 countries worldwide on more than 10 million hectares. Indonesia, the Philippines and India account for almost 75% of world coconut production with Indonesia being the world's largest coconut producer. A coconut plantation is analogous to energy crop plantations; however, coconut plantations are a source of a wide variety of products, in addition to energy. The current world production of coconuts has the potential to produce electricity, heat, fibreboards, organic fertilizer, animal feeds, fuel additives for cleaner emissions, eco-friendly cutlery and health drinks.

The coconut fruit yields 40% coconut husks containing 30% fibers, with dust making up the rest. The chemical composition of coconut husks consists of cellulose, lignin, pyroligneous acid, gas, charcoal, tar, tannin, and potassium. Coconut dust has high lignin and cellulose content. The materials contained in the casing of coco dust and coconut fibers are resistant to bacteria and fungi.

Coconut biomass is available in the form of coconut husk and coconut shells. Coconut husk and shells are attractive biomass fuels and are also a good source of charcoal. The major advantage of using coconut biomass as a fuel is that coconut is a permanent crop and available around the year so there is a constant whole year supply. Activated carbon manufactured from coconut shells is considered extremely effective for the removal of impurities in wastewater treatment processes. (Zafar, 2019)

Table 2.1 Lignocellulose coconut shell composition and other raw materials Source: Earth and Environmental Science 462 (2020)

PARTS (gm)	COCONUT MATURITY STAGE (MONTHS)	
Husk	1,190.0	518.5
Shell	140.0	156.6
Meat	20.3	244.5
Water	425.0	165.0

Chesson analysis results showed that the content of percent Lignin is 32.33%, lower than cajuput twigs 45.25%. The cellulose component is 36.13%, lower than sugarcane bagasse 44.44% and oil palm empty fruit bunch 42.56%, while hemicellulose in a coconut shell is 20.36% lower than rice straw 25.35% and sugarcane bagasse 22.90%. The amount of cellulose content of a substance can determine the rate of acid, furan and water in the liquid it is produced. The difference in cellulose content in this study is caused by differences in the material and place of plant growth, which can affect the content of cellulose and other chemical content of a substance. Each biomass has a different composition and the amount of value depends on the species and environmental conditions, while the content of lignin in an ingredient will determine the flavour of the liquid smoked product because in the process of pyrolysis, lignin will produce phenolic compounds and phenolic esters such as guacamole and siring that affect the smoke flavour (Surboyo et al. 2019).

2.3 Waste Coconut Shell Disposal Problem

Burning waste or old coconut shells is typically the most affordable and straightforward technique to decompose them. However, burning is not acceptable and is even illegal in certain nations due to the pollution and copious amounts of smoke it produces. Due in part to the quick decline in available sites for garbage disposal, landfilling is increasingly becoming an unattractive alternative. Therefore, the traditional approach is to keep it on bare ground, but doing so indirectly leads to a number of other issues because it becomes a bug and animal habitat or a fire threat. Some are moved through unauthorized onboard freight to other locations. Since coconut milk is widely consumed in Malaysia, it will be a major issue to dispose of coconut shell waste if it is produced by a high scrap provider with a small disposal site.

Coconut shells pose a serious disposal problem for the local environment. However, this waste can use as a potential material or substitute material in the construction industry. Next, the use of coconut shells in concrete demonstrates how the waste from coconuts is used after proper management as additives to improve life on the streets before addressing the problem. Thus, coconut shells are simple biodegradable material and the analysis found that the material can remain on earth for a long time without corruption. Some investigations have shown well-being hazards caused by inappropriate coconut shell removal wasted (Shahidan, 2017).

Figure 2.1 Discarded Coconut Shells

Source: Marlene Cimons (2014)

2.4 Coconut Shell

One of the solid waste products from the agricultural activity is coconut shells. Due to issues with solid waste disposal, coconut shell is employed as one composite material in the manufacturing of concrete. According to (Gunasekaran et al, 2013) over 60% of home waste is made up of coconut shell disposal presents a significant environmental challenge in the area but in the building sector, this trash might be exploited as a prospective resource or a replacement resource.

According to a prior study by (Osei et al, 2016) coconut shell is a by-product of the manufacture of coconut oil. Because of their hardness and high carbon content, coconut shells are utilized in the synthesis of active components of carbon. Hence, due to their high strength and modulus qualities, coconut shells are promising candidates for new composite materials in concrete mix design, according to (Kambli et al, 2014). Next, using coconut shells in place of traditional materials will have many advantages for the manufacture of concrete. It is advantageous for the environment and low-income families, particularly in the region around coconut tree farms, if the coconut shell is used for structural purposes. Figure 2.2 depicts coconut shells in action.

Due to its higher volatile matter content, lower ash content, and low cost, coconut shell is a better candidate for the pyrolysis process because of the greater fixed carbon content, a high-quality solid residue that can be employed as activated carbon in wastewater treatment is produced. In areas where coconut meat is typically used in food preparation, coconut shell can be easily gathered.

Figure 2.2 coconut shells without coir

Source: Salman Zaafar (2022)

2.5 Classification of Coconut Shell

The coconut tree (Cocos nucifera) is a member of the palm tree family (Ericaceae) and the only living species of the genus Cocos. The term "coconut" (or the archaic "cocoanut”) can refer to the whole coconut palm, the seed, or the fruit, which botanically is a drupe, not a nut. The name comes from the old Portuguese word coco, meaning "head" or "skull", after the three indentations on the coconut shell that resemble facial features. They are ubiquitous in coastal tropical regions and are a cultural icon of the tropics.

Dried coconut flesh is called copra, and the oil and milk derived from it are commonly used in cooking – frying in particular – as well as in soaps and cosmetics. Sweet coconut sap can be made into drinks or fermented into palm wine or coconut vinegar. The hard shells, fibrous husks and long pinnate leaves can be used as material to make a variety of products for furnishing and decoration. Hence, a hard shell encloses the insignificant embryo with its abundant endosperm, composed of both meat and liquid. Coconut fruits float readily and have been dispersed widely by ocean currents and by humans throughout the tropics.

