ABSORPTION AND STRENGTH OF CONCRETE CONTAINING OF WOODBLOCK AS PARTIALLY COARSE AGGREGATES

FARAH AMIRA BINTI ADNAN

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

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Position : LECTURER

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Full Name : PN. ROSLINA BINTI OMAR

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FARAH AMIRA BINTI ADNAN

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ABSTRAK

Baru-baru ini, penggunaan konkrit berkekuatan tinggi menjadi semakin popular dalam pembinaan bangunan. Hal ini kerana, konkrit mempunyai kekuatan yang tinggi untuk menangung beban. Walau bagaimanapun, penggunaan agregat kasar semakin mahal pada masa akan datang. Di samping itu, ramai penyelidik mencari idea untuk mengatasi masalah ini dengan menggantikan bahan lain untuk digantikan dalam konkrit seperti bahan buangan terutama kayu. Kayu yang digunakan adalah kayu yang dikitar semula. Oleh itu, kajian ini adalah untuk mengurangkan penggunaan agregat kasar dan blok kayu sebagai pengganti agregat kasar. Blok kayu yang diperolehi adalah dari kilang kayu dan kawasan pembinaan. Kajian ini menunjukkan hasil penyerapan air dan kekuatan mampatan yang dijalankan ke atas spesimen konkrit yang bergred 25 N/mm^2 yang mengandungi 0%, 3% dan 6% blok kayu dalam campuran konkrit. Tempoh pengawetan konkrit pada 7 dan 28 hari. Daripada keputusan ujian kekuatan mampatan dan ujian penyerapan air menunjukkan 6% adalah hasil terbaik untuk penggantian aggregat kasar.

ABSTRACT

Recently, the use of high strength concrete is become increasingly popular in building construction. This is because concrete has a high strength to capture the load. However, a mixture of coarse aggregates is inaccessible and costly. Besides that, many researchers find the idea to overcome this problem by substituting another material to the concrete such a waste material especially wood and timber. The recycling of woodblock or wood Therefore, the study is to reduce the use of coarse aggregates and woodblock as a replacement of coarse aggregates. The woodblock obtain from the wood waste at the construction site and timber factory. This report shows the results of absorption and the compressive strength conducted on the normal strength concrete specimens 25 N/mm^2 containing 0%, 3% and 6% of woodblock by coarse aggregates weight. The period of curing of the concrete at 7 and 28 days. From the results of the compressive strength test and water absorption test for the replacement of coarse aggregates shows the 6% was the best results to replace it.

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LIST OF ABBREVITAION

ASTM	American Society for Testing and Materials
BS	British Standard
LWC	Light Weight Concrete
OPC	Ordinary Portland Cement
PWP	Para Wood Particle
RCA	Recycled Coarse Aggregates
RHA	Rice Husk Ash
RILEM	International Union of Testing and Research Laboratories for Materials and Structures
SSD	Saturated Surface Dry
W/C	Water Cement
W/A	Water Absorption

CHAPTER 1

INTRODUCTION

1.1 Background Study

Concrete is a kind of composite material that is often used in construction. It is a combination of cement and aggregates such as sand, fine and coarse aggregates. These materials are added according to the specified mixing rates as specified.

Besides, concrete is one of the most important and most used building materials in a construction project. Therefore, the techniques used to produce good concrete need to be understood and carefully considered. The quality of the concrete produced depends on the quality of raw materials used such as cement, aggregates and water, mixing rate, how to mix, how to transport and how it is compressed. If the raw material used is no quality, then the resulting concrete will have a low quality and will result in the concrete being not strong and does not meet the specifications.

Concrete consists of several types which are normal weight concrete, high strength weight concrete and lightweight concrete. Normal weight concrete is concrete that has ingredient such as aggregates, water and cement. Basically, the development strength of the concrete starts after 7 days. In addition, normal concrete characteristics are strong in compression but weak in tension. High strength concretes are the concrete that has quality aggregates which are selected from the best materials and added with admixtures to strengthen the bond between cement and aggregates. Lightweight concrete is concrete which has substantially lower mass per unit volume then the concrete made of ordinary ingredients is called lightweight concrete. Usually, the aggregates used in concrete is lighter or amount of the aggregate was reduced. This type of concrete suit for parapet wall, road lining and to reduce impose dead load.

Nowadays, lightweight concrete widely uses in many of construction because some of the lightweight concrete can bear load same with the high concentration concrete. some of the researcher want to produce sustainability concrete that can give benefit to human and eco-friendly to the environment.

1.2 Problem Statement

The construction industry is very rapidly developed in many countries especially countries that want to develop advance in their economy and others. For examples structure like skyscraper, tower, railway and others. Most of the building is construct because due to increasing growth of population. It gives high demand for construction materials such as cement, sand, gravel and granite. Gradually, the use of raw material decreasing due to the demand and one day it becomes the problem in the future to get the raw material such as sand, gravel and others. Next, in the recent research, wood waste was added as a supplement in concrete mix or as a replacement of ordinary Portland cement in concrete. Furthermore, the substitution of sand in the concrete is also important to study because of the depletion of raw materials. The replacement of sand by wood waste gives advantages of lightness and decreases carbon dioxide emissions in the field of construction.

However, the problem that identifies in woodblock aggregate is potentially incompatible with cement and wood to form a concrete. In this research, the percentage of woodblock aggregate influences the strength and water absorption in the concrete.

1.3 Objective of Study

The objectives of this research are:

i. To determine the properties of raw and coating woodblock as replacement material.
ii. To determine the initial and final water absorption of concrete using woodblock as partially coarse aggregates.
iii. To determine the strength of concrete containing different percentage of woodblock as partially coarse aggregates by using air and water curing

1.4 Scope and Limitation of Study

The aim of this research to determine the durability and lifespan of the woodblock concrete. The woodblock will be used as aggregates substitute the coarse aggregates in this study. Ordinary Portland Cement (OPC) will use to produce a sample of woodblock concrete.

