COCONUT SHELL AS AGGREGATE IN CONCRETE ROOF TILES

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DECLARATION

We hereby, declared this report entitled “Coconut Shell Concrete Roof Tiles” is the result of our research except as cited in references.

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Signature: ..........................................................................................................

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Date: June 6, 2014
APPROVAL

This report is submitted to the Faculty Of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for Diploma of Manufacturing Engineering. The member of the supervisory committee is as follow:

........................................................................................................................................
(Principal Supervisor)
(En Baharuddin Bin Abu Bakar)
DEDICATION

For our beloved father and mother and also to our family who always give us support.
ACKNOWLEDGEMENT

First and foremost, I would like to convey our highest and outmost sincere gratitude to Mr. Baharudin Bin Abu Bakar, our Final Year Project supervisor, who has graciously offered his time, attention, experience, dedication, and guidance throughout this project. We would also like to extend our thanks to him for his assistance and provision on the development of this project. Aside from Mr. Baharudin Bin Abu Bakar, we would like to thank especially our panel moderator, Professor Madya Lokman and project panel, Dr Hj. Muhammad Arfauz Bin Rahman for their evaluation, attention and marks especially during this project presentation. Last but not least, we would like to thank each and every individual who have either directly or indirectly helped us throughout the efforts of this report be it in the form of encouragement, advice or kind reminders. A special thanks to the course mates also for their consistent words of wisdom and in sharing their advice and experiences.
ABSTRACT

Due to environmental and economic crisis, this study focuses on generating product using agricultural waste as well develop an alternative construction material that will lessen the social and environmental issues. It also paved the way to the recognition of using coconut shells as substitute for aggregates in developing concrete roof tiles. As a whole, the study’s main concern is the environment and the construction and building technology to enhance natural world as well as building materials. This also aims to design a technical specification of concrete roof tiles using coconut shell as aggregates that will meet the ASTM requirements in order to help contribute to the industry in saving the environment, to encourage the government to find solutions regarding the disposal to landfills of waste materials and save the environment, to provide new knowledge to the contractors and developers on how to improve the construction industry methods and services by using recycled coconut shells, and to sustain good product performance and meet recycling goals. A conventional concrete roof tiles was compared to concrete blocks with coconut shells of the same proportions. Observations from the tests performed were conducted in the laboratory where precise data were gathered and completely attained. Some of the interesting insights of the study are:

1. Coconut shells are applicable as partial substitute as coarse aggregates for concrete roof tiles.

2. The good indicators of coconut shell quality as aggregate of concrete roof tiles are particles, shape and texture, resistance to crushing, absorption and surface moisture, and light-weight.

3. The compressive strength gained higher than the conventional concrete roof tiles after 7th days.
### LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FYP</td>
<td>Final Year Project</td>
</tr>
<tr>
<td>AIDS</td>
<td>Acquired Immune Deficiency Syndrome</td>
</tr>
<tr>
<td>SARS</td>
<td>Severe Acute Respiratory Syndrome</td>
</tr>
<tr>
<td>HEP C</td>
<td>Hepatitis C</td>
</tr>
<tr>
<td>CS</td>
<td>Coconut Shell</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society for Testing &amp; Materials</td>
</tr>
<tr>
<td>CAD/CAM</td>
<td>Computer-Aided Design / Computer-Aided Manufacturing</td>
</tr>
</tbody>
</table>
LIST OF TABLES & GRAPHS

Chapter 2

Table 2.1 - Top ten coconut producing countries in the world

Chapter 4

Table 4.1 – Alternative design concept -design A 27
Table 4.2 – Alternative design concept -design B 27
Table 4.3 – Alternative design concept -design C 28
Table 4.4 - Evaluation of proposed alternative design – design A 29
Table 4.5 - Evaluation of proposed alternative design – design B 29
Table 4.6 - Evaluation of proposed alternative design – design C 30
Table 4.7 - Alternative design against evaluation criteria 30
Table 4.8 - Bill of Material (BOM) 33
Table 4.9 - Table of weight test 38
Table 4.10 -Table of Flexural test result 39
Table 4.11 -Table of Compressive test result 40
Graph 4.1 - Graph of Control Concrete Compressive test result 39
Graph 4.2 - Graph of 10% of Coconut shell Compressive test result 39
# LIST OF FIGURES

Chapter 2

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1.1 – The 3R logo</td>
<td>4</td>
</tr>
<tr>
<td>Figure 2.2 – Aluminium container</td>
<td>6</td>
</tr>
<tr>
<td>Figure 2.3 – Aluminium container with plant</td>
<td>6</td>
</tr>
<tr>
<td>Figure 2.4 – Household batteries</td>
<td>7</td>
</tr>
<tr>
<td>Figure 2.5 – Solar panel</td>
<td>7</td>
</tr>
<tr>
<td>Figure 2.6 – Plastic bottles</td>
<td>7</td>
</tr>
<tr>
<td>Figure 2.7 – Crashed plastic bottles</td>
<td>7</td>
</tr>
<tr>
<td>Figure 2.8 – Coconut trees</td>
<td>7</td>
</tr>
<tr>
<td>Figure 2.9 – Coconut trees bridge</td>
<td>10</td>
</tr>
<tr>
<td>Figure 2.10 – Coconut tree root</td>
<td>10</td>
</tr>
<tr>
<td>Figure 2.11 – Coconut tonic</td>
<td>10</td>
</tr>
<tr>
<td>Figure 2.12 – Coconut shell</td>
<td>11</td>
</tr>
<tr>
<td>Figure 2.13 – Musical instrument</td>
<td>11</td>
</tr>
<tr>
<td>Figure 2.14 – Coconut husk</td>
<td>12</td>
</tr>
<tr>
<td>Figure 2.15 – Rope</td>
<td>12</td>
</tr>
<tr>
<td>Figure 2.16 – Coconut milk</td>
<td>13</td>
</tr>
<tr>
<td>Figure 2.17 – Hair loss treatment milk</td>
<td>13</td>
</tr>
<tr>
<td>Figure 2.18 – Coconut juice</td>
<td>13</td>
</tr>
<tr>
<td>Figure 2.19 – Coconut antiseptics</td>
<td>13</td>
</tr>
<tr>
<td>Figure 2.20 – Flat tiles</td>
<td>15</td>
</tr>
</tbody>
</table>
Figure 2.21 – Imbrex and Tegula tiles

