STRENGTH PERFORMANCE OF COCONUT FIBER ASH AS CEMENTITIOUS MATERIAL

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Report submitted in fulfillment of the requirements for the award of the degree of B. Eng (Hons.) Civil Engineering

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JULY 2014

ABSTRACT

Natural fiber ash is the product that is produce from the burning process of the specific type of natural fiber that exist in this world for example sisal fiber, jute fiber, kenaf fiber, and bamboo fiber. For more specific, natural fiber is actually the thread like materials which can be used for different purposes and also can be used in different application of field. Other than that, the other benefits of natural fiber are can lead to have sustainable development , easy usage/handling of fibers due to their flexibility, have good strength- and stiffness-to-weight ratios, and require only around 20-40% of the production energy. By using the natural fiber ash in concrete production, we can minimize the amount of cement used and definitely it can save the cost of construction due to the expensive cost of cement. In this study, the coconut fiber ash will be used as cementitious material in order to produce high strength concrete and will be burn in furnace for 2 hours at 500^0C. Not only that, the concrete with cementitious materials can be stronger and have high durability than concrete with Ordinary Portland cement (OPC). The percent replacement of the ash used are 1%, 2%, 3% and 4% from the weight of cement used and will be compared with 0% (without coconut fiber ash replacement). The testing that will be conduct in this study is fixed for all size cubes (100 x 100 x 100 mm) that are compressive strength. The curing days are 7 days, 14 days and 28 days. From the data during this study was conduct, the most successful compressive strength is the concrete with 1% coconut fiber ash replacement than the others percentage.

ABSTRAK

Abu serat semula jadi adalah produk yang dihasilkan daripada proses pembakaran sesuatu jenis serat semula jadi sebagai contoh sisal , serat rami , serat kenaf, dan serat buluh. Untuk lebih khusus, serat semula jadi sebenarnya benang seperti bahan-bahan yang boleh digunakan untuk tujuan yang berbeza dan juga boleh digunakan dalam aplikasi bidang yang berlainan. Selain daripada itu, faedah lain daripada serat semula jadi adalah boleh membawa kepada pembangunan yang kukuh dan kekal, penggunaan mudah / pengendalian gentian kerana fleksibiliti mereka, mempunyai kekuatan- baik dan nisbah kekerasan kepada berat, dan memerlukan hanya sekitar 20% - 40 % daripada tenaga pengeluaran. Selain itu, abu serat juga boleh mengurangkan jumlah simen yang digunakan dan pasti ia dapat menjimatkan kos pembinaan kerana kos simen yang mahal .Dalam kajian ini, abu sabut kelapa akan digunakan sebagai bahan penambah gantian simen untuk menghasilkan konkrit berkekuatan tinggi dan akan membakar dalam relau selama 2 jam pada 500^0C . Bukan itu sahaja, konkrit dengan bahan-bahan penambah gentian simen boleh menjadi lebih kuat dan mempunyai ketahanan yang tinggi daripada konkrit dengan simen Portland biasa (OPC). Penggantian peratus abu yang digunakan dalam kajian ini adalah 1 %, 2 %, 3% dan 4% daripada berat simen yang digunakan dan akan dibandingkan dengan 0 % (tanpa abu serat kelapa penggantian) . Ujian yang akan dilakukan dalam kajian ini adalah tetap untuk semua saiz kiub (100mm x 100mm x 100 mm) iaitu kekuatan mampatan. Tempoh prngawetan adalah 7 hari, 14 hari dan 28 hari. Dari data semasa kajian ini, kekuatan mampatan yang paling berjaya adalah konkrit dengan 1 % abu serat kelapa penggantian daripada peratusan yang lain.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Coconut fiber ash material as a cementitious material is currently a great deal of interest in developing the concrete mix in order to produce high strength concrete rather than use a large amount of cement that are more costly. Coconut fiber ash or also called as natural fiber exist in reasonably large quantities all over the world and mostly these type of natural fiber such as bamboo, cane and henequen are unused and not disposed properly. Rather than abundantly available, coconut fiber ash material are also claimed to offer environmental advantages such as reduced dependence on non-renewable energy, lower pollutant emissions, lower greenhouse gas emissions, enhanced energy recovery and end of life biodegradability of components (Noor Md. Sadiqul Hasan et. al., 2012).