2.5.1 The Function of Coconut Shell

Coconut shells are useful for many things once treated and can be used as bowls and utensils. The unused shells make good flammable material for an outdoor stove fire. Coconut shells, once discarded for no use, are now a greatly demanded raw material for many products.

Coconut shells are used in the production of activated carbon due to their hardness and high carbon content. Besides, coconut shells are potential candidates for the development of new composite materials in concrete mix design because of their high strength and modulus properties (Kambli, 2014).

2.5.2 The Shell of Coconut

The mesocarp is composed of a fiber, called coir, which has many traditional and commercial uses. Both the exocarp and the mesocarp make up the "husk" of the coconut, while the endocarp makes up the hard coconut "shell".

2.5.3 The Element in Coconut Shell

Coconut shell is one of the raw materials that is very potential to be used as liquid smoke; coconut shell contains 27.7% pentose, cellulose 26.6%, lignin 29.4%, water 8%, extraction solvent 4.2%, urinate anhydrous 3.5%, and ash 0.6%. (Yan et al. 2018)

2.6 The Characteristics of Coconut Shell

Coconut shell is high potential material due to its high strength and modulus properties. Coconut shell exhibits admirable properties compared to other materials such as low cost, renewable, high specific strength to weight ratio, low density less abrasion to machine and environmentally friendly.

Partial replacement with coconut shell coarse aggregates was studied as a means to produce lightweight coconut shell concrete (CSC). Coconut shell concrete is a structural grade lightweight concrete that has a lower self-load compared to normal weight concrete (NWC), which allowed the production of larger precast units. An experimental study and analysis were conducted using different volume percentages of 0%, 10%, 30%, 50%, and 70% of coconut shell as coarse aggregates, to produce M20 grade concrete. The compressive strength of the NWC and CSC were obtained on the 7th and 28th day. The optimum results obtained for M20 grade concrete on the 7th and 28th day of CSC were 34.2 and 38.6 MPa, respectively. In addition, the workability and weight reduction were analysed and compared with NWC. Scanning electron microscopy (SEM) with energy dispersive X-ray spectroscopy (EDS/EDX) and Fourier transform infrared spectroscopy (FTIR) was also used to investigate the structural morphology, chemical composition, and infrared functional groups of the concrete. (Chin & Rahman, 2021).

2.6.1 Development of Coconut Shell in Research

Coconut shell is an agricultural solid waste originating from the coconut industry used for many useful purposes but most of the coconut shell wastes are yet to be utilized commercially. Since coconut shells have the potential to be used as coarse aggregate in concrete, utilizing this waste in the construction industry not only reduces the solid waste management problems associated with it but also will be a valuable contribution to the industry as an eco-friendly construction material. According to (A. Sujatha & Deepa Balakrishnan, 2020). coconut shell was used for the production of high strength lightweight concrete. The dry density and cube compressive strengths were measured. Coconut shell aggregate concrete of compressive strength 35.09 N/mm^2 and dry density was produced.

Therefore, coconut shells have good durability characteristics, high toughness and abrasion resistant properties; it is suitable for long standing use. Coconut shells are mostly used as an ornament, making fancy items, household utensils and as a source of activated carbon from its charcoal. The coconut shell is also used in the industries of plastics, glues, and abrasive materials and it is widely used for the manufacture of insect repellent in the form of mosquito coils and aggravates. This author of the study goal is to create concrete using coconut shells as coarse material. The whole entity could be called coconut shell aggregate concrete (CSAC) (Mantech, 2020). After the coconut is scraped out, the shell is usually discarded as waste as shown in Figure 2.1. The vast amount of this discarded coconut shell resource is as yet unutilized commercially; its use as a building material, especially in concrete, on the lines of other LWA is an interesting topic for study. The study of coconut shells will not only provide a new material for construction but will also help in the preservation of the environment in addition to improving the economy by providing a new use for the coconut shells. Therefore, attempts have been taken to utilize the coconut shells as coarse aggregate and develop the new structural LWC.

2.7 Advantages of Using Coconut Shell

The study result shows that Coconut Shell Concrete (CSC) can be used as lightweight concrete. The use of Coconut Shell as a substitute for aggregate will not only is cost-effective and eco-friendly but also help to resolve the problem of shortage of conventional materials such as coarse aggregate.

Besides that, aggregates provide volume at a low cost, comprising 66% to 78% of the concrete. With increasing concern over the excessive exploitation of natural and quality aggregates, the aggregate produced from industrial wastes and agricultural wastes is a viable new source for building materials. According to study of (Gunasekaran, 2008) was carried out to determine the possibilities of using coconut shells as aggregate in concrete. Utilizing coconut shells as aggregate in concrete production not only solves the problem of disposing of this solid waste but also helps conserve natural resources. In this paper, the physical properties of crushed coconut shell aggregate were presented. The fresh concrete properties such as density and slump and 28-day compressive strength of lightweight concrete made with coconut shell as coarse aggregate are also presented.

The findings indicated that water absorption of the coconut shell aggregate was high about 24% but the crushing value and impact value was comparable to that of other lightweight aggregates. The average fresh concrete density and 28-day cube compressive strength of the concrete using coconut shell aggregate were 1975 kg/m^3 and 19.1 N/mm^2 respectively. It is concluded that crushed coconut shells are suitable when it is used as a substitute for conventional aggregates in lightweight concrete production (Gunasekaran, 2008).

Coconut shell carbon is a renewable source that's safe for the environment, water filtration, and food consumption. It's also safe to use in specific medical devices. Essentially, coconut shell carbon is doorless, virtually tasteless, and non-toxic.

2.8 Applications of Coconut Shell Concrete

The applications of concrete material in the construction industry are growing rapidly. This demonstrates the need for various types of concrete to meet the diverse needs of the users. Normally, the quality of concrete with high durability can be generated by adjusting the composition of the materials used such as cement, sand, aggregates or water. Besides that, the mix design and manufacturing processes such as mixing, transporting and pouring concrete are among the factors which can contribute to higher quality concrete. Recently, sustainability in construction is one of the principles practiced by developed countries to create a healthier environment and to reduce the environmental impact of a building over its entire lifetime. At the same time, this will optimize its economic viability and the comfort and safety of its occupants. One of the steps that can be implemented in order to create sustainability in the construction industry is to use materials that are categorized as agricultural waste materials in concrete manufacturing.