Figure 2.22 – Geometry of Imbrex and Tegula tiles

Figure 2.23 – Roman tiles

Figure 2.24 – Pantiles

Figure 2.25 – Mission or barrel tiles

Figure 2.26 – Mission or barrel tiles position

Figure 2.27 - Interlocking Roof Tiles

Figure 2.28 – Dimension Of Interlocking Roof Tiles

Figure 2.29 – Raw materials

Figure 2.30 – Composition of raw materials

Figure 2.31 – Manufacturing process of roof tiles

Chapter 3

Figure 3.1 - Flow chart of Final Year Project’s process

Chapter 4

Figure 4.1 – Complete detail design of the selected concept

Figure 4.2 – Complete detail design of the selected concept

Figure 4.3 – Cleaning the shell process

Figure 4.4 – Shell after being cleaned

Figure 4.5 – Crush the shell using cruncher machine

Figure 4.6 – Shell after being crushed

Figure 4.7 – Mould design
Figure 4.8 – Mould
Figure 4.9 – Mixed raw materials
Figure 4.10 – Composition of mixed raw materials
Figure 4.11 – Cement mixture being compressed into mould
Figure 4.12 – Finishing process
Figure 4.13 – Curing process
Figure 4.14 – Curing process
Figure 4.15 – Concrete roof tile
Figure 4.15 – Process of removal the concrete roof tile from mould
Figure 4.16 – Coating Process
Figure 4.17 – Drying and finishing process
Figure 4.18 – Flexural test
TABLE OF CONTENT

Dedication ........................................................................................................ iii
Acknowledgement .............................................................................................. iv
Abstract ............................................................................................................. v
List of Abbreviation ........................................................................................ vi
List of Tables & Graphs .................................................................................... vi
List of Figures .................................................................................................. vii

Chapter 1 Introduction
   1.1 Background ............................................................................................... 1
   1.2 Problem Statement ...................................................................................... 2
   1.3 Project Objective ......................................................................................... 2
   1.4 Project Scope ............................................................................................... 2

Chapter 2 Literature Review
   2.1 The definition of 3R Reduce, Reuse and Recycle
      2.1.1 Reduce .................................................................................................. 3
      2.1.2 Reuse .................................................................................................... 3
      2.1.3 Recycle .................................................................................................. 3
   2.2 The why’s of 3R Reduce, Reuse and Recycle
      2.2.1 The why’s of Reduce ........................................................................... 4
      2.2.2 The why’s of Reuse ............................................................................. 4
      2.2.3 The Why’s of Recycling ...................................................................... 5
   2.3 The recycling system and benefits ................................................................. 5
   2.4 The example of 3R
      2.4.1 Reuse .................................................................................................. 6
      2.4.2 Reduce ................................................................................................ 6
2.4.3 Recycle.........................................................................................7

2.5 Material.............................................................................................8

2.5.1 Coconut Plant..................................................................................8

2.5.2 World coconut production...............................................................8

2.5.3 The uses of coconut trees .................................................................9

2.5.4 Properties of coconut shell .............................................................14

2.6 Roof Tile

2.6.1 What is Roof Tiles?........................................................................14

2.6.2 Type Of Roof Tiles........................................................................15

2.6.3 Raw Materials Of Roof Tiles .........................................................18

2.6.4 Manufacturing Process Of Roof Tiles .........................................19

Chapter 3 Methodology.........................................................................21

Chapter 4 Result and Discussion

4.1 The Specification

4.1.1 Identify customer requirement....................................................23

4.1.2 Functions of the product.............................................................23

4.1.3 Design requirement.....................................................................24

4.1.4 Evaluation criteria.......................................................................25

4.2 Create Design Concepts

4.2.1 Propose several alternative design concepts..............................26

4.2.2 Evaluate each propose design alternative....................................29

4.2.3 Rate each alternative against each evaluation criteria ............30
4.3 Select the optimum design concept .....................................................31
4.4 Complete detailed design of the selected concept .............................31
4.5 Bill of Material (BOM).......................................................................33
4.6 Detail Fabrication Process.................................................................34
4.7 Weight Test.......................................................................................38
4.8 Flexural Test.....................................................................................38
4.9 Compressive Test .............................................................................40

Chapter 6 Conclusion and Recommendation ......................................41
References ............................................................................................43
Appendix ...............................................................................................44
CHAPTER 1
INTRODUCTION

1.1 Background

Nowadays, solid waste management has been considered as a vital topic for Malaysian government and owing to major issue. As the result of alarming rate of waste generated due to the increase in population, affluence and changing lifestyles in Malaysia, the environmental restrictions have been encountered which included the stringent control of waste disposal sites, resource restrictions such as emphasizing the awareness of the public about the depletion of natural resources, the natural disasters issues such as global warming that caused by the greenhouse effect [1].

In other perspective, the improper waste management’s will face serious biohazards, in some cases, it might even cause death. All of these issues have been addressed as roadblock toward the government’s efforts to attain sustainable development approach vision 2020. In the meantime, the demand for recyclable consumer products is ever-increasing while supplies of raw materials are eventually being reduced. It is estimated over 23,000 tons of waste is produced each day in Malaysia and it is expected to rise to 30,000 tones by the year 2020 [2], sadly most of the wastes generated are dumped illegally and disposed in landfills. If such a concern is the fact, then the waste and recycling issue will requires an urgent action to be taken. Henceforth, recycling is an alternative solution instead of land filling, however, the public awareness toward recycling is alarmingly low, and the future outcomes of our country didn’t even cross their mind. Likewise, it also reported that an average of 0.8 kilogram of waste is generated by an individual per day which a kilogram of the recyclable material is cost at 20 cents [3]. Consequently, it has shortened the lifespan of landfills and caused a massive loss to our country economic, as the simplest measure of the acceptance of recycling is economical [4]. A waste should not be treated as a waste until it was confirmed useless. Waste management is a vital issue that needs the effectual solutions and recycling is always viewed as a crucial aspect of an effective and efficient solid waste management system.
Coconut shell is one of the most important natural fillers produced in tropical countries like Malaysia, Indonesia, Thailand, Sri Lanka and India. Many works have been devoted to use of other natural fillers in composite in recent past and coconut shell filler is a potential candidate for the development of new composites because of their high strength and modulus properties. The use of aggregates for construction is one of the most important parts of construction for it will add strength to the concrete. Finding a substitute for the aggregates used today is a task that is worth studying because the quarrying of aggregates from rivers and mountains harms the environment. If a substitute for aggregate can be obtained naturally and the source is abundant and can be regenerated, obtaining the aggregate would deplete its source. As a conclusion, 3R concepts plays a major role in term of conserves the natural resources and prolongs the lifespan of landfill sites around the world. In the same time, it will reduce global warming and pollutions which beneficial to publics.

