THE COMPRESSIVE STRENGTH OF CONCRETE WITH COCONUT ASH AS CEMENT REPLACEMENT.

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ABSTRAK

Kajian ini dilaksanakan adalah untuk menghasilkan konkrit yang lebih mesra alam dengan menggunakan debu yang dihasilkan daripada fiber kelapa. Penggunaan debu fiber kelapa adalah sebagai tujuan untuk mengurangkan simen dalam bancuhan konkrit. Tujuan untuk menghasilkan konkrit tersebut adalah untuk mencapai objektif utama projek tersebut iaitu untuk menentukan kebolehkerjaan konkrit dan menentukan sifat mekanikal konkrit. Nisbah bahan yang telah digunakan ialah 1:2:4 untuk membancuh konkrit. Bahan tambah iaitu debu yang dihasilkan daripada fiber kelapa digunakan untuk menggantikan simen adalah sebanyak 0%, 2% dan 4%. Konkrit yang akan dihasilkan dengan menggunakan acuan yang bersaiz 100mm panjang, 100mm lebar dan 100mm tinggi. Konkrit yang dihasilkan akan dibiarkan kering dan direndam selama seminggu sebelum diuji pada hari ke-7, seterusnya hari ke-14 dan ke-28.

ABSTRACT

This study was carried out to produce concrete that is more environmentally friendly by using coconut fiber ash as cement replacement. The reason to use coconut fiber as cement replacement is to reduce the amount of cement usage in concrete mix. It is aimed to achieve the min objectives of this study which are to determine the workability of concrete and to determine the compressive strength of concrete. The ratio of materials used is 1:2:4 to do the concrete mix. Additives which are coconut fiber ash used to replace the cement are 0%, 2% and 4%. The mold used to produce concrete is 100mm length, 100mm width and 100mm height. The concrete will then be let dry and soaked for 1 week before it tested on 7^{th} days, then continued by 14^{th} days and 28^{th} days.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Compressible materials are typically the first choice of materials for building construction not only in Malaysia, but also globally. Concrete is frequently used in construction because it can provide strength, durability, and versatility during the structure's construction. Concrete's good properties have made it a dependable and long-lasting choice of construction companies for both industrial and residential construction. However, the cost of construction materials has risen over time as they have become one of the most important materials in building construction and have become increasingly difficult to obtain. Simultaneously, a massive amount of industrial waste, agricultural waste, and other types of solid waste are posing a serious environmental threat. To reduce and minimise the negative impact of the concrete industry's short-tempered use of raw materials, the use of artificial wastes as supplementary cementitious materials, the source of which is both reliable and suitable for alternative preventive solutions, promotes the industry's environmental sustainability (Aprianti, 2017).

Furthermore, there are numerous innovations that have been implemented from various types of elements within our country's construction industry. These elements include Green Construction Technology based on the building, which is gaining attention from all over. Furthermore, green building materials have gained a lot of attention among builders and developers because they are made from renewable materials that can be considered environmentally friendly to reduce the effect of environmental pollution (Syed et al., 2020).

Several studies had been carried out in order to develop an alternative that could be used as a cement substitute or replacement. Cement replacement materials are a ground-breaking green alternative to raw materials. Materials that can be used to replace cement as a binder can come from a variety of sources, including agriculture, industry, and the maritime industry. This chapter will go over the purpose, problem statement, research benefits, and scope of study in detail.

1.2 Problem Statement

Some building material suppliers are looking for a unique way to reduce costs while increasing profits in the current economic climate. As is well known, the use of concrete in building construction is becoming increasingly important. The most visible in projects that use concrete as the primary building material are the walls, beams, and columns. Simultaneously, a large amount of agricultural waste is disposed of in many tropical countries and remains for thousands of years. If agricultural wastes could be used as a sustainable material, it could help to solve both social and environmental issues (Janani et al., 2022).

Global warming and climate change have emerged as the most pressing environmental issues, with negative consequences not only for the environment but also for human health (Choong et al., 2019). Environmental concerns arose as a result of high energy costs and CO2 emissions associated with bonding, resulting in a weight reduction in the use of valuable materials in concrete (Ramesh Kumar & Kesavan, 2020).

1.3 Objectives of the Study

According to the problem statement, the main goal of this project is to develop a new type of concrete by using coconut ash as a cement replacement in order to reduce the chemical effects of the cement while also reducing mass disposal of coconut to solve environmental issues. Several objectives have been identified in order to achieve the goal, as follows:

i. To determine the workability of concrete with coconut ash as cement replacement.

ii. To determine the compressive strength of concrete with coconut ash as cement replacement.