According to a prior study by (Raihan Ramzi, 2017) the use of agricultural waste in the construction industry holds a high potential of reducing the global environmental pollution. Agriculture waste has many advantages. Some of the advantages include high specific strength and modulus and low density. renewable nature, biodegradability and absence of health hazards. Their usage for improving the properties of composites costs very little compared to other construction materials. Coconut shells, oil palm shells, oil palm clinkers, corncobs ash and rice husk ash are examples of agricultural by-products. Although some of these materials can be used as animal feed or fuel in biomass power plants or boilers of various industrial sectors to produce steam, a lot of these materials are still disposed of into landfills or burnt. The disposal of agricultural waste has caused severe environmental problems.

To eliminate or reduce the negative environmental impacts of the concrete industry, the use of industrial waste as part of the materials for mixing concrete is considered an alternative solution to prevent excessive consumption of raw materials. This will indirectly promote the environmental sustainability of the industry. Based on previous studies, coconut shells have been used as aggregate replacement in the production of lightweight concrete. Coconuts are grown in more than 90 countries covering an area of 14.231 million hectares with a total production in terms of copra equivalent to 11.04 million. Indonesia (25.63%), the Philippines (23.91%), and India (19.20%) are the main coconut-producing countries in the world. Due to the increased dumping of agricultural waste, it is viable for coconut shells to be used in concrete (Raihan Ramzi, 2017).

2.9 Properties of Concrete

2.9.1 Concrete Slump

Concrete slump is generally known to affect the consistency, flowability, pump ability, compatibility, and harshness of a concrete mix. Hence, an accurate prediction of this property is a practical need for construction engineers.

2.9.2 Thermal Efficiency

The thermal efficiency of concrete improves due to a decrease in thermal conductivity, values as low as 5% have been observed when using small percentages of coconut shells in concrete. It will have a great impact on the concrete mix.

2.9.3 Evaporate/ Thaw Resistance

Does not evaporate - concrete melt resistance improves when the coconut shell is subjected to 5% water integrated before mixing into the concrete design mix with a certain proportion. This is because the coconut shell acts as a finite water-impermeable material that needs time to absorb water into the shell as well as when the water freezes in the concrete, preventing disruption/ cracking of the concrete matrix.

2.9.4 Impact Resistance

The impact resistance of concrete is improved when mixing it with certain shell parts. The high elasticity of the shell absorbs the energy or impact taken and further improves the resistance.

2.9.5 Air Content

Numerous researchers have shown that utilizing coconut shells as an aggregate in concrete creates concrete that is more workable without using expensive ingredients. This could be as a result of the coconut shell particles' non-polar nature and propensity to absorb water due to their rough surface. Additionally, because coconut shells have the propensity to repel water, they may repel air when added to the concrete mixture, which could cause the air to attach to the particles. Because there is less air in the concrete mix as a result of using more coconut shells, the mix's unit weight is further decreased (Kamar and Dhane, 2012).

2.9.6 Unit Weight

Due to the high specific gravity of coconut shell particles, the unit weight of the mixture containing the shell increases with the increase in the percentage of shell content. The unit weight increases when the shell content increases because the coconut shell is uniformly mixed as stated by (Khan & Mazli, 2001) in their study. The unit weight of concrete mixed with shells can be reduced by as much as 75% of the normal concrete mix.

2.9.7 Fire Resistance and Subsequent Release of Hazardous

Routes of Exposure Inhalation: Dust may cause mild irritation to the upper respiratory tract. Skin: Dust may cause mild irritation and possible reddening. Eyes: Dust may cause mild irritation and on, possibly reddening. Ingestion: Dust may cause mild irritation to the digestive tract resulting in Nausea or Diarrhea.

2.10 Fresh and Hardened Concrete Properties

2.10.1 Fresh Concrete Properties

Fresh concrete must be satisfactory in terms of its workability and cohesion.

2.10.2 Workability

Workability may be defined as the property of the concrete which determines its 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 independently characteristic as follows:

a. Consistency

I. Is the firmness of form of a substance or the ease with which it will flow

II. It is the measure of wetness or fluidity

b. Mobility

I. The ease with which concrete mix can flow into and completely fill the formwork or mould

c. Compatibility

I. The ease with which a given concrete mix can be fully compacted to remove all trapped air

II. To achieve the maximum possible density

III. The increase in compressive strength with an increase in the density

There are three tests that are being used widely to measure workability. Workability may be measured by the slump test and compacting factor test. These methods have found universal acceptance and their merit is due to the simplicity of operation and ability to detect variations in the uniformity of a mix of given nominal proportions.

Table 2.2 workability categories and their application

Workability category	Slump (mm)	Compacting factor	Applications
Extremely Low	0	Over 20	Lean mix concrete for roads (compacted by vibrating roller). Precast paving slabs.
Very Low	0-10	12-20	Roads compacted by power operated machines.
Low	10-30	6-12	High quality structural concrete. Mass concrete compacted by vibration.
Medium	30-60	3-6	Normal purposes reinforced concrete compacted by vibrating poker or manually.
High	60-180	0-3	Areas with congested reinforcement, concrete for placing underwater.

Source: Taylor, 2000

2.10.3 Factors Affecting Workability

There are several factors affecting the workability of the concrete such as the proportion of the ingredients such as the ratio of water, cement and aggregate. Second, the physical characteristics of the cement and aggregate. Third, the size and spacing of the reinforcement. Fourth, the size and shape of the structure. Lastly admixtures. In terms of the physical characteristics of the cement and aggregates, a smaller aggregate will result from a higher specific surface of the overall mix. More water is required for the larger area involved to achieve desirable workability. For aggregate shapes, crushed (angular) aggregate will result from a larger specific surface than rounded uncrushed (irregular) aggregate and hence resulted from a different workability concrete paste.