This agriculture waste product obtained in the processing of coconut oil and available in the tropical regions of the world especially in Africa, Asia and America and this type of natural fiber is commonly used in construction industry. In countries where abundant agriculture wastes are discharged, these wastes can be used as a potential material or replacement material in construction industry. Due to the stiff surface of organic origin, they will not contaminate or leach to produce toxic substances once they bound in the concrete mix.

Besides that, in this study, as a cementitious material, the coconut fiber ash will properly dry and burnt with a temperature 500^0C by using a furnace and this temperature is fixed for all the cubes. Other than that, the percent of replacement for the coconut fiber are different for each concrete mix design which is 1%, 2%, 3% and 4%.

1.2 PROBLEM STATEMENT

Concrete is a major construction material which is usually made by mixing cement, water, fine and coarse aggregates and sometimes admixtures in their right proportions. Portland cement is a major constituent used in the production of concrete. There is an increasing rise in the cost of cement and this affects the production cost of concrete and consequently slows down infrastructural development in developing countries. Cement production produces greenhouse effect, which is a major contributor to environmental hazards. The gases emitted pollute the air and this poses as a threat to human health (Okere Chinenye Elizabeth et. al., 2013).

So, coconut fiber ash that acts as a cementitious material can help to save the uses a large amount of cement because we will replace it by percentage of coconut fiber ash. According to Noor Md. Sadiqul Hasan et. al., (2012), the coconut fiber ash is agriculture waste products that are abundantly available and by treating the agriculture waste in the production of concrete is rather good than not disposed it properly that would lead to environmental problems. Besides, the use of coconut fiber ash has a great potential in the production of concrete especially in the construction of low-cost concrete structure. Other than that, the uses of agriculture fiber ash might enhance higher toughness of concrete mix.

1.3 OBJECTIVES

1) To determine the strength of concrete produce using coconut fiber ash as cementitious material.
2) To determine the chemical properties of coconut fiber ash burned with 500^0C.

1.4 SCOPE OF STUDY

i. The size of the cubes used in this study is 100mm x 100mm x 100mm.
ii. The curing day are 7, 14, 28 days and the cubes were cured by immersion in water.
iii. The percentages replacements of coconut fiber ash are 1%, 2%, 3% and 4%.
iv. The burning temperature is 500°C and the timing for burning process is 2 hours. The machine used to burn the coconut fiber into ash is furnace.
v. The testing that was conduct is compressive strength test.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Natural fiber ash is the product that is produce from the burning process of the specific type of natural fiber that exist in this world such as sisal fiber, jute fiber, kenaf fiber, bamboo fiber, pineapple fiber, coconut fiber, palm oil and banana fiber. For more specific, natural fiber is actually the thread like materials which can be used for different purposes and also can be used in different application of field.

2.2 INTRODUCTION TO CONCRETE

Concrete has been used in construction for over 2000 years, perhaps first by the Romans in their aqueducts and roadways. Concrete was a name applied to any number of compositions consisting of sand, gravel, crushed stone, or other coarse material, bound together with various kinds of cementitious materials. According to the type of binder used, there are many different kinds of concrete. For instance, Portland cement concrete, asphalt concrete, and epoxy concrete. In concrete construction the Portland cement concrete is utilized the most. Thus, in our course, the term concrete usually refers to Portland cement concrete.

Concrete is widely used in domestic, commercial, recreational, rural and educational construction. Communities around the world rely in concrete as a safe, strong and simple building material. It is used in all types of construction; from domestic work to multi-storey office blocks and shopping complexes. Besides that, concrete major used were for buildings, columns, beams, roofs, floor slabs, foundation walls, footings, staircases, sidewalks, paving, highways, bridges and other. Other than that, concrete was widely used all around the world because of its advantages which are fireproof, watertight, economical and easy to make.

2.2.1 Historical and development of concrete

According to Denis Urquhart (2013), the use of concrete as construction material can be traced back to ancient times, with well documented example of the Roman making extensive use of hydraulic cement concrete, a mixture of lime putty and pozzolan. This material should not be confused with Roman cement; a quite different material developed by James Parker in the 1780s. Roman concrete was used mainly as a filling within masonry and brick walls. Besides that, the concrete was firstly used mainly in the construction such as foundations, harbors and bridges, where its inherent compressive strength and setting capability could be used to great advantage.