1.2 Problem Statement

1. The number of coconut shell waste is high and this may cause larger space area in site for disposal of waste material
2. The weight of conventional roof tiles is high

1.3 Project Objective

1. Reuse waste product of coconut shell by replacing aggregate in concrete mixture.
2. Reduce the weight of concrete roof tiles.

1.4 Project Scope

The project scopes are:

1. To design a sustainable material of product according to the theme selected.
2. To design a prototype product ‘Development material of the Roof tiles by using Coconut Shell’ as a concrete aggregate as the material of the product.
CHAPTER 2
LITERATURE REVIEW

This chapter would discuss on the ideas and points which help put this project together, linking one part to the other. These reviews helped us very much in our research in order to carry out the development for this project including the background and basis for this whole project – the recycling.

2.1 The Definition of 3R Reduce, Reuse and Recycle

2.1.1 Reduce

Waste minimization is a process that involves reducing the amount of waste produced in society and helps eliminate the generation of harmful and persistent wastes, supporting the efforts to promote a more sustainable society [1]. Waste minimization involves redesigning products and/or changing societal patterns, concerning consumption and production, of waste generation, to prevent the creation of waste.

2.1.2 Reuse

To reuse is to use an item again after it has been used. This includes conventional reuse where the item is used again for the same function and new-life reuse where it is used for a different function. In contrast, recycling is the breaking down of the used item into raw materials which are used to make new items. By taking useful products and exchanging them, without reprocessing, reuse help save time, money, energy, and resources. In broader economic terms, reuse offers quality products to people and organizations with limited means, while generating jobs and business activity that contribute to the economy [2].

2.1.3 Recycling

Recycling is a process to change (waste) materials into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution (from landfilling) by reducing the need for "conventional" waste disposal, and lower
greenhouse gas emissions as compared to plastic production[3][4]. Recycling is a key component of modern waste reduction and is the third component of the "Reduce, Reuse and Recycle" waste hierarchy [6].

![Image of 3R logo]

**Figure 1.1**

2.2 **The Why’s of 3R Reduce, Reuse and Recycle**

2.2.1 **The Why’s of Reduce**

Food production, goods manufacturing, transportation and storage contribute to greenhouse gas emissions and costs that are passed on to us all. Making careful decisions about what we buy and trying to reduce waste can have a big impact. The cost of what we put in the bin every week is a good reason to reduce waste. Throwing out less reduces the amount of energy needed to transport and process waste and means less landfill too, which makes for a cleaner and greener country [7].

2.2.2 **The Why’s of Reuse**

Reusing an item can help you to reduce the amount of waste you produce and cut the environmental costs of making new goods. Making and transporting new goods requires energy and involves extracting and processing raw materials. Throwing away old items can cause unnecessary landfill and pollution.
2.2.3 The Why’s of Recycling

Recycling occurs for three basic reasons: altruistic reasons, economic imperatives and legal consideration. In the first instance, protecting the environment and conserving resources have become sulfas being in everyone’s general interest. Second, the avoided cost of environmentally acceptable disposal of waste has risen to a level where when combined with the other costs associated with recycling, it now makes economic sense to recycle many materials. Finally, in responding to both public demand and growing lack of alternatives waste disposal method, government is requiring recycling and providing for a wide variety of economic and civil penalties and incentives in order to encourage recycling[8].

2.3 The Recycling System and Benefits

The recycling process involves processing used materials into new products to prevent the waste of potentially useful materials, reduce air pollution due to incineration and water pollution due to land filling by reducing the need of conventional waste disposal, reduce consumption of fresh materials, reduce usage of energy, and lowering emissions of greenhouse gases. Recycling is a key component to modern waste management and it is also the third component of the “Reduce, Reuse, Recycle” waste hierarchy.

Materials which may be recycled include many types of glass, paper, metal, plastics, textiles, and electronics. Electronics in this case are such as cell phones and computers. Although the effect is similar, the compositing or other reuse of biodegradable waste, such as food or garden waste, is not usually considered recycling. Materials to be rejected are brought either to a collection center or picked up from the outside, the sorted, cleaned, and finally reprocessed into new materials especially involved in manufacturing industries.
There many benefits which may be obtained from recycling. Some of them are such as

I. Conserve and protect valuable resources and protect the environment
II. Promote a clean and healthy environment
III. Eliminate non-bio-degradable waste
IV. Reduce and eliminate landfill spaces
V. Encourage local industries
VI. Stop presenting hazardous waste concerns

2.4 The Example of 3R

2.4.1 Reuse

1. Aluminum foils and container – Clean flattens and put it back in the drawer. Container can be used for seeds tray as shown in figure 2.2 and 2.3.
2. Cooking oil – it is purposes for biodiesel project and old oil can be used to add life to wooden garden furniture, wooden compost bins.

![Figure 2.2](image1.png) ![Figure 2.3](image2.png)

2.4.2 Reduce

1. Batteries household – Cut down on batteries uses by use the sun. By solar powered, or clockwork equipment. Otherwise use rechargeable batteries and a battery charger or solar panel as shown in figure 2.5.
2. Plastic packaging – avoid buying over packaged product especially polystyrene and plastic wrapping which is not generally recyclable. Look for starch base biodegradable packaging that dissolve in water that can be composted.

![Figure 2.4](image1)

Figure 2.4

![Figure 2.5](image2)

Figure 2.5

2.4.3 Recycle

1. Cans- rinse cans at the end of your dishwashing and recycle like in figure 2.6. Aluminum can are the most effective-cost materials to recycle to make new products.

2. Plastic bottles - remove the tops and squash them as shown in figure 2.7.

![Figure 2.6](image3)

Figure 2.6

![Figure 2.7](image4)

Figure 2.7
2.5 MATERIAL

2.5.1 Coconut Plant

Coconut Plant (Cocosnucifer) is a large palm, growing up to 30 m (98 ft) tall, with pinnate leaves 4–6 m (13–20 ft.) long, and pinnae 60–90 cm long; old leaves break away cleanly, leaving the trunk smooth. Coconuts are generally classified into two general types: tall and dwarf.[6] On very fertile land, a tall coconut palm tree can yield up to 75 fruits per year, but more often yields less than 30, mainly due to poor cultural practices.[7] In recent years, improvements in cultivation practices and breeding have produced coconut trees that can yield more[8].