2.10.4 Consistency

The consistency of the fresh concrete was affected by the factors of mix proportion and also properties of the ingredients such as water, cement, and aggregate used. Different mix proportions will cause the consistency of the mix to differ as the concrete matrix largely depends on the material used.

2.11 Fresh Concrete Properties from Testing

The properties of fresh concrete mainly focus on how the concrete can be handled, placed, moulded or compacted before it is dried and hardened. It is basically evaluated through testing as below:

2.11.1 Slump Test

The slump test is a test widely used in site work all over the world. Neville (1981) stated that the slump test does not measure the workability of the concrete but is very useful in detecting variations in the uniformity of a mix of given nominal proportions. This is to make sure every batch of the concrete mix is about the same. Slump test is easy and simple, equipment are portable and does not require an electricity supply.

2.11.2 Compacting Factor Test

Neville (1981) claimed that the compacting factor test measures the degree of compaction of fresh concrete. The compacting factor test is not possible to establish consistency between the slump or vebe test, as stated by Taylor (2000). This test is more suitable on a drier mixture as it is sensitive and reflected in a large change in compacting factor.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The purpose of this study is to examine concrete strength in terms of physical characteristics, focusing primarily on workability and concrete strength resistance to failure. Concrete mixtures of grade 20 N/mm will be created, with fine aggregate having two distinct weight ratios of 95% sand and 5% residual composition waste from coconut shell clippings instead of fine aggregate. The shredded coconut shells measure roughly 5 mm x 5 mm.

Tests were performed for the properties of fresh concrete, namely the slump test and compaction factor test. The cube test will be conducted using 20 different specimens for 7 days and 28 days by placing the cube in a compression testing machine to obtain the compressive strength of the concrete. The test results show a significant improvement or change in the properties of normal concrete after mixing coconut shell waste as a partial replacement of fine aggregate and can be used effectively in the structural area.

3.2 Experimental Plan

The flow of this study was presented below:

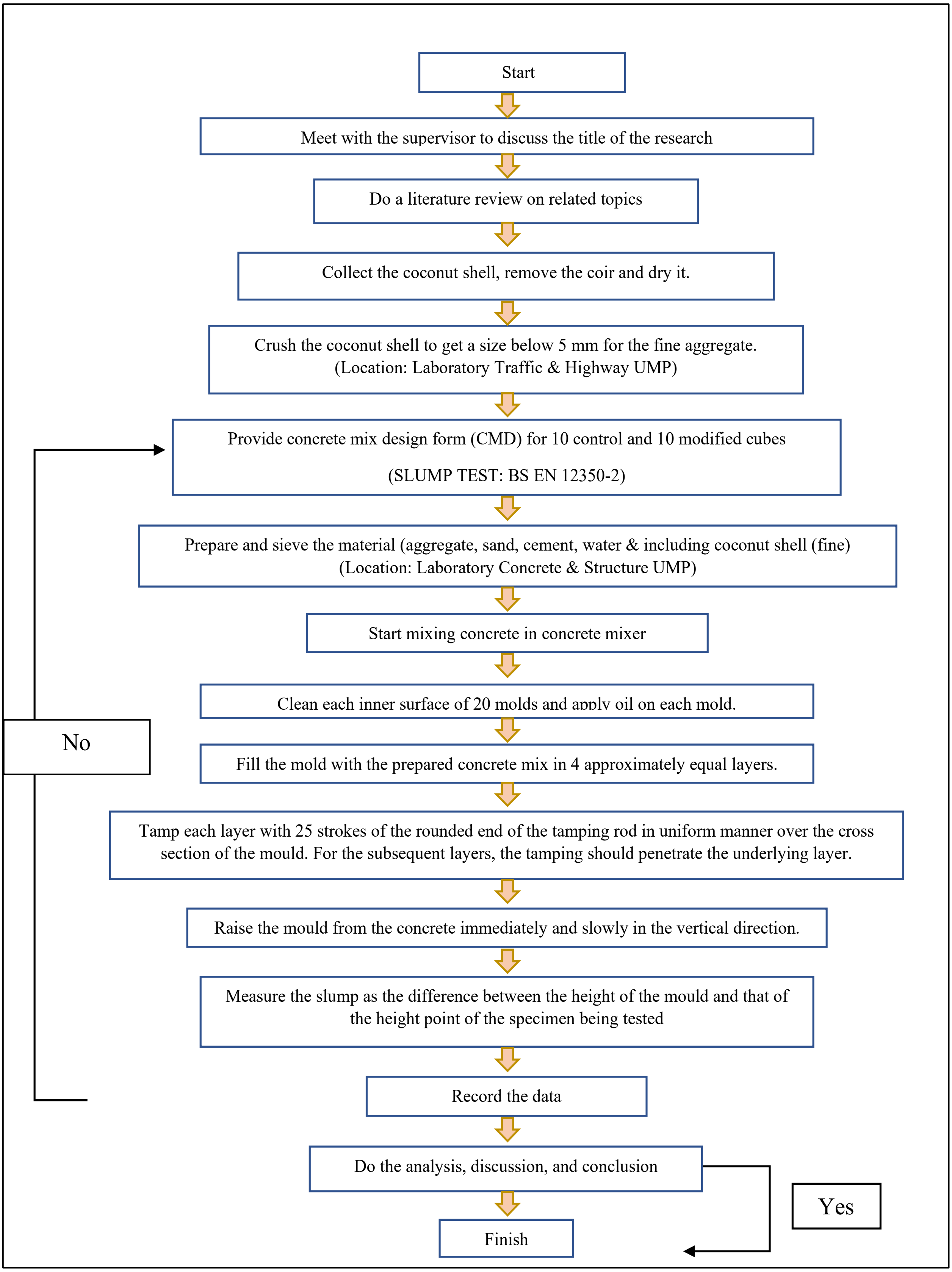

Figure 3.1 Flow chart of research methodology process

3.3 Material

The above materials will be used in the concrete mix design to obtain a concrete mix designed according to the standards of the Department of the Environment (DOE), UK.