Besides that, the Roman are well known for their extensive use of concrete more than two millennia ago, yet experience and knowledge of cement materials is still developing and expanding. The earliest use of concrete dates back to before 5600 BC: a 250mm floor slab from this period, which was made using a red lime, sand and gravel mix, has been discovered on the banks of the Danube in Yugoslavia. In Egypt, murals dating from 1950 BC show various stages of the process of making concrete (Peter Reed et. al., 2008).

2.3 ADVANTAGES AND DISADVANTAGES OF CONCRETE

There were several advantages of concrete that listed by P.K.Mehta (1999), which are flow ability or pump ability, workability, quicker finishing, high ultimate strength, resistance to penetration of chloride ions, electrical resistivity and environmental friendless. Concrete also need less maintenance required means that no need for coating or painting. Besides that, concrete has a relatively high compressive strength, better resistance to fire than steel and has a long service with low maintenance cost.

Besides, there were some limitation or disadvantages of concrete which are quasi-brittle failure mode, low tensile strength (about 1/10 of its compressive strength), low toughness which means less ability to absorb energy. Other than that, concrete also need a formwork to shaped it and time consuming will lead to costly as well as long curing time and working with crack.

2.4 FRESH CONCRETE

Fresh concrete is the stage of concrete in which concrete can be moulded and is in plastic state. This is also called "Green Concrete". Another term used to describe the state of fresh concrete is consistence, which is the ease with which concrete will flow. For fresh concrete to be acceptable, it should be easily mixed and transported, be uniform throughout a given batch and between batches, be of a consistency so that it can fill completely the forms for which it was designed. Besides that, it also should have the ability to be compacted without excessive loss of energy, and not segregate during placing and consolidation. Other than that, it also must have good finishing characteristics. There are several properties of fresh concrete which are workability, consistency, segregation and bleeding. According to Flavio de Andrade Silva et. al.,(2009), the samples were consolidated using a vibrating table operated at a frequency of 65 Hz.

2.4.1 Water-cement ratio

As mentioned by K.S.Pann et. al.,(1975), the water-cement ratio controls the workability of fresh concrete and the strength of the hardened concrete was a well-known engineering principle as early as concrete was first used more than a century ago. The strength of concrete primarily depends upon the strength of cement paste. Strength of cement paste depends on the dilution of paste or in other words, the strength of paste increases with cement content and decrease with air and water content.

There a relation between water/cement ratio and the strength of the concrete and already proved by the graph showing approximately hyperbolic in shape. It can be seen that lower water/cement ratio could be used when the concrete is vibrated to achieve higher strength, whereas comparatively higher water/cement ratio is required when concrete is hand compaction.

2.4.2 Mix proportion

RESEARCHERS	NATURAL FIBERS	AGGREGATE	SAND/WATER	CEMENT	ADDITIONAL MATERIALS
J.Kim.et.al (2012)	Jute Fiber	1629 kg/m^3	Not stated	400 kg/m^3	100 kg/m^3
Baruah and Talukdar (2007)	Jute and coir fiber (1:1.67:3.64)	Fine : 568.40kg Coarse : 1239.40 kg	Water : 182kg	350kg	0.5% , 1% , 1.5% & 2%
Okere Chinenye Elizabeth.et.al (2013)	Coconut fiber ash	Fine : 4.85 kg Coarse : 9.7 kg	Water : 1.58 kg	2.43 kg 2.31 kg 2.19 kg 2.07 kg 1.94 kg 1.82 kg	0% 5% 10% 15% 20% 25%
Noor.Md.et.al (2012)	Coconut fiber ash (1 : 2 : 3)	3	Sand : 2	1	1% ,3% ,5% , 7%
Joo Hwa Tay	Oil palm ash (1 : 2 : 4)	4	Sand : 2	1	10% ,20% , 30% , 40% , 50%

Table 2.1: Mix proportion of previous researchers

Table 2.1 shows the different mix proportion of the concrete between the previous researchers. This table was made in order to compare the different amount of the material used such as water, cement, aggregate, sand as well as the natural fiber used in concrete mix design. The material used was in same categories which is natural fiber and the percentage of replacement are slightly different between the researchers.