The ratio of the mixture based on concrete mix design to prepare the materials which are represented for water, cement and coarse aggregates. Therefore, the uses of woodblocks in the concrete mixture will be added according to the percent that will be used and at the same time percentage used of coarse aggregates will be reduced as a substitution. Replacement of woodblock as aggregates added in a mixture based on the percentage that fixed at rates 0%, 3% and 6%. The aim of replacement of aggregates woodblock is to identify the durability and the strength of the concrete.

1.5 Significance of Study

This study is based more on experimental is to identify the effective of woodblock concrete in building. While developing a new building material, it is hoped that the study will contribute to the process of developing more sustainable and affordable material that will have an easier impact on better housing and the fast delivery of housing to different income earners. The study aims to better understand the impact of housing expenditure on the affordability of housing in socio-economic groups, with the hope that it will contribute to the knowledge and appreciation of real housing conditions and lead to improved housing strategies.

Other than that, the environmental pollution it comes from waste material that cannot be sustained by landfill for the future. To save our world we have to generate idea to maintain our world in good condition. By using waste materials (woodblock, wood shaving and other waste material) in the production of the new and added value material, it offers a more sustainable approach to waste management practices that will be of immense environmental, economic and social benefit.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In the current year, our global environment in the concern level and increasing energy insecurity has led to increased demand in renewable energy and their sources. Sources of renewable energy and low operational cost is biomass resources which are forestry and agriculture waste. Moreover, the uses of timber industry by products such as, sawdust, woodblocks, wood bark, saw mill craps and others in the production of power material as an efficient disposal by the wastes of product.

Furthermore, in the early 1960s cement bonded wood composite had been already use in construction so this composites are not new material in this industry. Other than that, some of these materials have a commercial value but it more environmentally friendly and inexpensive products. Thermal conductivity in material such as wood fiber is very good as well as polystyrene and glass wool. Additionally, these materials are easy to use both for new constructions and renovations. Another advantage of this material is they are excellent in phonic insulation because of their ability to dampen sound waves.

Research related to wood material and concrete had emphasized in many categories according to suitability to producing the product for an example to produce product that have benefits to contractor and environmentally friendly. These wastes still have not been wide utilized for years. Most wastes such as sawdust, bark and chipping are disposed uncontrollable wastes pits of dumped into open areas. Hence, to overcome environmental issue, wastes recycling the good way to reduce of building material costs (Woraphot et al., 2011)

2.2 Concrete

Concrete is a material that are produced from cement, water, fine grindstone and crushed stone mixed with a certain mix of mixtures and allowed to form a structural member (Zakaria, 2015). Concrete is comprised of a mixture of coarse-grained stone, fine-grained stone and cement. The ingredients are treated with water which allowed hard to a certain ratio to form concrete. The concrete was originally made by using ashes by Assyria and Babylonians as cement in their concrete. However, in ancient Egypt they used cypress and gypsum cement in their concrete mix. During the Roman Empire the concrete was produced using a quicklime mixture, pozzolanic / pozzolana ash and a stirrup made of pumice resembling modern Portland cement concrete.

Concrete manufacturing techniques, concrete quality, concrete mix ratio and should be emphasized on the creation of good and quality concrete. Concrete strength is one of the most important concrete properties to give a comprehensive overview of concrete quality as strength is directly linked to the structure of hardened cement blades. The wood-aggregated concrete is made of wasted wood and in reuse, non-toxic and very strong for use in construction houses and small buildings. The strength of concrete also increases according to its age and the increase in strength continues for some time. However, concrete at 28 days is used as a measure of strength. The increase of concrete compression strength depends on temperature and humidity during hardening process. Cement water ratio is one of the main factors that control concrete strength.

2.3 Light weight Concrete. (LWC)

Nowadays, many of researchers do a research regarding of light weight concrete. Purpose of this research to find the material that suit to bind with concrete, study the strength of the concrete and so that it will use in construction. Moreover, majority of the light weight concrete either will be reduced the ordinary material or added with the any material as a replacement of coarse aggregates or fine aggregates it depends on suitability of the material that will be replaced in the concrete. Table 2.1 show the types of lightweight concrete with all the types of aggregates. Usually, the material used are reused material such as, recycle coarse aggregates (RCA), rice husk ash (RHA), wood waste, glass, rubber tyres and many more. All these materials have a potential in the concrete but the content to add or replace will be considered to improve the strength of concrete have a same strength with the normal concrete. According to Sabir (2016), normal concrete has a density of 2,400 kg/m^3 while densities range from 1,800, 1,700, 1,600 down to 300 kg/m^3. Compressive strengths range from up to 40 MPa down to almost zero for the really low densities. Generally, it has more than excellent thermal and sound insulating properties, a good fire rating, is non-combustible and features cost savings through construction speed and ease of handling. Lower concrete density maybe specified for nonstructural applications.

Table 2.1 Types and grading of lightweight concrete

Type Of Lightweight Concrete	**Type Of Aggregate**	**Grading of Aggregate (Range of Particle Size)**
No-fines concrete	Natural Aggregate, Blast-furnace slag, Clinker	Nominal single-sized material between 20 mm and 10 mm BS Sieve.
Partially compacted lightweight aggregate concrete	Clinker, Foamed slag, Expanded clay, shale, slate, vermiculite and perlite, Sintered pulverized-fuel ash, and pumice.	May be of smaller nominal single sizes of combined coarse and fine (5mm and fines) material to produce a continues but harsh grading to make a porous Concrete

Structural lightweight aggregate concrete	Foamed slag, Expanded clay, shale or slate and sintered pulverized fuel ash.	Continues grading from either 20mm or 14mm down to dust with an increased fines content (5 mm and fines) to produce a workable and dense concrete
Aerated concrete	Natural fine aggregate, Fine lightweight aggregate, Raw pulverized-fuel ash, Ground slag and burnt shales.	The aggregates are generally ground down to finer powder, passing a 75 µm BS sieves, but sometimes fine aggregate (5mm and fines) is also incorporated