3.3.1 Ordinary Portland Cement

Cement can be described as a material with binding agents and cohesive properties that make it adept at binding mineral fragments into a solid whole. It is hydraulic in the sense that it is set and hardened by the action of water. The Portland cement used in this research is Ordinary Portland Cement (OPC). Ordinary Portland cement is commonly used in most construction projects in Malaysia. It is suitable for use in general concrete construction when there is no exposure to sulfates in the soil or groundwater.

Figure 3.2 Ordinary Portland Cement

3.3.2 Coarse Aggregate

The maximum size of the coarse aggregate will be set as 10 mm and 20 mm when designing the concrete mix. Crushed aggregate will be used in the concrete mix. This is to make sure the rough surface of the crushed aggregate will enhance the bonding between each component within the concrete mixture when hardened. The aggregate that will imply in this research is in accordance to BS 882.

Figure 3.3 Coarse Aggregate

3.3.3 Fine Aggregate

The size of sand will use is uncrushed fine aggregate which is river sand. The purpose of the fine aggregate is to fill the voids between the coarse aggregate and to act as a workability agent. The aggregate that will imply in this study is in accordance to BS 882.

Figure 3.4 Fine Aggregate

3.3.4 Waste Coconut Shells

Coconut shells are incorporated in concrete mix with two different percentages as a fine aggregate replacement by weight. It has potential cost benefits as well as contributing to improved performance. The coconut shell were crushed into 5 mm x 5 mm size using heavy scissors, aggregate impact of value and hammer.

Figure 3.5 Crushed the Coconut Shells

3.3.5 Water

The water that will be implied in this study is according to BS 3148. Water plays an important role in concrete mix design because it acts as an agent to change cement from a powder form to a hard material with workability, strength and durability. Two aspects must be avoided in water quality to avoid reduction in strength, namely organic pollution such as silt, soil, organic acids, and other organic substances such as salts and alkalis. Usually, the water used to mix concrete is clean and clear water that forms impurities or is taken from an approved source.

3.4 Coconut Shell Preparation

The first method is to use fractions of coconut shells in an existing dry state and mix them in a mixing machine with other materials such as sand, cement, water and aggregate.

The second method is to soak the coconut shells overnight so that the water absorbs into the shell and after 24 hours drain the shell and let the water drip until no drops of water fall so the coconut shell will be moist because the water has been absorbed.

Figure 3.6 Immerged coconut Shells in water for 24 hours

3.5 Sieving and Grading

Sieving can be done for two categories which are coarse aggregate and fine aggregate. Grading is determined by passing aggregates through a set of standard sieves as the particular sieve used depends on the maximum aggregate size. In this study, the sieve is carried out by BS 812 - 103.1. Coarse aggregate was sieved and the different sizes of aggregate were used to create a better concrete mixture.

3.6 Concrete Mixing

Concrete mixing is a stage where all the materials and parameters set during design are applied. The quantities of material required is calculated during design is mix together until a consistent distribution is attained. The consistencies of the concrete matrix are ensured so as to avoid neither too stiff nor too wet conditions.

3.6.1 Normal Concrete Procedure

I. The required materials were placed near the mixer and the mixture was on standby for use.

II. The mixes started working and 1/3 of the water was added.

III. Coarse aggregate was placed in the mixer gently.

IV. Then fine aggregate was added in the mixer followed by 1/3 of the water.

V. The cement was added gently and the remaining water was added in.

VI. Lastly after the mixture was mixed thoroughly, the mix was poured into the respective mould.

3.7 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 suitable for detecting changes in workability. This test is being used extensively on site. There are three type of slumps which is true slump, shear slump and collapse slump. Figure 3.6 shows the method to measure the slump.

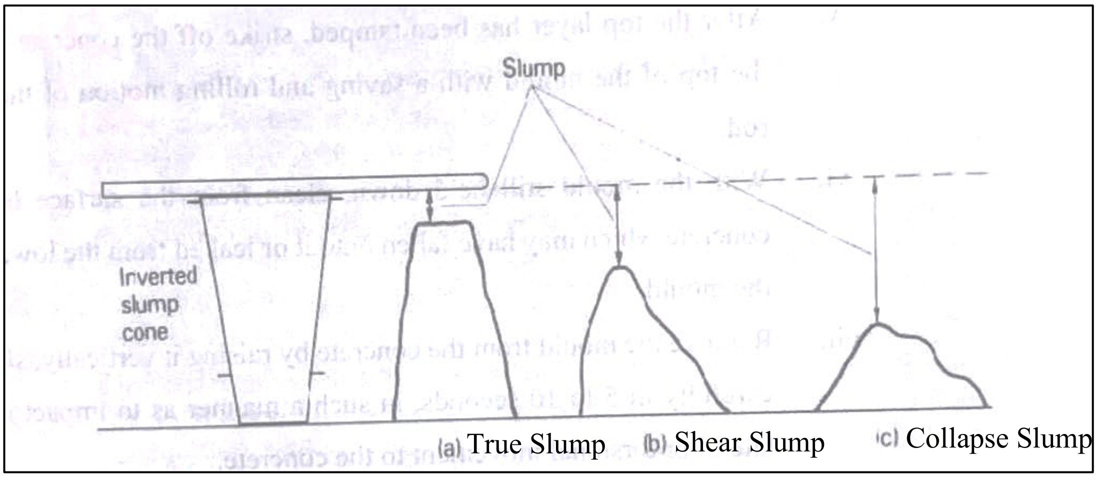

Figure 3.7 Method of measuring slump in slump test together with types of the slump

3.7.1 Apparatus

I. Slump Cone
II. Base Plate
III. Tamping Rod

3.7.2 Procedure

I. Ensure the internal surface of the mould is clean and damp but free from superfluous moisture before commencing the test.
II. Place the mould on a smooth, horizontal, rigid and non-absorbent surface free from vibration and shock.
III. Hold the mould firmly against the surface below. Fill in three layers, each approximately one-third of the height of the mould when tamped.
IV. Tamp each layer with 25 strokes of the tamping rod, the strokes being distributed uniformly over the cross-section of the layer.
V. After the top layer has been tamped, strike off the concrete level with the top of the mould with a saving and rolling motion of the tamping rod.
VI. With the mould still held down, clean from the surface below any concrete which may have fallen onto it or leaked from the lower edge of the mould.
VII. Remove the mould from the concrete by raising it vertically, slowly and carefully in 5 to 10 seconds, in such a manner as to impact minimum lateral or torsional movement to the concrete.
VIII. The entire operation from the start of filling to the removal of the mould shall be carried out without interruption and shall be completed within 150 seconds.
IX. Immediately after the mould is removed, measure the slump to the nearest 5 mm using a measuring scale to determine the difference between height of the mould and highest point of the specimen.