2.4.3 Curing process

According to Okere Chinenye Elizabeth (2013), the strength development is believed to continue as long as the curing period is prolonged to allow hydration process to be complete. Concrete cubes were cast and tested at curing ages of 7, 14, 21, 28 and 60 days using 0%, 10%, 15%, 20% and 25% replacement levels. The slump test results shows that the workability of the concrete decreased as the coconut fiber ash content increased. The compressive strength of coconut fiber ash concrete increased with curing age but decreased with increasing percentage of coconut fiber ash. After being removed from the moulds, the cubes were cured by immersion in water, and tested for compressive strength after curing periods of 3,7,14 and 28 days (Noor Md. Sadiqul Hasan et. al., 2012)

2.5 HARDENED CONCRETE

Hardened concrete is the concrete that is fully cured and must be strong enough to withstand the structural and service loads which will be applied to it and must be durable enough to withstand the environmental exposure for which it is designed. If concrete is made with high-quality materials and is properly proportioned, mixed, handled, placed and finished, it will be the strongest and durable building material. Below are several properties of hardened concrete.

2.5.1 Strength of concrete

Factor that affect the strength development of concrete are several including materials used, mixture procedures, curing environment, test methods, and others (K.S.Pann et. al., 1975). The strength of concrete is where the concrete has the ability to resist the load in the compression, flexural or shear. The process of strength growth is called 'hardening'. This is often confused with 'setting' but setting and hardening are not same.

Traditionally, this is done by preparing concrete cubes or prisms, then curing them for specified times. Common curing times are 2,7,28 and 90 days. After reaching the required age for testing, the cube or prism are crushed in a large press. These are several factors that affecting concrete strength are concrete porosity, water-cement ratio, soundness of aggregate, aggregate paste bond and cement related parameters (Nick Winter, 2005).

2.5.1.1 Compressive Strength

The strength of concrete is controlled by the proportioning of cement, coarse and fine aggregates, water, and various admixtures. The ration of the water to cement is the chief factor for determining concrete strength. The lower the water-cement ratio, the higher is the compressive strength. A certain minimum amount of water is necessary for the proper chemical action in the hardening of concrete (Vahid.K.Alilou et.al., 2010).

Besides, compressive testing of the concrete was done in accordance with OSI (OS 1977). Each cube was first dried, weighed, and placed between plates were placed beneath and on the top of the block separating it from the platens of the machine. As the mentioned by K.S Al-Jabri et.al, (2009), the load was applied in small increments until failure, and the failure load of the block was recorded.

Compression test determines the behavior of materials when it is subjected to crushing load. The machine used for compression testing was the hydraulic compression. The compression test was conducted at a cross-head speed of 5mm/min. Sample dimensions was 160mm x 40mm x 40mm. The maximum load before crack was recorded (Alida Abdullah et.al., 2011). According to J.Kim et.al., (2012), the addition of jute fiber up to 1% by volume in the normal strength concrete does not shows a significant increase, but the graph shows that increase in compressive strength by approximately 55% when compared to the one without ash.

2.6 INTRODUCTION TO COCONUT FIBER ASH

The coconut fiber ash has a versatilities functions and its widely application in different branches of engineering, particularly in civil engineering as a construction material. Coconut fiber ash is one of the natural ashes abundantly available in tropical region, and is extracted from the husk of coconut fruit and from the burning process of the outer shell of a coconut. There are two types of coconut fiber, brown extracted from matured coconuts and white fibers from immature coconut. Brown fiber is thick, strong and has high abrasion resistance and mostly used in engineering field (Majid Ali, 2010).

2.6.1 Properties of coconut fiber ash

Chemical Composition	Percentage composition (%)
Silicon Dioxide (SiO_2)	14.34
Aluminium Oxide (Al_2O_3)	35.61
Iron Oxide (Fe_2O_3)	0.18
Calcium Oxide (CaO)	33.27
Manganese(II) oxide (MnO)	0.21
Magnesium Oxide (MgO)	19.86
Potassium Oxide (K_2O)	1.03
Sulphur Trioxide (SO_3)	0.004