Source : Sarja (1988)

2.4 Water Absorption in Concrete

One of the most important properties of an excellent good concrete is low permeability, mainly one immune to freezing and thawing. A concrete with low permeability resists ingress of water and is not as susceptible to freezing and thawing. Water enters pores within the cement paste or even within the aggregates (Nurazwa et al., 2017). Environment has significant effects on the water absorption of concrete materials. Water absorption is measured by measuring the increase in mass as a percentage of dry mass. The water absorption of concrete can greatly affect by curing condition. De Schutter & Audenaert (2004) and Zong & Zhang (2014) stated the absorption of water by immersion gives an estimation of the total (reachable) pore volume of the concrete, but gives no indication on the concrete permeability, which is more important with regard to durability. The rate of water absorption is more important, not the final value.

2.5 Fiber Wood in Concrete

In Malaysia, the wastes of wood are rising day by day, because of that the National Agricultural Policy-1984 recommended a new outcome of wastes that can give benefit (Zain, 2008). Therefore, the use of woodblocks in the concrete is from waste of construction and furniture can be defines as lightweight woodblocks concrete. It is easy to find and it also one of the sustainable concrete.

Wood fiber concrete is defined as a composite material containing at least hydraulic cement, water and fiberglass the finest size with the majority of the fiber length of 5 mm (Sarja, 1988). Other than that, wood fiber concrete also contains fine and coarse aggregates, substitute such as pozzolna or fly ash additive such as accelerators or inhibitor materials. However, wood fiber has many features and uses according to concrete constituents such as mix design and production methods. It can be classified in Table 2.2:

Table 2.2 Types of wood

Types	Basic constituents	Density (kg/m³)	Sealed	Uses
Scroll board	The long wood mix(length> 80 mm), cement, water and additive	350-600	No	Thermal coating, acoustic panel and mold panel
Woodchip concrete	Solid woodchip (long, < 20 mm), cement, water and additive.	400-600	Pure	Blocks for carpentry such as wall and thermal coating
Wood particle concrete	Solid woodchips (long < 20 mm), cement, water and additive.	1000-1200	Moderate	Partition board, ceiling and floor
Fiber wood structure concrete	Solid woodchips (long <30 mm), cement, aggregates, water, additives and replacement material	1200-1800	Good - moderate	Structure wall and slab component

2.6 Characteristics of Material

According to Bouguerra (2012) including wood chipping (3-8 mm) in a cement of a clay matrix and tested the water sorptivity. The macroporous wood aggregates reduce the capillary absorption inside the material. Besides that, the composite material also displays good thermal and insulating properties. The properties of the material for various types of concrete fibers are very wide can summarized in Table 2.3 (Sarja, 1988)

Table 2.3 Mechanical properties for fiber wood concrete

Types / **Characteristics**	**Scroll thread shape wood**	**Concrete wood mixture**	**Wood particle concrete**	**Fiber wood structure concrete**
Density (kg/m^3)	350-600	400-600	1000-1200	1200-200
Bending: Tensile strength (N/mm^2)	0.4-1.7	0.7-1.0	10-15	2-6
Compaction: prism strength (N/mm^2)	(1)*	1.2-2.0	(2)*	6-20
Modulus of elasticity (N/mm^2)	(1)*	300	3000	3000-200
Workability: after hardening	Easy to cut, no bonding	Easy to cut, no bonding	Can be sawed with normal tools, limited bonding	Can be sawed with normal tools and special tools, strong bonding

Notes: (1)* *not defined on the compressive strength of 0.3 (N/mm^2)*

(2)* *not defined* (Sources: Sarja, 1988)

Physical characteristics are based on Table 2.4 taking in water absorption and swelling due water absorption, insulation and sound absorption also thermal conductivity (Sarja, 1988). He also discussed in terms of swelling due to water seepage, concrete fiber concrete is tested by increasing. The humidity environment (RH) which hardens the concrete from 40% to 90%.

Table 2.4 Physical properties for fiber wood concrete

Types / **Characteristics**	**Scroll (wood wool)**	**Concrete wood mixture**	**Wood particle concrete**	**Fiber wood structure concrete**
Thermal conductivity (kJ/K)	0.10-0.15	0.10-0.15	0.23-0.35	0.37-0.80
Moisture conductivity (kg/Pa x 10^{-12})	Very high	50-25	20-15	15-10
Sound breaking	No	Moderate	Good	Very good
Sound absorption	High (>60%)	High (±60%)	Good (±40%)	Good (30% - 40%)
Fire resistance	Class 1 BS 476: Part 7, 1968	Fire resist	Fire resist	Flame retardant

(*Source: Sarja 1988*)

Sarja (1988) found that there was no swelling due to water absorption that has happened. For other tests, the sample is preserved in humidity relative environment (RH) 65% and soaked in water for 24 hours. On the density of 700 kg/m^3 and 1500 kg/m^3, is the result of their swelling worth 3 x 10^{-3} and 2 x 10^{-3}. Therefore, he concluded that strain result due to swelling is increased at 8%.

Wood ash replacement percentage up to 10% of the weight binder can be successfully used an additive in place of cement to produce structure grade concrete. If the percentage of wood ash higher than 10% the strength of the concrete is low. The incorporation of wood ash in concrete does not have negative impact on its ability to resist freeze thaw resistance (Chowdury et al., 2014).

According to Li & Khalifa (2017), states experimental test regarding woodchip as coarse aggregates in the concrete with the mechanical properties like moduli of rupture and elasticity can be identified by bending tests and the ratio between the flexural and compressive strength is 47%. It can classify as lightweight wood concrete because the swelling and absorption test shows the low values of the density. The rates of water absorption is below 30%. Thus, it can be used in contact places with water without the risks of freezing and drying.