3.8 Compacting Factor Test (BS 1881: Part 103 (1983)

The workability of concrete has been defined as the amount of work required to place the concrete and to compact it thoroughly. It is simpler to apply a standard amount of work to the concrete and to measure its degree of compaction is defined as the compacting factor which is measured by the density ratio, for example, the ratio of density achieved in the test to the density of the same concrete fully compacted. The test is suitable for concrete with a maximum size of aggregate up to 40 mm and it is described by 1881: Part 103: 1983.

The apparatus consists essentially of two hoppers, each in the shape of the frustum of a cone, and one cylinder, the three being above one another, about 1.2 m high as shown in Figure 3.7. The 'compacting factor' is:

I. Mass of partially compacted concrete
II. Mass of fully compacted concrete

Figure 3.8 Compacting Factor Apparatus

3.8.1 Apparatus

I. Compacting Factor Apparatus
II. Balance
III. Tamping Rod

3.8.2 Procedure

I. Weight the empty cylinder and record its mass to the nearest 10 grams it.

II. Make sure the internal surfaces of the hoppers and cylinder are smooth, clean and damp but free from superfluous moisture.

III. Close the two trap doors and place the two floats on the cylinder so as cover its top.

IV. Place the sample of the concrete gently in the upper hopper using the scoop until the hopper is filled to the level of the rim.

V. Open the upper trap door o that the concrete falls into the lower hopper. Immediately after the concrete has come to rest, remove the float from the top of the cylinder. Open the trap lower and allow the concrete to fall into the cylinder.

VI. Help the concrete through by pushing the tamping rod gently into the concrete from the top until the lower end emerges from the bottom of the hopper.

VII. Cut off the excess concrete remaining above the level of the top of the cylinder by holding a float in each hand, with the place of the tamping rod horizontal and moving them simultaneously one from each side across the top of the cylinder.

VIII. Within 150 seconds of placing the sample in the upper hopper, weigh the cylinder and its content. By subtracting the mass of the empty cylinder, calculate and record the mass of the partially compacted concrete to the nearest I0 gram.

IX. Empty the partially compacted concrete from the cylinder and refill it with concrete from the sample in such way as to remove as much entrapped air is possible.

X. Through the scoop, place the concrete in the cylinder in six layers approximately equal in depth and compact each layer by using the compacting bar.

XI. After the top layer has been compacted, smooth its level with the top of the cylinder using one of the plaster's floats.

XII. Weight the cylinder and its content to the nearest 10 grams and by subtracting the mass of the empty cylinder, calculate and record the mass of the fully compacted concrete to the nearest 10 grams.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

In this chapter, the results for each test in this study include the slump test and the compaction factor test. In this study, changes in the physical properties of fresh concrete were integrated with 95% fine aggregate and 5% coconut shell replacement according to CMD calculations. The comparison between normal mixed fresh concrete and modified concrete with the replacement of 5% fine aggregate (coconut shells) will be elaborated further.

4.2 Data Analysis for Slump Test

For the slump test, the change in workability between normal mix fresh concrete, and 5% replacement of fine aggregate by weight was observed. The relationship between the results of the deterioration test and the different percentages of the cutting edge is shown in Figure 4.1, the workability of fresh concrete subjected to slump test for concrete with different percentages of additions, cutting diameter decreases with decreasing slump value.

Table 4.1 Slump test result

Slump Test	1st Batch		2nd Batch	
	Type of Slump	**Slump value**	**Type of Slump**	**Slump value**
Control	Zero slump	15 mm	Shear Slump	60 mm
Modified 5% coconut shell replacement (dry state)	Zero slump	5 mm		
Modified 5% coconut shell replacement (wet state)			True Slump	32 mm