2.5.2 World Coconut Production

Coconuts are produced in 92 countries worldwide on about 11.8 million hectares (29.5ac) land. World production has been estimated at 61.7 million tons (FAO, 2009) with an average yield of 5.2 tons / ha. The top ten producing countries are listed in table 1 below:

Table 2.1: Top ten coconut producing countries in the world

<table>
<thead>
<tr>
<th>Country</th>
<th>Production (tons) 2009</th>
<th>% of World Production</th>
<th>Acreage under Production (ha)</th>
<th>Yield/ha (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indonesia</td>
<td>21,565,700</td>
<td>34.9</td>
<td>3,231,710</td>
<td>6.67</td>
</tr>
<tr>
<td>Philippines</td>
<td>15,667,600</td>
<td>25.4</td>
<td>3,401,500</td>
<td>4.61</td>
</tr>
<tr>
<td>India</td>
<td>10,148,000</td>
<td>16.4</td>
<td>1,903,000</td>
<td>5.33</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>2,099,000</td>
<td>3.4</td>
<td>394,840</td>
<td>5.32</td>
</tr>
<tr>
<td>Brazil</td>
<td>1,973,370</td>
<td>3.2</td>
<td>284,058</td>
<td>6.95</td>
</tr>
<tr>
<td>Thailand</td>
<td>1,380,980</td>
<td>2.2</td>
<td>237,882</td>
<td>5.80</td>
</tr>
<tr>
<td>Vietnam</td>
<td>1,128,500</td>
<td>1.8</td>
<td>121,500</td>
<td>9.29</td>
</tr>
<tr>
<td>Mexico</td>
<td>1,004,710</td>
<td>1.6</td>
<td>155,713</td>
<td>6.45</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>930,000</td>
<td>1.5</td>
<td>216,000</td>
<td>4.30</td>
</tr>
<tr>
<td>Malaysia</td>
<td>459,640</td>
<td>0.7</td>
<td>166,400</td>
<td>2.76</td>
</tr>
<tr>
<td>WORLD</td>
<td>61,708,358</td>
<td></td>
<td>11,864,344</td>
<td>5.20</td>
</tr>
</tbody>
</table>

2.5.3 The Uses of Coconut Trees

A coconut fruit is actually a one-seeded drupe. On the outside is the husk, which is initially green but turns brown after being picked and dried. Inside the outer coat of the fruit lies the mesocarp, which is packed with vascular bundles. This fiber is called the coir and is used for making mats and rope. What we buy in the grocery store is the "stone" of this drupe, which has a hard "shell," the endocarp, and the seed, which is inside of the shell. The shell is used for containers and is widely employed by artisans to make ornaments and decorations. Next occurs the seed coat, which is thin, and then the white flesh or copra and the "coconut milk." Both the copra and the milk are the endosperm of this seed. Yes, coconut is unique among plants in having copious liquid endosperm, which bathes the young embryo. Initially the milk is fairly sweet and the copra is thin, but as the seed matures, the liquid is converted into solid endosperm rich in oils (triglycerides). The solid endosperm, copra, is harvested, dried, and then pressed to release the oil, widely used for chief ingredients of shampoo and hair conditioners.

![Coconut Tree](image)

Figure 2.7

1. Coconut Tree Trunk

Coconut Trunk uses for buildings parts. Out of the Coconut Trunk, handy and durable wood is obtained to make various pieces of furniture and novelty items. Paper pulp can also be extracted from the trunk. The examples of product that have been made by coconut tree trunk are; Book or Photo Album Cover, Furniture, Small bridges as depicted in figure 2.9, Canoes can be carved out of a coconut tree trunk.
2. Coconut Roots

Unlike some other plants, the palm tree has neither a tap root nor root hairs, but has a fibrous root system. The coconut palm root system consists of an abundance of thin roots that grow outward from the plant near the surface. Only a few of the roots penetrate deep into the soil for stability like in figure 2.10. The type of root system is known as fibrous or adventitious, and is a characteristic of grass species. Coconut roots can be used for beverage, dye stuff, herbal medicines like treatment for diarrhea and dysentery as shown in figure 2.11 and can be made for toothbrush from its frayed piece of root and even tonics.
3. **Coconut Leaves**

The coconut palm produces a crown of pinnately compound yellow-green leaves called fronds. Each frond reaches 15 to 17 feet in length. Coconut leaves produce good quality of paper pulp, midrib brooms, hats and mats, fruit trays, fans, midrib decors, lamp shades, bag, and utility roof materials. In a provincial City of Cebu, Coconut leaves are used to wrap white rice called Puso and in Malaysia called ‘Ketupat’.

4. **Coconut Shell**

Coconut shell is discarded by-product which will be salvaged for biomass purpose to dry food or substance. The food being dried with coconut shell will also come along with the unique coconut flavor. Coconut shell, a part of coconut fruit produce items such as handicrafts items, charcoal for cooking, bangles, bird feeder, bowls, musical instruments as depicted in figure 2.13, small animal homes and even a weapon of choices for octopus in Australia. They also use it as shelter.

![Figure 2.12](image1.png) ![Figure 2.13](image2.png)

5. **Coconut Husk**

Coconut husks are the rough exterior shells of the coconut. While the husks are not used for food, like the meat and liquid found within the exterior shell, the husk can be used in several ways, including creating enriched potting soil and as chips that can be used to provide ground cover for flower beds. It is possible to purchase mass produced husk products or create the products at home using the shells of fresh coconuts. Coconut husks
also a part of coconut fruit is also used to obtain coir. An elastic fiber used for rope like in figure 2.15, matting, and coarse cloth. It can be used for compost material, decorative element of a dish of food, floor polisher, lashing, mating scrubber to clean floors and cooking pots, smoke of the burning husk is a natural mosquito repellent.

6. **Coconut meat**

Coconut meat is the rich white lining that is contained within the shell of a coconut. Coconut meat can be juicy and tender, or slightly thick and crunchy, to tough and fibrous depending on how long the kernel has been stored. It can be used for animal feed, candies effective natural laxative, flour, relief from colitis, diarrhea, dysentery, indigestion, piles, ulcers and rids the body of worms and parasites.