Table 2.2: Chemical Composition of Coconut Fiber Ash

The coconut fibers were gotten from local farmers in Badagry, Lagos State and also Nigeria. The fibers were properly dried and burnt in open air with a temperature range of 600°C to 700°C when the fibers turned into ash. The ash was collected and made to pass through 150 microns sieve. Then, a sample of the ash was

taken to the laboratory to determine the chemical composition of the coconut fiber ash (Okere Chinenye Elizabeth, 2013). Several researchers have worked on agricultural wastes like rice husk, groundnut husk, corn cob, bagasse, palm oil fuel as supplementary cementitious materials in concrete production. The ashes from these agricultural wastes have been proven to be good pozzolanas. They have been used to produce concrete having almost the same behavior as normal concrete. Utilization of these waste materials is a partial solution to environmental and ecological problems.

2.6.2 Advantages of coconut fiber ash

Other than low cost, low density and acceptable specific strength, the use of sisal, a natural fiber ash with enhanced mechanical performance, as cementitious material in cement based matrix has shown to be a promising opportunity. As mentioned by Flavio de Andrade Silva et.al., (2009), this work addresses the development and advances of strain hardening cement composites using sisal fiber as cementitious material. Sisal fibers were used as a fabric to reinforce a multi-layer cementitious composite with a low content of Portland cement.

Besides that, the natural fiber ash such as coconut fiber ash contented siliceous and aluminuous material as well as low cellulose, so it is resilient, strong and highly durable, biodegradable, heat retardant and it was considered as renewable material (R. C. Kanning, 2014). According to Okere Chinenye Elizabeth et. al., (2013), the natural fibers ash are also claimed to offer environmental such as reduced dependence on non-renewable energy sources, lower pollutant emission, and end of life biodegradability of components.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

Explanations about properties of concrete and coconut fiber ash already have been discussed briefly in Chapter 2. So, this chapter will be discussed more about the methodology and procedures that were applied in order to achieve the objectives of the study in the aspect on how the material will be gained, where is the sources, the steps of the work including batching, mixing together with casting and lastly the testing of the concrete mix design. The collection information of coconut fiber and concrete was done from a few sources such as journal, internet and articles. Figure 3.1 is to show the flowchart of research methodology.