1.4 Scope of Study

The primary goal of this project is to investigate the compressive strength of concrete using coconut ash as a cement substitute. This project could also be one of the alternative ways to reduce agricultural waste, specifically waste of coconut fibre. The quantity of materials such as coconut fibre ash, cement, and water are calculated in this study using the concrete mix design method and form. The percentages of coconut fibre ash used were 0 %, 2 %, and 4 %. There are three concrete sample blocks for each percentage of coconut fibre ash.

The experiments were carried out at the Faculty of Civil Engineering Technology, University Malaysia Pahang's Laboratory. The concrete dimensions is 100 mm^3 cubic. This study will involve the testing of concrete blocks using compression tests (BS 1881: Part 116: 1983 and ASTM C 39-03) (BS EN 12350-2: 2019). The total numbers of specimens' water curing are 54 cubes and with 7, 14 and 28 days.

1.5 Significance of Research

According to the study, using coconut ash as a cement replacement has several benefits for the community and the development sector in our country. Among the benefits obtained from this study is that it was used, implying that coconut fibre ash is an environmentally friendly material. Typically, unused coconut parts such as coconut husk are discarded as waste or burned in the open air, polluting the environment. Furthermore, the housing industry has emerged as the most significant source of greenhouse effect because it emits a large amount of carbon dioxide gas, and climate change has received widespread attention in recent years (Li et al., 2022). As a result, the unused portion of the coconut must be handled carefully in order to increase its value and reduce global pollution.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter investigates the environmental problems caused by agricultural waste, concrete manufacturing, and the environmental impact of concrete. To begin with, cement is the primary binder for concrete, which has been identified by environmentalists as one of the industries that is not environmentally friendly because the burning of cement raw materials in kilns requires energy up to 1450°C and the output air waste CO_2. Calcium Hydroxide, CaOH, is the compound content of cement that can be used in innovation (R Bayuaji et al, 2016). As a result, recycled agricultural waste may be transformed into environmentally friendly concrete.

2.2 Concrete in Construction

Since the introduction of reinforced concrete as a structural material, the construction industry has made remarkable progress. Concrete is the most commonly used material, with three tonnes used per year for every person on the planet (Gagg, 2014). Concrete is one of the most commonly used construction materials in many civil engineering constructions today. This is because concrete has irreplaceable advantages over other building materials, so the level of concrete construction technology also determines to some extent (Yuzhen, 2021). Traditional concrete is composed of cement, water, and coarse and fine aggregates. When they are put together, they produce a construction substance that hardens over time. Concrete is a common building material in the construction industry, and it has been widely used in the construction of residential and commercial buildings and infrastructures not only for its excellent structural properties, but also for its formability, which allows it to achieve any shape regardless of geometric complexity (Li et al., 2022).

2.3 Environmental Impact Caused by Conventional Concrete

The most significant environmental issue with cement and concrete production is energy consumption. Cement manufacturing is one of the most energy-intensive industrial manufacturing processes. Cement production requires approximately 1,758 kWh per tonne of cement, including direct fuel use for mining and transporting raw materials. The industry's reliance on coal results in particularly high levels of CO_2, nitrous oxide, and sulphur emissions, among other pollutants. Coal is also used to generate a significant amount of electricity (Dan Babor, Diana Plian & Loredana Judele, 2009).

Water pollution is another environmental issue associated with cement and concrete production. Wash water from equipment cleaning is frequently discharged into setting ponds at the batch plant, where the solids settle out. Some returned concrete is also placed in settling ponds to be washed away and the aggregate recovered (Dan Babor, Diana Plian & Loredana Judele, 2009).

2.4 Concrete Mix

The proportions of concrete components such as cement, sand, aggregates, and water are referred to as the concrete mix. These mix ratios are determined by the construction type and mix design. As a standard structural concrete mix, the cement ratios of 1:2:4 were chosen for the concrete mix. Other possible mixes were investigated, and they included 1:1:2 as the best quality of combination and 1:3:6 as a poor quality of mixture that is commonly used for concrete infill. Because of its widespread use, the 1:2:4 ratio was chosen (Chon et al., 2014).