7. **Coconut Milk**

Coconut milk is the liquid that comes from the grated meat of a brown coconut as shown in figure 2.16. The color and rich taste of the milk can be attributed to the high oil content. Most of the fat is saturated fat. It can be used for bath soak, beverage, body lotion, body wash, bone builder (contains high level of phosphorus), cooking, cuticle soak, cough syrup substitute, hair loss treatment like in figure 2.17 and maintains blood sugar.
8. **Coconut water**

Coconut water as shown figure 2.18 is the clear liquid inside young green coconuts (fruits of the coconut palm). It acts as a diuretic, acts like an antioxidant and scavenges free radicals, aids body in fighting in factions, aids in breaking kidney stones and also flushes the toxins out of the kidneys, aids in removal of intestinal worms and parasites, antiseptic properties kill blood based diseases such as AIDS, measles, SARS, Hep C, herpes, and influenza as shown in figure 2.19.
2.5.4 Properties of coconut shell

Coconut shell is one of the most important natural fillers produced in tropical countries like Malaysia, Indonesia, Thailand, and Sri Lanka. Many works have been devoted to use of other natural fillers in composites in the recent past years and coconut shell filler is a potential candidate for the development of new composites because they have high strength and modulus properties along with the added advantage of high lignin content. The high lignin content makes the composites made with these filler more weather resistant and hence more suitable for application as construction materials. Coconut shell flour is also extensively used to make products like furnishing materials, rope etc. The shells also absorb less moisture due to its low cellulose content the report focuses on studying the effectiveness of coconut shell particles as a source of natural material for reinforcing epoxy resins towards their flexural properties [10].

2.6 Roof Tiles

2.6.1 What is Roof Tiles?

A tile is a manufactured piece of hard-wearing material such as ceramic, stone, metal, or even glass, generally used for covering roofs, floors and walls. The word is derived from the French word “tuile”, which is, in turn, from the Latin word “tegula”. Roof tiles are designed mainly to keep out rain, and are traditionally made from locally available materials such as terracotta or slate. Modern materials such as concrete and plastic are also used and some clay tiles have a waterproof glaze. A large number of shapes (or "profiles") of roof tiles have evolved. Roof tiles are designed mainly to keep out rain, and are traditionally made from locally available materials such as terracotta or slate. Modern materials such as concrete and plastic are also used and some clay tiles have a waterproof glaze. A large number of shapes (or "profiles") of roof tiles have evolved. Meaning a roof tile composed of fired clay. Roof tiles are designed mainly to keep out rain, and are traditionally made from locally available materials such as terracotta or slate. However, with modern technology, modern materials such as concrete and plastic are also used and
some clay tiles have a waterproof glaze. A large number of shapes of roof tiles have evolved.

2.6.2 Type Of Roof Tiles

Nowadays, with modern technology, many design/ type of roof tile have evolved. Some of the examples of roof tiles available in market are flat tiles, imbrex and tegula, roman tiles, mission and barrel tiles and interlocking roof tiles.

1. Flat Tiles

The simplest type, which are laid in regular overlapping rows as shown in figure 2.20. An example of this is the clay-made "beaver-tail" tile, commonly used in Southern Germany. Flat roof tiles are usually made of clay but also may be made of stone, wood, plastic or concrete.

Figure 2.20

2. Imbrex and Tegula

An ancient Roman pattern of curved and flat tiles that make rain channels on a roof. Imbrex and Tegula were overlapping roof tiles used in ancient Greek and Roman architecture as a waterproof and durable roof covering as shown in figure 2.2.1. They were made predominantly of fired clay, but also sometimes of marble, bronze or gilt. In Rome, they replaced shingles, and were used on almost every type of structure, from humble outbuildings to grand temples and public facilities [19].
3. **Roman tiles**

   Flat in the middle, with a concave curve at one end and a convex curve at the other, to allow interlocking as shown in figure 2.23.

4. **Pantiles**

   Is a type of fired roof tile, normally made from clay. It is S-shaped profile like in figure 2.24, allowing adjacent tiles to interlock. These result in a ridged pattern resembling a ploughed field. Pantiles are commonly used in eastern coastal parts of England and Scotland including Norfolk, east central Scotland.
5. Mission or Barrel Tiles

Semi-cylindrical tiles laid in alternating columns of convex and concave tiles as shown in figure 2.25 and 2.26. Originally they were made by forming clay around a curved surface, often a log or the maker's thigh. Today barrel tiles are mass-produced from clay, metal, concrete or plastic.

6. Interlocking Roof Tiles

Similar to pantiles with side and top locking to improve protection from water and wind.
2.6.3 Raw Materials Of Roof Tiles

Concrete roof tiles provide an aesthetically pleasing, affordable, durable roof for life. The materials used in their manufacture are sources locally. The main raw materials used to manufacture the roof tiles are course sand, fine sand, cement and oxide as shown in figure 2.27.

River sand is mixed with a clean finer pit sand to provide the correct sand grading before 42.5MPa Portland cement is added and mixed with water. Color is obtained by adding various colored synthetic iron oxide pigments at the mixing stage at around 3% of cement mass. The wet mix is then fed into the "tile extrusion machine", which extrudes the concrete into the required shape onto an aluminum pallet, which has already been sprayed with a pallet release agent. Water ratios in the mix are normally around 8.5% depending on the aggregate quality. The wet tile is then cured overnight, in heated curing chambers for at least 8 hours at very high humidity of +90% RH and +42°C temperatures. After
curing the dry tile is then separated from the aluminum pallet so that the pallet can be re-
used for every shift in the tile extrusion process. The dry tile can either be directly
stacked in the yard or first coated with acrylic coating if required. If this occurs a
further drying process is necessary before stacking the tiles.

The exact compositions of raw material to make the roof tiles are cement (1kg),
water(0.3-0.4litres), sand(3-3.5kg) and oxide (35grams ) like in figure 2.28 above.