The inhibition of the setting of concrete with poplar sawdust is characterized with the maturity test that has an effect on its mechanical strength. This strength decreases drastically with increasing poplar sawdust percentage. The lower of the strength reaches 50% for a concrete with a 30% sand substitution through sawdust, and 65% with a 60% substitution. However, the approach of concrete production by means of vibro compaction will increase the strength and could lower the inhibitory impact of wooden on the hydration reaction of the concrete. Substitution of 50% of sand by means of poplar sawdust in the masonry concrete block manufactured via vibro compaction is proposed. Certainly, this concrete composition offers comparable mechanical strength to that of the conventional manufacture of masonry concrete block. (Zhi Xing et al., 2015).

Abdullahi et al. (2013), stated the optimum replacement of sand with sawdust has been found to be 10% to achieve the strength of the concrete based on the British standard (BS). Sawdust was used to replace fine aggregates from 0% to 50% in steps of 10%. From the results, the optimum sawdust content was obtained at 10% and its corresponding compressive strength at 28 days is 7.41 N/mm^2 which falls within the characteristic strength of plain concrete (7–10 N/mm^2). This concrete cannot be used for structural applications.

2.7 Characteristics of Wood Aggregates Concrete

Properties of woodblock aggregates which are light and easy to use make it important in construction especially in structure that no support too much load. For an example wall partition and high indoor blocking (Sarja, 1988)

2.7.1 Fire resistance

As we know, lightweight concrete is concrete that has low heat rate. Therefore, this features are appropriate made of protective cover for reinforcement concrete. Lightweight concrete is much better compare to ordinary concrete in thermal endurance. By referring to Table 2.4 woodchip concrete is a good material in fire resistance while structural fiberglass concrete is a flame retardant material. This is contrast to conventional opinion that assume the concrete that contains wood has no resistance and endurance of fire (Siddique, 2004 and Sarja, 1988)

2.7.2 Heat insulator

According to Siddique (2004) lightweight woodchip concrete is a good thermal insulator. Thus it suits for use in the room and prevent air condition flow out. Directly, we can save energy (Siddique, 2004). Table 2.4 shows that wood fiber concrete uses wood scroll aggregates Structured shapes, chip, particle and fibers have value good thermal conductivity. Low thermal conductivity value between 0.10 kJ/K up to 0.80 kJ/K show low thermal conductivity in concrete wood aggregates (Sarja, 1988).

2.7.3 Sound Absorption

Sound absorption for lightweight concrete is much better than ordinary concrete. Because of this advantages, it uses widely in construction in wall partition due to the production of noise in a room will be not affected the room on the other side. Maria (2008) stated that wood is material that can absorb the sound and this condition can assist the concrete containing woodchip in the mixture absorber.

2.7.4 Durability of Woodblock Concrete

Lightweight concrete has high permeability and means it can easily absorb water and air. Besides that, it exposed to pest attack agents and chemical attack. In addition, it not suit for structure to use in the sulfate water, chloride and exposed to hot weather. However, this material can use as preparation of the membrane as protective.

The durability aspect across an aggressive environment is referring to concrete ability to protect itself from attack chemicals, cooling and weather changes. Furthermore, to achieve these criteria the concrete must consist of a quality type and have a mixing rate of suitable ingredients. From the research, it has been reported that silicate admixture in wood waste has the effect of improving resistance against insect and fungal attack.

Thandavamoorthy (2015) stated, from the compressive test and durability test, it is concluded that structural concrete can be prepared using wood as a coarse aggregate, as its properties are in line with that of the crushed stone used in control concrete. The optimum percentage of stone aggregate replacement was 15%. As it is a new development, it may take some time for the construction industry to get convinced of its benefit and adopt this concrete in practice.

2.7.5 Water Absorption of Woodblock Concrete

For LWC, the penetration of water and harmful substances is affected not only by capillary pores in cement paste, but also by pores in the porous aggregate and by other factors. Thus, comprehensive parameters, such as water accessible porosity, might be more useful in evaluating the LWC's resistance to the penetration of water and harmful substances. More importantly, the water accessible porosity can be easily determined in the laboratory. The wood additives showed an improvement in the water absorption properties of the stabilized bricks compared to that of cement stabilized samples. The percentage water absorbed by cement stabilized samples ranges between 6% and 15% which is considered high while that of the wood additives ranges between 2% and 6%. (Fadele & Ata, 2018). According to Prabagar et al. (2015), the wood ash has the potential ability to replace the cement partially in cement block manufacturing industry. Water absorption capacity is obtained at 15% of wood ash replacement after 21 days curing period.

2.8 Factor Influence the Strength of Concrete

Factors influence strength of concrete is affected by many factors, such as quality of raw materials, water/cement ratio, coarse and fine aggregate ratio, age of concrete, compaction of concrete, temperature, relative humidity and curing of concrete.

2.8.1 Water-Cement Ratio

Water is used to produce concrete mixtures that are plastic and easy to work. If water is excessive than the proper limits, the strength and density of the concrete will decrease while if the water is used too much, the concrete is hard to work and the hydration process is not perfect.

The relationship between the water and cement ratio in the concrete mix is known to the ratio of cement water. Cement water ratio refers to the rate of water and cement used as the ratio of the mix. Generally, the lower the cement water ratio, the concrete strength is increasing and the workability is much less that concrete casting and compacting concrete work is more difficult.

2.9 Water

Water is needed in concrete for hydration and concrete workability. Water is often used to mix the concrete should be free of impurities such as silt, soil, organic acids and other organic matter such as salt and alkali. Usually, the water used to mix concrete is water that can be drunk or taken from an approved source.