2.5 Material for Concrete

2.5.1 Cement

Cement is a substance created by heating a mixture of limestone and clay. Cement has cohesive and adhesive properties, allowing it to join constituent components like sand and mortar to form solid concrete. The most common building material is cement. It can be used in conventional concrete construction in areas where there is no water or sulphate in the soil. Cement is a finely ground inorganic powder made from limestone and clay. The cement reacts with water to form a paste that sets and hardens through the hydration process (Choong et al., 2019).

2.5.2 Aggregate

Coarse aggregate is stone that has been broken down into smaller pieces and has an irregular shape. Coarse aggregates are used in a variety of ways in the construction industry, including as ballast in road and railway works to resist overall load distribution and to drain rainwater. Blasting quarries or crushing it by hand or with crushers can be used to obtain coarse aggregate. Coarse aggregate is defined as materials with a maximum size of 63 mm that can be retained on a 4.7 mm filter. The size of coarse aggregates affects concrete properties such as strength and workability, as well as the amount of water required.

Fine aggregate is any natural sand particles won from land through the mining process or crushed stone with most particles passing through 4.75mm sieve and retain on 0.075mm sieve. Fine aggregates are used in projects which need a smooth yet highly compacted surface. For examples, fine aggregates used in mortar, plaster, concrete, filling of road pavement layers and can even be used as soil amendment.

Aggregate materials are used to improve the compaction of the concrete mixes and it can also decrease the consumption of cement and water to contribute higher compressive strength of the concrete.

2.5.3 Water

Water is essential in combining cement, aggregates, and sand to form a paste. Water causes concrete to harden through a process known as hydration. The use of dirty water reduces the quality of a material unnecessarily. Water from an approved source must be used in conjunction with cemented constructions to ensure that the water is free of impurities that could have a negative impact.

2.6 Cement Replacement

When cement is mixed with water, chemical reactions between the various chemicals and the water begin. Many compounds will be produced as a result of the reactions, including tricalcium aluminate, which causes initial stiffening but contributes the least to ultimate strength, tricalcium silicate, which has a noticeable effect on concrete strength at early ages, and dicalcium silicate, which contributes the least to ultimate strength (Chon et al., 2014).

2.7 Waste

Waste is an unavoidable by product that happens from the phenomena of life, growth, change of lifestyle of societies and different kinds of industries. It is also considered as one of the main sources of environmental humiliation since it causes air, land and water pollution that contributing towards global warming. In Malaysia, the growing amount of agricultural waste has become a crucial environmental issue to be solved as the waste generated in Malaysia amounted to 38200 tons/day and only 5 percent of it is recycled (Global recycling magazine, 2017). Wastes are produced by numerous of human activities, both industrial and domestic will caused health problems and have a negative impact to the environment. Concrete wase recycling could reduce the amount of space taken up in landfills and eliminates pollution caused by trucks transporting concrete trash (Jindal & Ransinchung, 2018).

2.7.1 Coconut

Coconut, or the scientific name Cocos nucifera, is an important fruit tree in the world because it feeds millions of people, particularly in the tropical and subtropical regions. It is also known as the "tree of life" (Manisha DebMandal & Shyamapada Mandal, 2011) last name only. The coconut palm tree is the most widely grown and is found in all palm species. Coconut is a tall cylindrical stem palm with a diameter of 60 to 70 cm and a height of 30 m. The coconut tree is also one of the most useful plants on the planet (Bheel et al., 2020).

2.7.2 Fibre

Figure 2.7.2: Coconut fibre

Coconut fibre has good mechanical properties, does not rot easily, and is long lasting. Coconut fibres are not difficult to obtain because it is regarded as being rich in natural elements that can be put to good use in Asia, including island countries. The outermost section of the coconut is made of coconut fibre, a fibrous material with a thickness of about 5 cm. A coconut contains 35 percent fibre, 12 percent shell, 28 percent fruit flesh, and 25 percent fruit juice. Coconut fibre makes up 78 percent of the cell wall and 22 percent of the cavity (Khoufi As et al, 2017). Natural fibres that are easily accessible can be used as fibre reinforcement in concrete. These fibres are strong and ductile, as well as inexpensive and low in density. These fibres are widely used in lightweight concrete construction as well as insulating walls (Abbass et al., 2021). Coco peat, also known as coir pith, is a waste product of the coconut industry made from coconut husks. It is a porous substance with a high-water holding capacity, similar to a sponge. It is a special type of material used in mortar because it can reduce construction costs and porosity by using lightweight materials, soundproofing, thermal insulation, and effective air circulation (Oorkalan & Chithra, 2017).