2.6.4 Manufacturing Process Of Roof Tiles

The first stage in the roof tiles manufacturing is raw materials supply. All the basic raw
materials are supply by the supplier to the factory/plant. Next is mixing. In this stage, all
the raw material is mixed together with an exact composition. After that is extrusion. The
mixed mixture is extruded from the extruder to the mould of the roof tiles. After that, it
will undergoes pre-cure coating. At this stages, another coating layer is added on the
extruded mixture. Next, the roof tile will undergo the racking process and left for curing
process for several time period. After completed curing process, the roof tiles is depleting
and continue to next process which is post-cure coating and drying. After completing
drying and firing process, the manufacturing process is completely finished. Figure 2.29
below is the process of manufacturing with the aid of diagram.
Figure 2.31
CHAPTER 3

METHODOLOGY

Figure 3.1: Flow Chart of Final Year Project’s process
The flow chart as shown in figure 3.1 above is explaining about the flow of process and the processes involved upon the completion of this final year project. Firstly, the meeting with the Head Department of Diploma was conducted for explanation and briefing about this final year project’s execution. The meeting included a briefing about product development process and theme for this final year project. To accomplish this FYP, a group was formed which was each of group consisted of 2 students. Then, a confirmation of group member with the Head Department was done before finding and appointing the supervisor for the group. Supervisor acted as an expert person who was responsible for supervising and giving some advices while the project is carried out, and ensuring the project went smoothly by following the schedule and planning. The next step is a topic selection, this was carried out by having some research about the concept which are 3R. The needs of understanding about the concept of 3R is a significant thing before selecting the topic of the final year project that need to be conducted. Several meetings was done with supervisor for determining the topic and it was ended up with decision making when there were various topics need to be choose. After selection of the topic has been done, the planning and scheduling of the project was developed as guidance in the accomplishment of this project. The next process is literature review; this was carried out by having some researches again but more focusing on the topic selected. Then, a market survey was done to identify the customer needs. After identified several customer needs, the process moved to creating a design concept. Several design concepts was drafted and the selection of material was decided according to topic selected. After that, a fabrication process was carried out to develop the product. The product was tested to evaluate its physical, mechanical properties and strength. The tests that were done were weight test, flexural test and compressive test. The next process is exhibition, all group must undergo an exhibition session which was for product evaluation. , a presentation was done by explaining the functions and benefits of the product to the panel. The last process is report submission, the report was submitted to the supervisor.
CHAPTER 4

RESULT AND DISCUSSION
ANALYSIS AND DESIGN PROCESS

4.1 The Specification

4.1.1 Identify Customer Requirement

The customer requirement was identified by interviewing several people in the residential area. The feedbacks were compiled into one result and the data was analyzed into a form of theoretical data. It was interpreted into a design concept for roof tiles. All the aspects to meet the customer needs were evaluated by provide various designs of roof tiles.

4.1.2 Functions of the product

A roof is part of a building envelope, both the covering on the uppermost part of a building or shelter which provides protection for:

4.1.2.1 Human Protection

The basic purpose of any roof is to provide protection to persons inside a structure from the elements. This purpose is necessary in every part of the world as the roof provides shelter against something; the changes in weather, such as rain, snow, sleet, hail and high winds. Without a roof, inhabitants inside a structure would be directly subjected to all these weather changes and would, consequently, also suffer the physical ailments that result from this exposure.

4.1.2.2 Protection of Possessions

Without a roof, not only would human inhabitants become vulnerable to the changing weather, so would everything else inside a structure. Possessions such as furniture, appliances, carpets, artwork and clothing would be ruined quickly when rainwater or snow invades the structure. Also, the basic interior of the structure would be damaged by the weather, from the flooring, to doors and walls.
4.1.2.3 Water Protection

The exterior of a structure is also served by the presence of certain elements of a roof. Roof flashing is designed to protect exterior walls from water damage. Flashing is basically a piece of sheet metal that prevents rainwater from penetrating joints and causing damage. The flashing can be spotted by looking at the area around vent pipes that stick up through the roof or around chimneys. If the roof has vertical walls, flashing also provides protection in the intersections between the roof and the walls. Also, the gutters and downspouts on the edge of the roof provide a means to carry away the water that drains off the roof and divert it from the exterior walls and base of the structure.

4.1.2.4 Consequences

As the first line of defense for a structure, acting like a huge umbrella in receiving and deflecting all the potentially harmful weather that a structure would otherwise receive, a roof itself normally sustains damage. High winds can damage or remove the roof’s shingles. Continued exposure to rainwater can damage the valleys on the roof. Holes and roof leaks are always a major concern. Because of this, a roof should be checked at least twice annually and after major windstorms to spot any damage early.

4.1.3 Design Requirement

1. Adding a coconut shell as concrete aggregate.
2. Reducing the weight of roof tiles.
3. The product must be protected from the weather and must be capable of operating anywhere in Malaysia at temperature ranging from 23°C to 60°C.
4.1.4 Evaluation Criteria

a) Safety
   Safety is one of the most important criteria that need to be considered in the products. The design of the product should not be dangerous, and the material used in product should be non-hazardous.

b) Ease of service or replacement
   The product should ease for every consumer in order to service or replace the product to keep the product in good condition if any damage happens.

c) Low cost
   The product should be in low cost and most important is, the material used should be from waste product or material.

d) Ideal weight and size
   The product should in light load and ideal size of concrete roof tile.

e) Ease to manufacture
   The manufacturing process should be less in cost. This may achieve by avoiding a complex design that requires many process and planning.

f) Smooth for water flow
   The water’s flow should be in a straight-direct, not overflow exceed its channel/water course.

g) Attractiveness
   The design and color of the product should be more attractive, latest style of the design of concrete roof tiles.
4.2 Create Design Concepts

4.2.1 Propose Several Alternative Design Concepts

**Table 4.1 - DESIGN A**

<table>
<thead>
<tr>
<th>DIMENSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH : 180 mm</td>
</tr>
<tr>
<td>WIDTH : 160 mm</td>
</tr>
<tr>
<td>THICK : 10 mm</td>
</tr>
<tr>
<td>DIMENSION:</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>LENGTH:</td>
</tr>
<tr>
<td>WIDTH:</td>
</tr>
<tr>
<td>THICK:</td>
</tr>
</tbody>
</table>
Table 4.3 - DESIGN C

<table>
<thead>
<tr>
<th>DIMENSION</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH</td>
<td>250</td>
</tr>
<tr>
<td>WIDTH</td>
<td>200</td>
</tr>
<tr>
<td>THICK</td>
<td>50</td>
</tr>
</tbody>
</table>
### 4.2.2 Evaluate Each Propose Design Alternative

#### Table 4.4 - Design A

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>The interlocking system’s design is short due to high profile type.</td>
</tr>
<tr>
<td>Ease of service or</td>
<td>The service, replacement or installation process will be difficult because of the design requires more roof battens.</td>
</tr>
<tr>
<td>replacement</td>
<td></td>
</tr>
<tr>
<td>Low cost</td>
<td>The cost of manufacturing will be high as manufacturing process is difficult.</td>
</tr>
<tr>
<td>Light</td>
<td>Less in weight because of small dimension.</td>
</tr>
<tr>
<td>Ease to manufacture</td>
<td>The manufacturing process will be difficult because of complex design; the removal of concrete process from the mold and creating the mold require more time and process.</td>
</tr>
<tr>
<td>Smooth for water flow</td>
<td>Efficient water flow because of water course design is high profile type, the height ratio to width is higher: 1/5 over width.</td>
</tr>
<tr>
<td>Attractiveness</td>
<td>Attractive and exclusive profile, with aesthetic shape, the color is rich and unique, comes with permanent finish that will not fade over time.</td>
</tr>
</tbody>
</table>