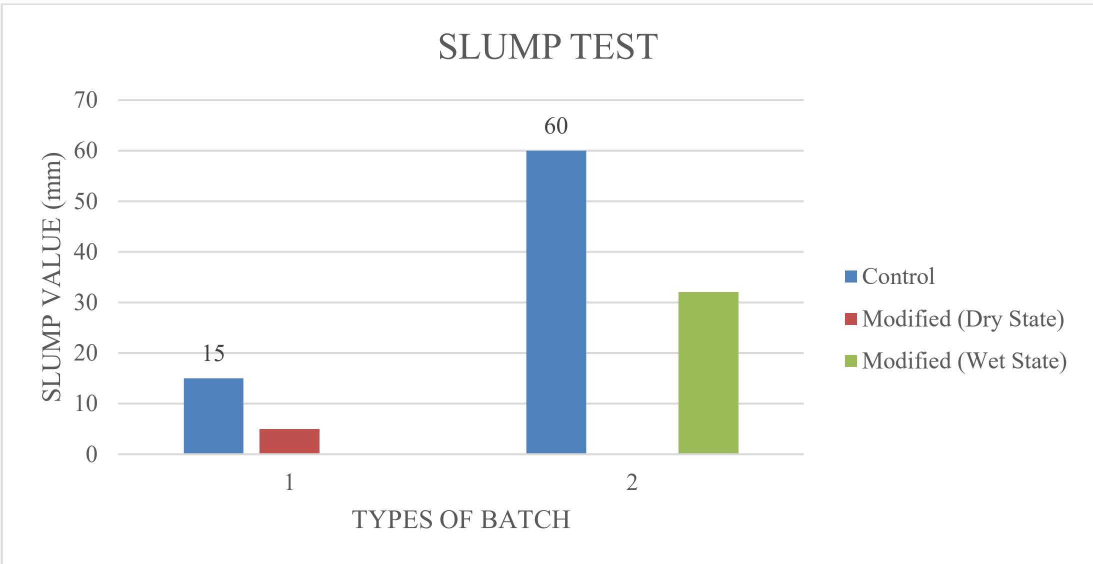

Figure 4.1 Workability of slump test

From the test results in Table 4.1 as well as Figure 4.1, it has been determined that the addition of 5% coconut shells as a substitute for fine aggregate to fresh concrete is the main reason for the change in normal behavior in terms of mobility. From the results obtained, the slump of fresh concrete has decreased for normal concrete is zero slumps with a slump value of 15 mm, while for the slump test modified (5% coconut shells fine aggregate) it is also reduced that is to get zero slump also with a slump value of 5 mm for the slump test the first. While for the second testing the results obtained, the slump of fresh concrete has increased for normal concrete is true slump with a slump diameter value of 60 mm, while for the modified slump test (5% coconut shell fine aggregate) it also increased which is a true slump and an increase in slump diameter which is 32 mm for the second slump test.

Furthermore, this reduction in shrinkage is usually caused by a reduction in the unit weight of the concrete mix after reducing the aggregate content and replacing it with other materials. Reducing the unit weight of fresh concrete mix will reduce the weight of fresh concrete, causing it to be more difficult to decline due to gravity when the content of coconut shells is replaced with fine aggregate.

Another reason is due to the vibration and compaction of fresh concrete during testing. It causes the particles of coconut shells to tend to move towards the upper surface of the mold, producing higher particles at the top and further causing the degradation of fresh concrete to be more difficult and less than that of normal concrete.

Finally, the ratio of water content in concrete is one of the factors that cause the concrete paste to deteriorate lower. The water content ratio used in designing the 20 N/mm grade is 0.71. This ratio may be too low for the mixture of coconut shells to produce usable fresh concrete.

4.3 Data Analysis for Compacting Factor

Fresh concrete mixed with coconut shell as a substitute for 5% fine aggregate was tested on a compaction factor test to determine its workability in terms of time taken to settle. The two compaction tests were performed and it was found that the weight of normal concrete and modified concrete was different. Table 4.3 shows the test results of the compaction factor of fresh concrete with the replacement of 5% coconut shell in the concrete. The relationship between compaction test results and different mold weights is shown in Figure 4.2. It has been observed that, the workability of fresh concrete subjected to compaction tests for concrete with different mold weights has increased.

Table 4.2 The coconut shells in an existing dry state (Modified)

Compacting Test	**1st Batch (weight kg)**	**2nd Batch (weight kg)**
Control	14.43 kg	15. 28 kg
Modified 5% coconut shell replacement (dry state)	14.72 kg	
Modified 5% coconut shell replacement (wet state)		15.98 kg

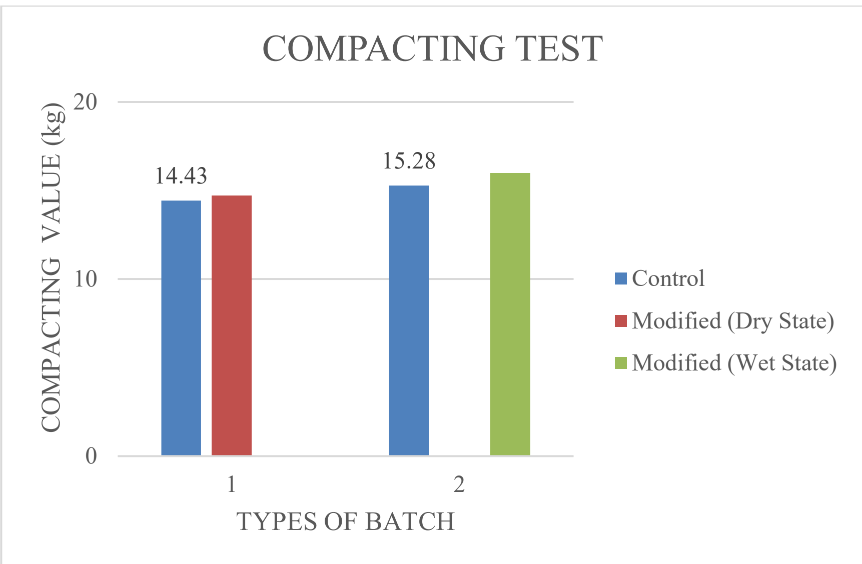

Figure 4.2 Workability by Compacting Factor Test for Concrete Mixed

This has been observed from the deterioration test findings in Table 4.2 and and Figure 4.2 that the main reason for the change in concrete weight is the addition of 5% coconut shell as a replacement for fine aggregate to fresh concrete. According to the results, the weight for the first compacting test for the modified slump test (5% coconut shell fine aggregate) is 14.72 kg, but the weight for the regular concrete fresh slump has increased with a weight of 14.43 kg for the concrete control. According to the findings of the second compacting test, the weight of new concrete has increased from 15.28 kg for standard concrete to 15.28 kg for the modified test (coconut shell fine aggregate 5%) which is the actual compacting and the increase in weight is 15.98 kg for the second compacting test.

The level of concrete compaction increases when coconut shells are mixed in the concrete mix. Specimens are easier to compact with less force applied. This is because the fresh concrete mix with the replacement of 5% of fine aggregate that is coconut shells becomes better after mixing coconut shells into it. Aggregate with a smooth and stiff surface will result in a decrease in compatibility compared to coconut shells with a rough and rough surface.