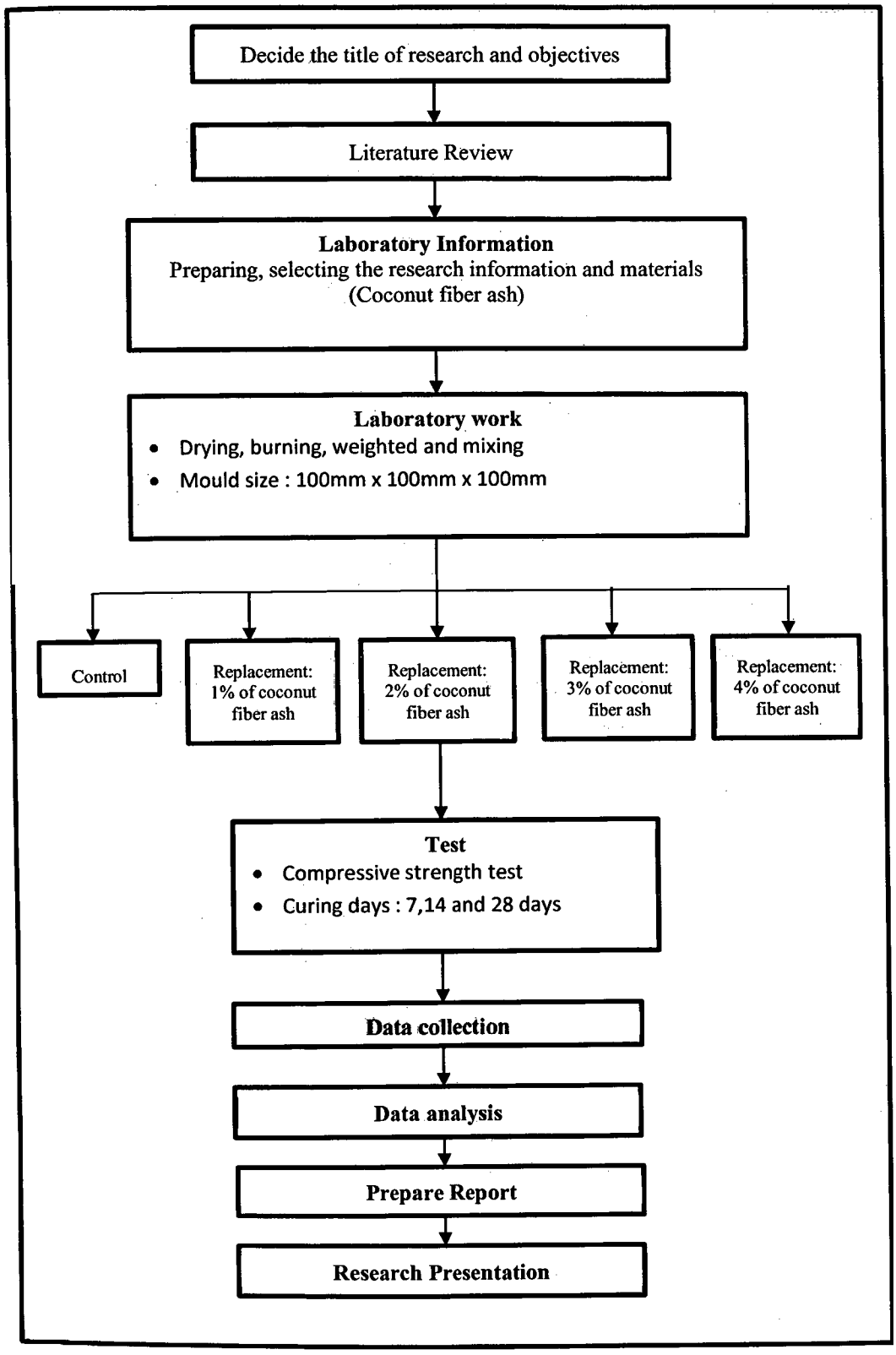

Figure 3.1: Research Methodology Flowchart

3.2 CONCRETE MIX DESIGN

Specimens	Cement (kg)	Water (kg)	Fine aggregate (kg)	Coarse aggregate(kg)	Percent of fiber by weight of cement (kg)
Control (0%)	4.78	2.85	8.45	15.68	-
A1 (1%)	4.73	2.85	8.45	15.68	0.05
A2 (2%)	4.68	2.85	8.45	15.68	0.10
A3 (3%)	4.64	2.85	8.45	15.68	0.14
A4 (4%)	4.59	2.85	8.45	15.68	0.19
Total	23.42	14.25	42.25	78.40	0.48

Table 3.1: Mix Design for Concrete

Concrete mix design is the process of determining required and specifiable characteristics of a concrete mixture. Mix design requirements are based on intended use, environment and others.

The materials used in order to produce the concrete were cement, water, fine aggregate, coarse aggregate and coconut fiber ash. The amount of the water, fine aggregate and coarse aggregate was remained same for all the cubes but there was some different in the amount of the cement due to the different percentages of coconut fiber ash.

Part 1:

a) Characteristic Strength : 25 N/mm^2 at 28 days (proportion defective 5%)

b) Standard Deviation : 8 N/mm^2

c) Margin (k $\times$б) : (k = 1.64), 1.64 $\times$ 8 = 13.12 N/mm^2

d) Target mean strength : 25 + 13.12 = 38.12 N/mm^2

e) Cement type : OPC

f) Aggregate Type: Coarse : Crushed

Aggregate Type: Coarse : Crushed

g) Free – water/cement ratio : 0.58

Maximum free – water/cement

Ratio : 0.65, use the lower value 0.57

Part 2:

a) Slump : 30 – 60 mm

b) Vebe time : 3-6 s

c) Maximum aggregate size : 20 mm

d) Free – water content : 210kg/m^3

Part 3:

Cement Content : 210 / 0.58 = 362.07 kg/m^3

Part 4:

a) Relative density of aggregate : 2.7

b) Concrete Density : 2400 kg/m^3

c) Total aggregate : 2400 – 210 – 362.07 = 1828 kg/m^3

Part 5:

a) Grading of the aggregate : 55 %

b) Proportion of fine aggregate : 35 %

c) Fine aggregate content : 1828 x 0.35 = 639.8 kg/m^3

d) Coarse aggregate : 1828 – 639.8 = 1188.2 kg/m^3