#### Table 4.5 - Design B

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>The interlocking system’s design is long due to flat profile type; with double overlapping system.</td>
</tr>
<tr>
<td>Ease of service or</td>
<td>The service, replacement or installation process will be easy because of simple interlocking system and the design requires less of roof battens.</td>
</tr>
<tr>
<td>replacement</td>
<td></td>
</tr>
<tr>
<td>Low cost</td>
<td>The cost of manufacturing will be low as manufacturing process is simple.</td>
</tr>
<tr>
<td>Light</td>
<td>Less in weight because of small dimension.</td>
</tr>
<tr>
<td>Ease to manufacture</td>
<td>The manufacturing process will be easier because of simple design; the removal of concrete process from the mold and creating the mold require less time and process.</td>
</tr>
<tr>
<td>Smooth for water flow</td>
<td>Inefficient water flow because of water course design is flat profile type; the surface rises up to $1/2$” of thickness.</td>
</tr>
<tr>
<td>Attractiveness</td>
<td>Unattractive because of conventional design with no aesthetic shape.</td>
</tr>
</tbody>
</table>
Table 4.6 - **Design C**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Design A</th>
<th>Design B</th>
<th>Design C</th>
<th>REF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td></td>
<td></td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Ease of service or replacement</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Low cost</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Light</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease to manufacture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smooth for water flow</td>
<td></td>
<td>+</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Attractiveness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.2.3 *Rate Each Alternative Against Each Evaluation Criteria*

Table 4.7

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>Design A</th>
<th>Design B</th>
<th>Design C</th>
<th>REF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Ease of service or replacement</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Low cost</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Light weight</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Ease to manufacture</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Smooth for water flow</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Attractive</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>PLUSES</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>SAMEs</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>MINUSES</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>NET</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>RANK</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>CONTINUE?</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
<td></td>
</tr>
</tbody>
</table>
4.3 Select The Optimum Design Concept

After done rating each of propose design concept against the evaluation, we selected design B as the optimum design concept.

4.4 Complete Detailed Design of The Selected Concept

Figure 4.1
4.5 Bill of Material (BOM)

Bill of material (BOM) based on overall planning process as shown in table 4.8.

Table 4.8: Bill of Material (BOM)

<table>
<thead>
<tr>
<th>No</th>
<th>Material</th>
<th>Quantity</th>
<th>Price/unit (RM)</th>
<th>Cost (RM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nail</td>
<td>1 packet</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>2</td>
<td>Wood 1/2&quot; x 1/2&quot; x 4 meter</td>
<td>4 pcs</td>
<td>2.20</td>
<td>8.80</td>
</tr>
<tr>
<td>3</td>
<td>Wood 1&quot; x 1/2&quot; x 4 meter</td>
<td>2 pcs</td>
<td>1.60</td>
<td>3.20</td>
</tr>
<tr>
<td>4</td>
<td>Plywood 400 x 200 mm</td>
<td>1 pcs</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>5</td>
<td>Sand</td>
<td>5 kg</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>Cement</td>
<td>3 kg</td>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td>7</td>
<td>Water</td>
<td>5 Liter</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>Plastic Container</td>
<td>3 pcs</td>
<td>2.40</td>
<td>7.20</td>
</tr>
<tr>
<td>9</td>
<td>Spatula</td>
<td>2 pcs</td>
<td>1.80</td>
<td>3.60</td>
</tr>
<tr>
<td>10</td>
<td>Roof coating paint</td>
<td>1 liter</td>
<td>18.00</td>
<td>18.00</td>
</tr>
<tr>
<td>11</td>
<td>Brush</td>
<td>1 pcs</td>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td>12</td>
<td>Gloves</td>
<td>2 pcs</td>
<td>1.40</td>
<td>1.40</td>
</tr>
<tr>
<td>13</td>
<td>Mask</td>
<td>1 packet</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>14</td>
<td>Masking tape</td>
<td>1 pcs</td>
<td>1.50</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>Total Cost</td>
<td></td>
<td></td>
<td>55.70</td>
</tr>
</tbody>
</table>
4.6 Detail Fabrication Process

1. The first process is separating the coconut meat from the shell. This process is done by using spatula and scrapper. After ensuring there is no any dirt ingained on the surface, the shells will undergo drying process under the sun for 1 day.

![Figure 4.3](image1.png) ![Figure 4.4](image2.png)

2. The second process is crushing the shells into 3mm solid piece using the cruncher machine. Then, it will be filtered for separating them from unwanted elements.

![Figure 4.5](image3.png) ![Figure 4.6](image4.png)

3. The third process is designing the mold. This design process by using CATIA software. After designing the mold, we start to fabricate the mold following its dimension.
4. All the raw materials which are cement powder, sand and coconut shells as aggregate are mixed together with an exact composition including water. Then it was mixed until all the cement blended in.
5. Next, the cement is poured into the mold gradually, for ensuring the cement is closely and neatly packed together, some small of force has been applied on it using flat wood to make it compacted. To get a better surface of concrete after its hard, cleaning process on the wet concrete using sponge has been done.

![Figure 4.11](image1.png) ![Figure 4.12](image2.png)

6. For the curing process, the concrete is left for 2 days. The concretes are left under semi-sunlight to keep the concretes moist and warm enough for hydration of cement can continue.

![Figure 4.13](image3.png) ![Figure 4.14](image4.png)
7. The next process is removal of hard concretes from their mold. The design of mold was customized so that the concretes will easily remove from the mold.

![Figure 4.15](image1.png)  ![Figure 4.16](image2.png)

8. The last process of fabricating is coating. A top surface of hardened concrete is painted using weather proof roof tiles paint. The painting process is done twice to get a better surface finish. The roof tiles were left for couples of hours under the sun to fasten the drying process.

![Figure 4.16](image3.png)  ![Figure 4.17](image4.png)
TESTING AND ANALYSIS RESULT

4.7 Weight Test

Weight test is conducted to find out the weight of 3 specimens which is control concrete, 5% CS concrete and 10% CS concrete. The procedure of the test is simple. The specimen is placed on the weight balance and the value is recorded in the table. The different value of weight was being compared.