The compaction factor test provides more accurate workability test results than the slump test but the slump test is easier to use on site for the purpose of testing the workability of fresh concrete because of its simple procedure and apparatus. Integrating fresh concrete with the replacement of 5% coconut shells in fine aggregate will definitely make the mixture denser than normal concrete instead of reducing the deterioration in the workability of fresh concrete.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 CONCLUSION

Based on the data obtained through experimental tests and discussions, the following conclusions can be made from the study of the physical properties of concrete mixed with 5% coconut shells in fine aggregate as an additive.

By using 5% coconut shells as a substitute for fine aggregate in the concrete mix, the workability of fresh concrete has increased compared to the control mix based on the workability test results obtained from the slump test and the compaction factor test for the second testing. Hence, the method of preparing coconut shells with 24-hour immersion has a positive effect on the second testing results. These results show that the existence of coconut shells as a substitute for fine aggregate can increase the strength of concrete as well as the workability of fresh concrete.

In this current study, two tests were performed using different methods on coconut shells, which gave different and significant results. Through several laboratory tests, the mixture of coconut shells and ordinary concrete materials did not produce good results in the workability and compressive strength of concrete. In fact, we need to use the method of preparing coconut shells by soaking the shells overnight so that good absorption occurs and corrosion does not occur when mixing the concrete. Cement is also bound with admixtures such as coconut shells as well as with common mineral aggregates, leading to increased workability in the fresh state and reduced strength development in the hardened state. For further research, a lower volume percentage of coconut shell mix should be tested to determine the best volume percentage of coconut shell mix that should get the strength and workability of normal concrete.

The potential of adding coconut shells as an aggregate replacement material in the concrete mix has not been realized, as further research is needed. The addition of coconut shells to cement-based materials can be used for both compressive strength and workability has been achieved by using the second testing method which is soaking coconut shells for 24 hours to prevent corrosion while mixing the concrete. The inclusion of coconut shells in concrete is a key factor because coconut shells can bind perfectly as mineral aggregates, causing early cracks in the concrete matrix and subsequently resulting in a decrease in compressive strength. As for workability, rubber concrete paste which has a lower workability than normal concrete paste is mainly affected by the low density of the rubber cutting unit and also in terms of lightness. In this study, only one type of cutting tire is used, which is a tire cube with different percentages. It is important to test different types of tire cuts to get better results. Finally, it is clear that further work is needed to characterize the rubber in terms of origin, size, shape, gradation, density and volume. In addition, a study on the influence of each parameter on the properties of concrete also needs to be carried out.

5.2 RECOMMENDATION

Through tests and studies of concrete properties that have been carried out, these are some recommendations for further studies in the future.

Increase the ratio of coconut shells in the concrete composition because in normal concrete, fine aggregate plays a major role in the development of strength. If the percentage of coconut shells used to replace the fine aggregate is increased, it should give better and stronger specimens.

Use a smaller fraction of coconut shells in concrete below 5 mm. Through several findings in this study, reducing the fractional size of coconut shells should help increase the strength of concrete. By doing this, the possibility of early cracking caused by coconut shells can be reduced and further increase strength.

Investigate hard concrete applications and various absorptions such as shock absorbers, in sound barriers, sound speakers (which effectively and control sound) and earthquake shock absorbers in buildings.

Try to increase the ratio of water content in the concrete mix and soak coconut shells for 24 hours before mixing it into the concrete mix. By doing so, the workability of coconut shells should be increased. More moisture content in the fresh concrete paste will make the concrete paste more workable such as easier to compact, move or shape.

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APPENDICES

APPENDIX A

CONCRETE MIX DESIGN FORM

(CMD)

TABLE 1: CONCRETE MIX DESIGN FORM

JOB TITLE: ……………………………………………………………………………

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	5 N/mm² or no data ___ N/mm²
	1.3 Margin	C1 or Specified	(k = 1.64) 5 x 1.64= 8.2 N/m² 20
	1.4 Target mean Strength	C2	+ 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/cementratio	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 ~~kg/m³~~ = 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 0.040 m³	10.854	7.695	33.576	16.767	33.57	

1 N/mm² = 1 MN/m² = 1 MPa
OPC = ordinary Portland cement; SRPC = sulphate-resisting Portland cement; RHPC = rapid-hardening Portland cement.
Relative density = specific gravity
SSD = based on a saturated surface-dry basis.

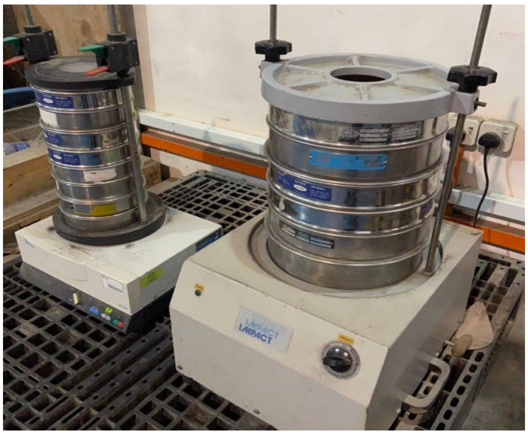
Edited by Aizat Aliason 30/01/2012
Amirulkhairi on 6/10/2021

Appendix 1: Progress of preparing coconut shells

The process to remove the contents and coir

Coconut shells drying

Crushed the coconut shells



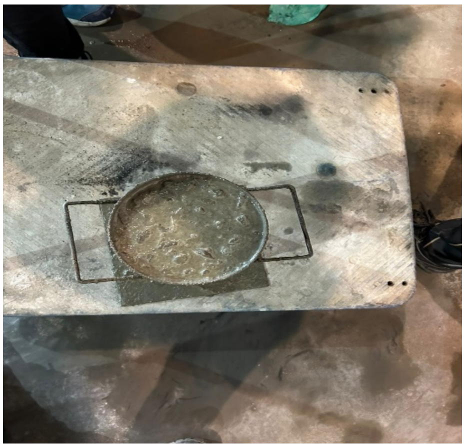
sieve coconut shells in 5 mm

Appendix 2: Activities during testing slump test and compacting test

Mixing the all materials

Slump test diameter

Tapping 25 times on the mould



Compacting the concrete mix design