2.7.3 Coconut Ash

The Centre of Environmental Health Engineering created Coconut Fibre Ash (CFA) with a 67.55 percent composition of chemical Silica (SiO_2). This mixture demonstrates that CFA and fly ash (FA) can be used in conjunction as cement replacement materials (Bayuaji et al., 2016). Coconut ash can be classified as high or low calcium depending on its CaO level. Coconut fibre still has a carbon content of less than 5 %. It is recommended for use due to its strength, low cost, and energy-saving properties (Ramesh Kumar & Kesavan, 2020). To make coconut ash, first harvest the coconut filaments, then dry the fibre properly before bringing it and consuming it outside in the sun to burn and turn it into ash. If coconut ash is successful in replacing cement as a result of these advancements, the impact of CO_2 emissions in the cement manufacturing process could be reduced (Bayuaji et al., 2016). As a result, the beneficial effects of concrete technology could be extended by using coconut ash in more environmentally friendly ways.

Coconut Fibre Ash (CFA) was created by the Center of Environmental Health Engineering using 67.55 percent composition of chemical Silica, (SiO_2). This mixture demonstrates the CFA and fly ash, (FA) could work together as cement replacement materials (Bayuaji et al, 2016). Depending on CaO level, coconut ash could be classified as high or low calcium. The carbon content of coconut fibre is still less than 5 percent. It is recommended to use because of its strength, cheap and energy-saving properties (Ramesh Kumar & Kesavan, 2020). The process to make coconut ash is first, the coconut filaments are harvested then the fibre is dried properly and then bring it and consumed it outside in the sun to burn and turn it into ash. The impact of CO_2 emissions in cement's manufacturing process could be reduce if coconut ash successful to replace cement due to these advancements (Bayuaji et al, 2016). Therefore, the positive impact of concrete technology could be continued by using coconut ash but in more environmentally friendly ways.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter will reveal the writing of an implementation method to achieve the study's objectives. This chapter was written to ensure that the project can be implemented properly. Obtaining all information about concrete used in construction is one of the tasks that must be completed. Following that is the production of M30 grade concrete using coconut fibre ash as a cement substitute. The concrete was tested using different percentages of coconut ash as cement replacement in 0 %, 2 %, and 4 %. The total number of concrete samples is 36. The concrete samples will be tested in this study using compression tests (BS EN 1881: Part 116: 1983) update and workability tests (slump test) (BS EN 12350-2: 2019).