Cement mixing is a material that is formed from a mixture of all physical features such as maximum size, shape and grade aggregate. Water plays an important role in the concrete mix:

i. Water gives pleasure to the concrete mix.
ii. Water is a chemical reaction in cement to bind all stones in concrete mixtures.

The amount of water required to mix concrete depends on the desired cement water ratio.

2.10 Cement

Cement is a material produced by burning a mixture of limestone and clay. The cement has cohesive properties that allow it to bind its component materials like fines and coarse aggregates into solid concrete. Cement has many types and is used according to the needs and the suitability of the situation somewhere.

Portland cement is usually used in construction. It is the base material for concrete, mortar construction and plaster. British engineer Joseph Aspdin introduced the Portland cement in 1824 and named after the limestone cliffs on the Portland Isle of Portland Islands in England due to its resemblance to the monumental rock there. Portland cement and similar materials are produced by heating the limestone (source of calcium) with a coating and grinding this material (known as clinker) with sulfate sources (usually gypsum). When mixing the resulting powdered water will form solid hydrates after a certain period of time.

There are so many types of cement in the market made for certain uses and meet specific requirements. Among the types of cement are:

i. Ordinary Portland Cement
ii. Fast Portland Cement Hardens
iii. Low Heat Portland Cement
iv. Portland Cement Sulphate Retardant
v. Customized Portland Cement
vi. High Portland Aluminia cement

2.10.1 Ordinary Portland Cement

Ordinary Portland cement is commonly used in the construction industry. This is because it is suitable for use in the building for general concrete and places where there is no sulfate or groundwater. The main chemical compounds are measured to have a moderate strength of growth and the heat evolution that is appropriate for the purpose of construction. The Portland cement properties change gradually according to its chemical composition.

2.11 Aggregates

Aggregates are terms used to describe materials such as sand and gravel used in concrete mix. Aggregates are used in concrete mixes as they provide durability and ease to concrete work. Aggregates are obtained either from a river or a probe. The forming of rocks from the rivers is round while the quarries are sharp. There are three types of coarse aggregates such as 10 mm, 20 mm, and 40 mm. The most widely used size is 20 mm size for reinforced concrete grade 20 or 1: 2: 4 mixed ratios 10 mm and 40 mm sizes are rarely used unless there is a very tight reinforcement or 20 mm and 40 mm sizes hard to fill a small space. Coarse aggregates of 10 mm, 20 mm and 40 mm can be mixed to form a better concrete. Types of aggregates commonly used in Malaysia are granite, limestone, sandstone, and conglomerate

The river and sea sand are the most suitable for use, as they are clean from any chemical impurities or other substances that can affect concrete quality. Existing sand is obtained in large quantities. Existing sand obtained from quarry through the crushing process of crushed sand graded and graded. Graded sand usually has a good quality and is comparable to the sand of the river and its low price and cheap.

2.11.1 Characteristics of Aggregates

Aggregates containing natural shale or shale like particles, soft and porous particles, and certain types of chert should be avoided since they have poor resistance to weathering. The properties of quality aggregates are described as follows:

i. The strength of stone and its bond.
ii. Physical properties such as comparative density, lump density, porosity, and absorption of moisture content, bulking soundness and resistance against acid and alkali attacks.
iii. Particle size and distribution.
iv. It is hardness must exceed the hardness of the cement.
v. Does not contain substances that prevent the hydration and damage of the iron.
vi. The shape must be almost round and its surface must be rough to produce strong strength.

2.12 Previous Research on Replacement of Coarse Aggregates Used Porcelain and Red Ceramic Waste

The increasing numbers of industry are producing waste ceramic cause the dumping in landfill. One way to prevent accumulation of waste product by substitute materials in concrete. This is because all the waste cannot be recycled to return to the production line in factories. Based on findings by Zahra and Davood (2018) concrete that contain porcelain for water absorption test with the aid of up to 54%, red ceramic waste extended it via 91% for water absorption.

Above 50% replacement, the clean wall tile performed better than waste tile from demolition (with mortar attached). However, in general, the clean or waste tile have presented a quite similar relative mechanical performance as the clay brick wastes, and this can be attributed to the fact that ceramic material do not have good adhesiveness to cement paste, due to a smooth surface texture, being this a common characteristic between brick and tile wastes attributes to the excessive porosity of crimson ceramics (Miguel Nepomucenoa et al., 2018).

2.13 Previous Research Wood and Paper Waste

Adding para wood particles in cement composites have negative effects on the strength and durability, the experimental results still present a potential for the use of Para wood particle waste in cement composites. Productions manufactured from these materials with the optimum content (2% to 10%) of PWP are acceptable for non-structural and structural (with low load carrying capacity) members (Woraphot et al., 2011).

According to Eboziegbe (2013), the compressive test results of samples after day 28 are shown in Table 2.5. Comparing block B with E, only 6% percentage difference is noticed in compressive strength likewise a 2% percentage difference when block E is compared with I as shown in Figure 2.1 and Table 2.5. This is evident that the ratio of sawdust to tradical lime did not necessarily play a significant role in the compressive strength of wood-crete after water absorption but rather other factors like the constituent of wood-crete e.g. the addition of waste paper in Figure 2.1. However, significant differences in compressive strength are observed in giving an insight of how well wood-crete behaves after being subjected to adverse weather conditions, although the water uptake was very low show in Table 2.5.