<table>
<thead>
<tr>
<th>Percentage of CS (%)</th>
<th>0</th>
<th>5</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g)</td>
<td>480.16</td>
<td>448.38</td>
<td>396.43</td>
</tr>
</tbody>
</table>

As shown in table 5.1, the weight of the concrete is reduced as the percentage of CS is decrease.

4.8 Flexural Test

Flexural strength is the ability of the composite material to withstand bending forces applied perpendicular to its longitudinal axis. Flexural test is performed using 3-point bending method according to ASTM C642-13 standard procedure. The approach of the test is by testing 2 concrete specimens which are control concrete (0% of CS) and CS concrete (10% of CS). The specimens are tested at a crosshead speed of 0.5 mm/min. The loading arrangement in the specimen was shown in figure 5.1. The dimension of the both specimens is same which constant variable. The dimension is 110mm x 87mm x 28mm. The age of curing is 7 days.

Figure 4.18 Flexural test
Table 4.10

<table>
<thead>
<tr>
<th>Percentage Of CS (%)</th>
<th>0</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Force Applied (kN)</td>
<td>1.2688</td>
<td>1.8469</td>
</tr>
<tr>
<td>Maximum Stress(MPa)</td>
<td>799.21</td>
<td>1163.40</td>
</tr>
<tr>
<td>Maximum Strain</td>
<td>1.7551</td>
<td>1.4771</td>
</tr>
</tbody>
</table>

Graph 4.1: 0% of CS Concrete
Graph 4.2: 10% of CS concrete
5.3 Compressive Test

The compression test is simply the opposite of the tension test with respect to the direction of loading. A compression test determines behavior of materials under crushing loads. The specimen is compressed and deformation at various loads is recorded. The approach of the test is by testing 2 specimens which are control concrete (0 % of CS) and CS concrete (10% of CS). Then the data recorded is compared. All the compression tests of both concretes are conducted on 100 kN servo hydraulic UTM machine. Specimen cross sectional area is 0.022 m$^2$. Test speed used in this test is 2.5 mm/min. Age of curing of both concrete is 7 days.

<table>
<thead>
<tr>
<th>Percentage Of CS (%)</th>
<th>0</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Load (kN)</td>
<td>17.58</td>
<td>43.50</td>
</tr>
<tr>
<td>Stress (Mpa)</td>
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As shown in the table 5.3, for the control concrete, the maximum load can be applied before it cracks is 17.58kN while CS concrete can withstand higher load than control concrete which is 43.50 kN. The stress is calculated by using formula $\text{stress} = \frac{F}{A}$. Where A is cross-sectional area of the specimen.
CHAPTER 5
CONCLUSION

In a nutshell, this project is one platform for applying all the knowledge learnt in a diploma course. All the knowledge learnt in subject such as Material Engineering, Machine Design, CAD/CAM, Manufacturing Process and Mechanic of Material are really useful in order to complete this final year project. Besides, by completing this project, the concept of 3R which are reduce, reuse and recycle is learnt and understand. Basically, 3R is an important concept or idea that needs to be understood and implement in the daily life in order to create a green earth and better environment for the future generations. In a conclusion, this project is successfully done. With aid from supervisor, Mr Baharuddin Bin Abu Bakar, friends and technicians, the coconut shell roof tiles are successfully designed and manufactured. Knowledge on product development process is learnt and gained by doing this final year project. By completing this project, all the skills such as cooperation with group partner, problem solving, time management and communication skill gained will be useful in real working environment. All the objectives set in this project are achieved. By reuse coconut shell as a concrete aggregate, the amount of coconut shell waste in dumping area will be reduced. Furthermore, by using coconut shell as a concrete aggregate in a concrete roof tiles, the weight of roof tiles will be reduced as well. This can be proved in a result and analysis section. In fact, the coconut shell also can enhanced the mechanical properties of the concrete itself. Coconut shell concrete can withstand greater amount of load, high stress and high force compared to the normal concrete.
RECOMMENDATION

There are few improvements can be done and implement for this project. First and foremost, design of the roof tiles. There are a lot of designs can be considered to make a roof tiles. The selected design must be better in attractiveness, safety, and meet customer needs. Secondly, longer age of curing. Before done the mechanical test, the age of curing of concrete roof tiles must be matured enough which is 28 days. After 28 days, the mechanical structure of the concrete is strong. So that when undergo the test, the concrete can withstand higher load, force and stress and result gained is better. Next is water absorption test. The CS concrete need to be tested with water absorption test to determine their permeability level. A good concrete has a low permeability. A concrete with low permeability resists ingress of water and is not as susceptible to freezing and thawing.
LIST OF REFERENCES

Chapter 1


Chapter 2


## APPENDICES

### Gantt Chart

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Poster

**Coconut Shell Concrete Roof Tiles**

**WHAT IS 3R?**
- Reduce: Finding ways to decrease or lessen the amount of trash we throw away.
- Reuse: Reuse means finding ways to use things over and over again instead of throwing them away.
- Recycle: Recycling means taking something old and turning it into something new.

**Objectives**
1. Reduce waste product of coconut shell by replacing aggregate in concrete mixture.
2. Reduce the weight of concrete roof tiles.

**WHY Coconut Shell?**
Coconut shells have little or no economic value and their disposal is not only costly but may also cause environmental problems. Coconut shell is one of the most important natural fibers produced in Malaysia. Many works have been devoted to use of other natural fibers in composites. Coconut shell fiber is a potential candidate for the development of new composites because they have high strength and modulus properties along with the added advantage of high lignin content. The high lignin content makes the composites made with these fiber more weather resistant and hence more suitable for application as construction materials. The shells also absorb less moisture due to its low cellulose content.

**Methods/Process**
1. Separate coconut meat from shell
2. Crush the shell into 5mm size using crusher machine
3. Design & fabricate the roof tile mold
4. All the raw materials are mixed together with an exact composition
5. Mixture is compressed into the mold
6. The concrete is kept for 2 days for curing process
7. The concrete is removed from the mold
8. Casting & finishing process

**Testing Result**

- **Length Test**
  - Specimen size (mm)
  - Concrete tiles: 150 x 150 x 15
- **Flexural Test**
  - Specimen size (mm)
  - Concrete tiles: 150 x 150 x 15
- **Compressive Test**
  - Specimen size (mm)
  - Concrete tiles: 150 x 150 x 15