3.2 Flow Chart

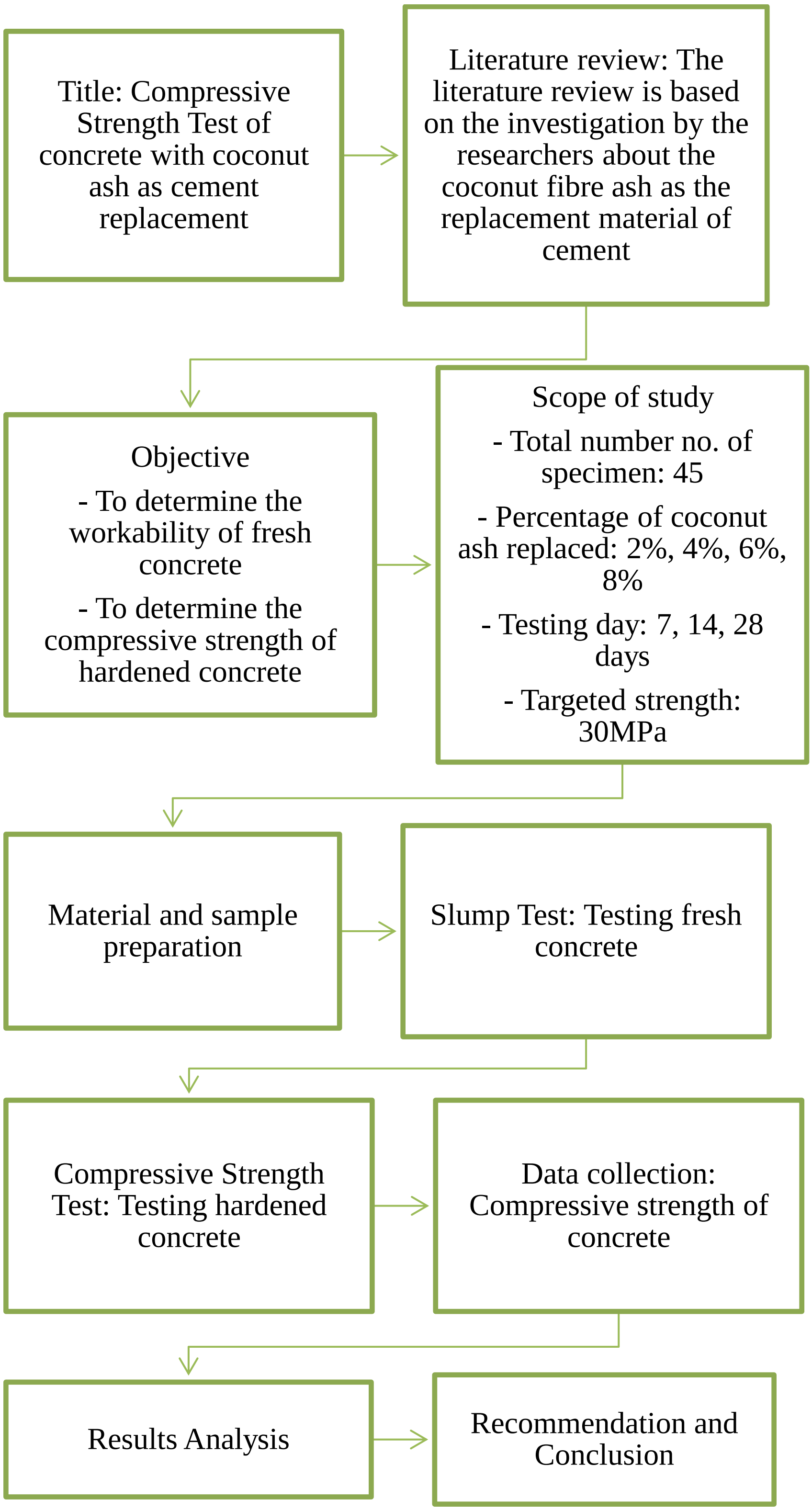

Figure 3.2: Flow Chart

3.3 Material use

3.3.1 Coconut Fibre

Fibrous substance with roughness and many cavities and can survive in all weather conditions. Coconut fibre will be burned to ash and used as cement substitute in concrete. It also can help to reduce the amount of the usage cement. Coconut fibre can be removed manually or simply immersing the coconut in water. These fibres are regarded as good materials as they are environmentally benign and can help to solve environmental problems.

3.3.2 Cement

The cement used in this project was Ordinary Portland Cement (OPC) as it is the most suitable and generally available on market. This cement also can be used in structural concrete, precast concrete, and other general-purpose applications. The cement is usually stored in a clean, dry and well-freshened location away from damp floor.

3.3.3 Sand

Sand is type of naturally occurring material that is of a granular, loose fragmented composition that consisting of particulate matter such as rock, coral, shells and so on. Sand is typically finer than gravel but coarser than silt. Usually, the sand size used to product concrete, mortar and plaster are 4.75mm to 0.15mm. Sand can be used to mix concrete and make bricks.

3.3.4 Coarse Aggregate

Coarse aggregate is stone that are broken into smaller sizes and irregular in shape. Coarse aggregates are used in different ways in construction industry and used as ballast in road and railway works to resist the overall load to distribute the load properly to the soil base and drain off the rainwater. Coarse aggregate can be obtained by blasting quarries or crushing it by hand or by using crushers. Coarse aggregate are materials with a maximum size of 63mm and are large enough to be retained on a 4.7mm filter. The size of coarse aggregates will affect the concrete properties including the strength and the workability as well as the quantity of water needed.

3.3.5 Water

Water is the key ingredient to bind the cement with aggregates and sand together to form paste. The water causes the hardening of concrete through a process called hydration. The usage of dirty water will cause a material's quality to suffer unnecessarily. Water obtained from an approved source must be utilised in conjunction with cemented constructions to ensure the water is clear of impurities that might have negative consequences.

3.4 Specimen preparation

The samples used in this study was based on the concrete mix design. There are a total of 3 samples for each concrete based on the percentage of cement replacement. The percentages that used to replace the cement are 0%, 2% and 4%. The result of the performed tests on coconut ash fibre concrete will then be compared with normal concrete. Thus, all of the results could be determined whether it was better than normal concrete or not.