Table 2.5 Compressive strength for 28 days wood-crete

No	WP%	Compressive strength (MPa)	Compressive Strength (MPa)
		28days water soaked	**dry blocks**
All sample made with de-fiberd paper and sawdust : tradical lime of 1:2			
A	75	0.094	0.8
B	50	0.09	0.61
C	30	0.088	0.48
D	15	0.08	0.41
E	10	0.074	0.35
F	0	0.061	0.26
No.	**WP%**		
All sample made with de-fiberd paper and sawdust : tradical lime of 1:1			
G	50	0.092	0.49
H	25	0.083	0.41
I	10	0.071	0.31
J	5	0.063	0.22
K	0	0.068	0.21

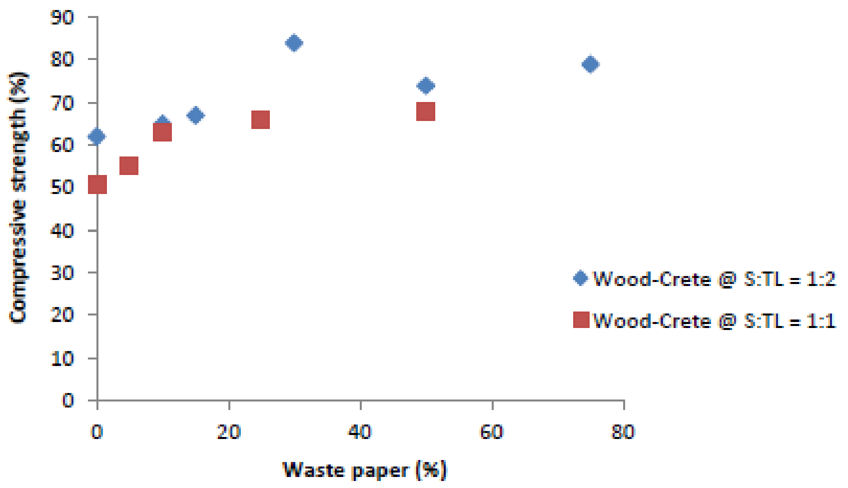

Figure 2.1 Compressive strength of wood-crete after water soaking

2.14 Previous Research Outcomes

Table 2.6 Summary of related research

Researcher	Research Title	Year	Parameter	Material added/ replacement	Percentage of material suit to be added
Chong T. W.	Partial Replacement of Coarse Aggregate With Porcelain Granite Tile Waste (PGTW) in Reinforced Concrete Beam	2016	Strength Flexural	Porcelain Granite Tile Waste	20%
Kartini, K., Mahmud, H.B. & Hamidah, M.S.	Absorption and Permeability Performance of Selangor Rice Husk Ash Blended Grade 30 Concrete	2010	Strength Water absorption	Rice husk Ash	20%
Siddique R.	Utilization of wood ash in concrete manufacturing	2012	Strength	Wood ash	5%
Eboziegbe P.A.	Development of Wood-Crete Building Material	2013	Water absorption Strength	Wood waste Paper waste Wool	6%
Osuji, S. O., Adegbemileke, S. A. & Agbonze, K.	Effect of Crushed Tiles Aggregate and Oil Palm Additive on the Strength Performance of Concrete	2018	Strength Slump Flexural	Tiles aggregates	10-20%

Researcher	Research Title	Year	Parameter	Material added/ replacement	Percentage of material suit to be added%
Li, M. & Khalifa M.	Mechanical charactrerization of concrete containing wood shavings as aggregates	2017	Strength Flexural	Wood shaving	3%
Chowdury, S., Mihir, M. & Suganya, O. M.	The incorporation of wood waste ash a partial cement replacement material for making structural grade concrete	2014	Strength	Wood ash	8%
Woraphot, P., Abideng H., & Thaniya K.	Feasibility Study of Cement Composites with Para Wood Particle Wastes.	2011	MOE	Para wood particles	10%
Zhi-hai He, Long-yuan Li & Shi-Gui Du	Creep analysis of concrete containing rice husk ash	2017	Creep	Rice husk ash	15%
Thandavamoorthy, T.S.	Wood waste as coarse aggregates in the production of concrete	2016	Strength	Recycle wood waste	15%

CHAPTER 3

METHODOLOGY

3.1 Introduction

Research methodology is a neat plan or plan in terms of course throughout the study. In order to launch our study journey, the methodology should well be prepared. With this, our study will not exclude from the established objectives and also to address the issues to be resolved.

3.2 Research Methodology

The flow chart of the research was summarized the research of the study show as Figure 3.1.

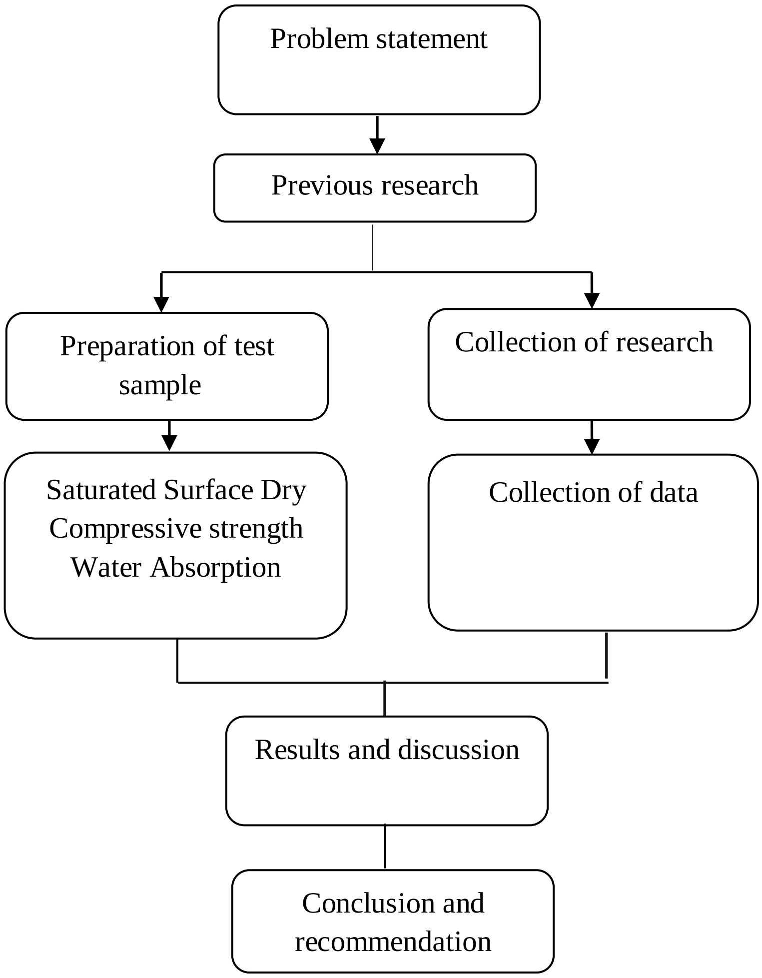

Figure 3.1 Flow chart of research

3.3 Preparation of Material

Materials that used in concrete for this experiment are ordinary Portland cement (OPC), fine aggregates and coarse aggregates, water and the last material was woodblock.

3.3.1 Cement

Cement is a material produced by burning a mixture of limestone and clay. The cement has cohesive properties that allow it to bind its component materials like fines and coarse aggregates into solid concrete. Cement has many types and is used according to the needs and the suitability of the situation somewhere. Usually, Portland cement is the most cement used in construction and for the precaution the cement must be placed to be arranged and kept at dry place to avoid it to become hardened. The main chemical compounds are measured to have a moderate strength of growth and the heat evolution that is appropriate for the purpose of construction. The Portland cement properties change gradually according to its chemical composition.

Figure 3.2 Ordinary Portland cement.

3.3.2 Coarse Aggregates

The coarse aggregates was obtained from quarry Sungai Berkelah, Pahang .The forming of rocks from the rivers is round while the quarries are sharp. For this study, two types of coarse aggregates were used which are natural coarse aggregates and woodblock as a partial aggregates. The size of aggregates is used 10 mm and the maximum size was 20 mm is to mix in the concrete.

Figure 3.3 Natural coarse aggregates

3.3.3 Coated Woodblock

The woodblock obtained from sawmill factory. It is from the wood want to be discarded and used as fuel. The wood is cut in approximately sized is 15 mm to 20 mm. Before being incorporated into the concrete mixture, the wood block was coated using oil paint to prevent water absorption from occurring.

Figure 3.4 Coated woodblock

3.3.4 Fine Aggregates

Fine aggregates obtained from Sungai Pandan, Panching, Pahang. It is use for increased workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent. In addition, to obtain the required size for concrete mixing the fine aggregate was sieved. Apart from that, the fine aggregates needed fully dry before used in mixing due to wet sand may disturb the moisture content of concrete mix.

Figure 3.5 Fine aggregates

3.3.5 Water

Water is needed in concrete for hydration and concrete workability. Water is often used to mix the concrete should be free of impurities such as silt, soil, organic acids and other organic matter such as salt and alkali. Usually the water used to mix concrete is water that clean and clear from impurities or taken from an approved source.

3.4 Concrete Mix Design

The concrete mix design is method to specify the proportions of concrete mix ingredients in order to achieve the strengths that have been specified. The ingredient in the concrete which are cement, water, fine aggregates, natural coarse aggregates and woodblock as a partial coarse aggregates. For this research, the strength is 25 N/mm^2 for the design mix concrete at 7 and 28 days.

Three totally different of percentages replacement of coarse aggregate was determined by weight method. The percentage used in this research are 0%, 3% and 6% of woodblock. The mix design had been calculated based on 18 samples of cube for each mix type. Besides that, the mix design also including of 10% wastage. The data for the mix design tabulated in Table 3.1.

Table 3.1 Mix proportion table

Percentage (%)	Cement (kg)	Water (kg)	W/c ratio	Fine aggregate (kg)	Coarse aggregate (kg)	Woodblock (kg)
0%	6.37	3.56	0.56	13.3	23.65	-
3%	6.37	3.56	0.56	13.3	22.95	0.71
6%	6.37	3.56	0.56	13.3	22.23	1.42

Table 3.2 show the sample identification for each of the cube concrete with the percentage containing woodblock aggregate.

Table 3.2 Sample identification table

Sample Identification	Remarks
P1	0% of woodblock
P2	3% of woodblock
P3	6% of woodblock

3.5 Preparation of Equipment

In this research, cube mold sized 100 mm x 100 mm used for prepare 72 sample lightweight concrete. The equipment used in the preparation of lightweight concrete samples for this research are scope, spatula, iron tray, scales and wheelbarrow.

3.6 Preparation of Cube Concrete

Cube concrete produce use by prefabricated cube mold. Cube mold have to dab with oil for easy removal from mold when concrete was drying. The size of cube concrete was casted in the cube mold with size 100 mm x 100 mm x 100 mm.

Procedure to make cube specimen:

The surface of the cube molds have to apply with oil. Then, the mold placed at above the base of the flat condition. The woodblocks that have been coated with the grading size were prepared to mix in the concrete. The concrete was poured in two layers and it would have the same thick. Every layer must be compacted at least twenty-five (25) times using iron rod. All the cube concrete has marked with the numbers.

All the materials of the concrete were prepared according the mix design. Then, poured into concrete mixer for mixing process to ensure the material mix very well. After completed mixing process, the fresh concrete was poured into the mold and the concrete surface was finished with trowel to provide a smooth surface. Next, the specimen left for 24 hours after completion of casting. After 24 hours, the specimen was removed from the mold and the specimen were cure with different method.

Figure 3.6 The fresh concrete in the concrete mixer

Figure 3.7 The concrete cube in the mold after casting

3.7 Curing

Curing is to control the moisture content and temperature after the placement process is completed. This stage is important because it minimizes drying which can result in cracks after concrete completely hardening. In addition, it will build and achieve the required strength. Concrete curing can be done in several ways. Contain water or humidity close to concrete surfaces such as spraying water, sprinkling water, moist sand and saucers. Prevent moisture loss from concrete such as placing plastic sheets, spraying curing membrane and others.