3.5 Testing Procedure

3.5.1 Slump Test (BS EN 12350: Part 2 (2009))

Slump tests is a laboratory test or on-site method of determining concrete consistency. The slump test indicates the consistency of concrete in different batches. The shape of the concrete slump will reveal information about the workability of concrete and quality (Bheel et al, 2020).

First, clean the internal surface of the mould and apply oil. Secondly, place the mould on a smooth horizontal non-porous base plate. Then, fill the mould with the prepared concrete mix in 4 approximately equal layers. Tamp each layer with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould. For the subsequent layers, the tamping should penetrate the underlying layer. After that, remove the excess concrete and level the surface with a trowel and clean away the mortar or water leaked out between the mould and the base plate. Raise the mould from the concrete immediately and slowly in vertical direction. Lastly, measure the slump as the difference between the height of the mould and that of height point of the specimen being tested.

3.5.2 Compression Test (BS EN 1881: Part 16: 1983)

Compression tests are completed by loading the test specimen between two plates and then applying a force to the specimen by moving the crossheads together. During the test, the specimen is compressed and deformation versus the applied load is recorded.

First and foremost, remove the specimen from the water after specified curing time then wipe out excess water from the surface and take the dimension of the specimen to the nearest 0.2m. Then, clean the bearing surface of the testing machine and place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast. Align the specimen centrally on the base plate of the machine. After that, rotate the movable portion gently by hand so that it touches the top surface of the specimen. Last but not least, apply the load gradually without shock and continuously at the rate of 140 kg/cm^2/minute till the specimen fails and record the maximum load and note any unusual features in the type of failure.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the compressive strength of concrete with coconut ash as cement replacement. The normal concrete performance will be compared with the environmentally friendly concrete which is concrete with coconut ash as cement replacement.

4.2 Slump Test

The effect of concrete with coconut ash as cement replacement in workability is shown in Figure 4.2.

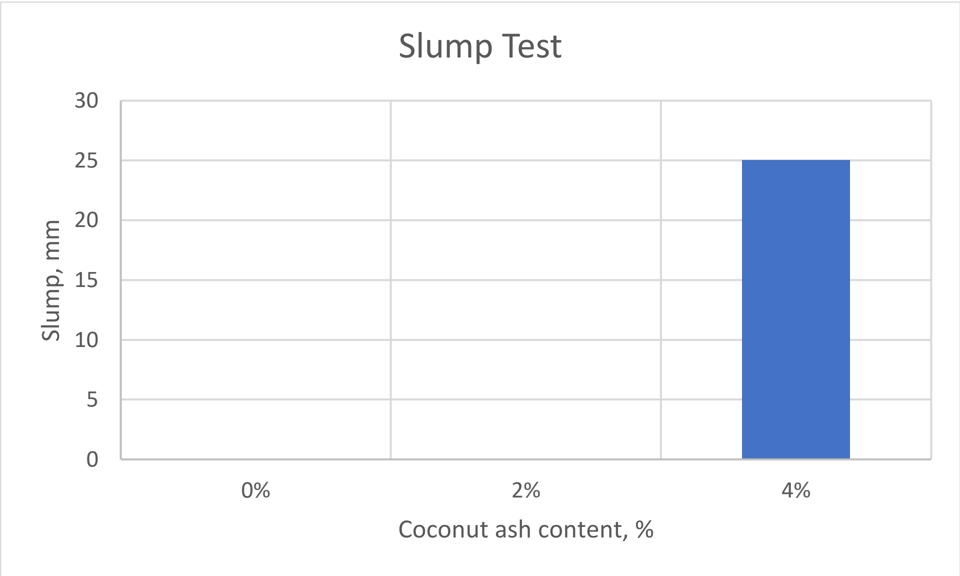

Figure 4.1: The workability of coconut ash as cement replacement

According to the slump test result obtained from this project, zero slump is obtained in normal concrete and concrete with 2% of coconut ash. There is a 25mm slump occur in concrete with 4% of coconut ash. As a result, the concrete with 4% of coconut ash has the greatest workability compared to normal concrete and concrete with 2% of coconut ash.

4.3 Compressive Test

Table 4.1 are the 28 days of compressive strength test of the concrete that had been done.

Table 4.1: data for compressive test

Days	Percentage of coconut ash, %		
	0	2	4
7	1: 18.7 2: 15.0 3: 14.0	1: 17.7 2: 15.3 3: 20.2	1: 15.5 2: 14.0 3: 15.0
14	1: 20.6 2: 20.8 3: 23.0	1: 22.6 2:19.8 3: 19.1	1: 16.8 2: 16.7 3: 17.8
28	1: 24.7 2: 30.0 3: 24.5	1: 27.4 2: 22.3 3: 26.8	1: 19.7 2: 19.0 3: 24.5

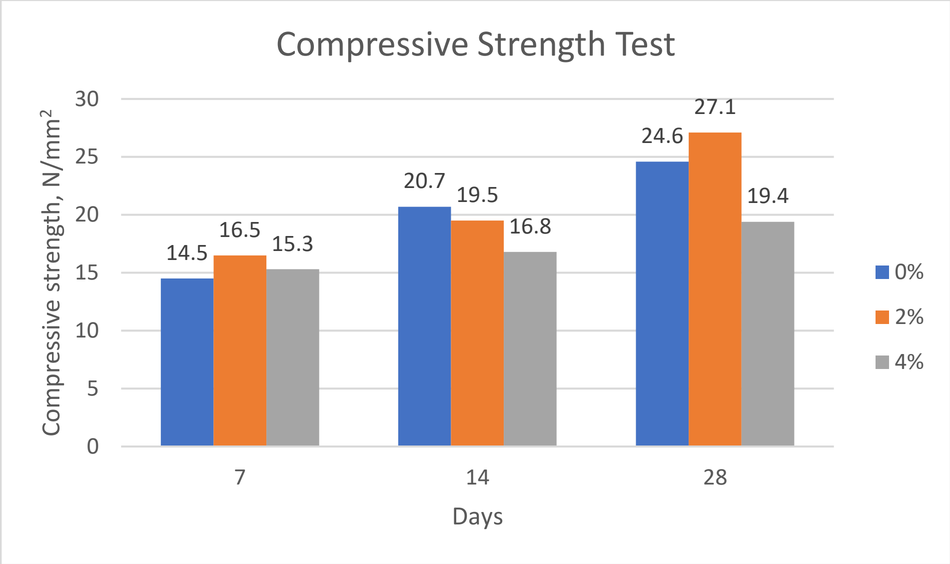

Figure 4.3: Compressive strength test graph

Based on the data obtained, normal concrete had achieved 24.6N/mm^2 at 28 days, concrete with 2% of coconut ash had achieved 27.16N/mm^2 at 28 days and concrete with 4% of coconut ash had achieved 19.46N/mm^2 at 28 days. As a conclusion, the concrete with 2% of coconut ash has the greatest compressive strength compared to normal concrete and concrete with 4% of coconut ash.

4.4 Discussion

From the result obtained, the workability of normal concrete and concrete with 2% of coconut ash are less work as there are no slump for this concrete due to the man-made error. For concrete with 4% of coconut ash has better workability as it has 25mm of slump. The compressive strength for concrete with 2% of coconut ash is better than the normal concrete and concrete with 4% of coconut ash as the concrete with 2% of coconut ash has the nearest value to the targeted strength.

CHAPTER 5

CONCLUSION

5.1 Introduction

This study is focused on the compressive strength of concrete with coconut ash as cement replacement. The primary findings of this project are to compare the strength between the normal concrete and concrete that with coconut ash and the workability of the normal concrete and coconut ash concrete.

5.2 Conclusion

In this project, the workability of normal concrete and concrete with 2% of coconut ash are less work as there are no slump for this concrete due to the man-made error. For concrete with 4% of coconut ash has better workability as it has 25mm of slump. The compressive strength for concrete with 2% of coconut ash is better than the normal concrete and concrete with 4% of coconut ash as the concrete with 2% of coconut ash has the nearest value to the targeted strength.

5.3 Recommendation

There are some recommendations for future study on this topic to provide better and useful results. Below are the suggestions to achieve the target of this study for future research:

i. Increase the water or cement ratio to improve workability.

ii. Increase the mixing time and temperature.

iii. Adjusting the cement type and quantity to improve compressive strength.

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APPENDICES

Appendix A: Slump Test

Figure 6.1: Slump test of 0% concrete

Figure 6.2: Slump test of 4% coconut ash concrete

Appendix B: Compressive strength test

Figure 6.3: Compressive strength test of 0% concrete

Figure 6.4: Compressive strength test