For this study, concrete samples have two different method of curing were used. Firstly, the cube specimen immersed in water as shown in Figure 3.8 and secondly, Figure 3.9 show air curing method after concrete samples were left dry for 24 hours after removed from their molds. The curing periods for the cube specimen are 7 and 28 days.

Figure 3.8 Water curing tank

Figure 3.9 Air curing

3.8 Material test

Materials are tested for diverse purposes to determine the properties of the raw material, to check quality at intermediate stages in production processes, to check finished products, and to aid research. Mechanical, physical, and chemical methods are used to study the properties of materials. The saturated surface dry test in this research based on ASTM C 127-04.

3.8.1 Saturated Surface Dry (SSD)

The test divided in three categories of material which are raw woodblock, coating woodblock and natural coarse aggregate. All of these materials tested to determine the density, relative density and absorption.

Firstly, all the material was needed to weight before placed in oven for 24 hours as shown in Figure 3.10. The temperature in the oven approximately 110^{o} ±5, then cool in air temperature for 1 to 3 hour for test the sample. Then, weighed the samples that have been cooled. Subsequently, the material immersed in water at room temperature for a period 24 ±4 hours as shown in Figure 3.11. This is required to identify the absorption and relative density values are used in proportioning concrete mixtures in which the materials have the moist condition. After 24 hours, the sample removed from the water and rolled it in large absorbent cloth until all visible films of water were removed. The larger particles wiped individually. A moving stream of air was permitted to assist in the drying operation. Take care to avoid evaporation of water from aggregates pores during the surface–drying operation. Lastly, the mass of the sample saturated surface dry condition was determined and all subsequent mass to the nearest 0.5g of the sample mass.

Figure 3.10 All the material placed in the oven

Figure 3.11 The aggregates immersed in the water for 24 hours

3.9 Concrete Test

Concrete testing is important for determining the strength of the concrete also workability the concrete. The factors that influence the strength of the concrete depends on water content, mixture ratio, size of aggregates, the shape of aggregates, additive and others. Thus, several tests will be conducted such as:

- Compression test
- Water absorption test

The process that involve the preparation of the concrete, first the concrete that contain ordinary mixture and second the concrete that contains woodblocks. Next, all the test will be conducted on the sample cube concrete on the 7 days and 28 days.

3.9.1 Compression Test

This test is made every time concrete work is carried out. Generally, six cubes for this test including of water curing and air curing for the concrete test. The test strength of three cubes shall be tested on the 0% of woodblock in the concrete, six cubes for 3% of woodblock and six other cubes 6% of woodblock in the concrete on the 7 and 28 day. The results of these tests will give the impression that the mixture is correct. It will also give a clear picture of the concrete strength that has been made. The equipment used for this preparation is: -

i. Cube specimen size 100 mm x 100 mm x 100 mm
ii. Tamping rod
iii. Liner
iv. Grease oil
v. Spatula
vi. Compressive Testing Machine

3.9.1.1 Procedure of Compression Test

Concrete compression test was conducted to determine the compressive strength of hardened concrete. The trying out for the compression strength need to be accomplished for this study after the curing is achieved with the hardened concrete with concrete strength at 7 days and 28 days. The end result that obtained based totally from that trying out could be evaluated and compare every of the woodblock and control specimen.

The concrete compression test, samples are prepared in a 100 mm x 100 mm x 100 mm concrete cube and subjected to the compression loading on acquiring most load. Methods of this test first of all, after the concrete reached the required day of curing, the cubes from curing water was removed. Then, the specimen and testing machine bearing surface are wiped clean with any viable unfastened grit so that the cubes will have complete touch with the platens. After that, to make sure load is applied similarly to the whole cube, the concrete specimen is placed at the center of compression plates. Slowly, the load was carried out in increasing nominal rate until no more load can be sustained by concrete specimen and the maximum load was recorded. The value of strength of concrete read on the compression machine. Figure 3.12 show the cube specimen place tested in the compression test machine

Figure 3.12 The specimen tested by compression machine testing

3.9.2 Water Absorption Test

This test was done as per procedure given in ASTM C 642-06 by oven-drying method. For this test 100 mm x 100 mm cube size was used. After 24 hours of demolding, the specimens were kept immersed in water. At the end of 7 and 28 days, the specimens were taken from the curing tank and air-dried to remove the surface moisture. Then, the specimens were dried in an oven at a temperature of 100 ±10^{o} C for 48 hours as in Figure 3.13, and allowed to cool at room temperature. At the end of 48 hours, the weights of the specimens were measured to an accuracy of 1g using a standard weighing balance. Then the specimens were kept immersed in water continuously for 72 hours. Initially up to 30 minutes the increase in weight was measured after wiping out the initial surface water using dry cloth.

Figure 3.13 The cube placed in oven to oven dry

3.10 Analyzing and Interpret the Data

The purpose analyzing and interpret the data to get the information and solutions to meet the research objectives. Data is interpreted in the form of charts and graph so that rough data can be changed and described in the easier form.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter introduced the results obtained from the experimental testing and discussions of test in preceding chapter which examine overall performance of woodblock waste in concrete composition. The outcomes of the test covered the saturated surface dry, water absorption, concrete density and compressive strength of the specimen. The results and discussions targeted on the material properties, concrete strength and mode of failure. All the results of the test were mentioned in this chapter and all the records were illustrated in table and graph for more detail description.

4.2 Density of Material

The density of material is use to determine density, more often referred to simply as density, is a quantitative expression of the amount of mass contained per unit volume. The standard unit is the kilogram per meter cubed (kg/m^3 or kg m -3). The density of woodblock is 614.0kg/m^3 for mold size 100 mm x 100 mm x 100 mm.

4.3 Saturated Surface Dry

The saturated surface dry test for material to measure the amount of water content in the material. Tested materials were sampled from three different sources raw woodblock, coating woodblock and course aggregates. The three samples show the different results for the SSD.

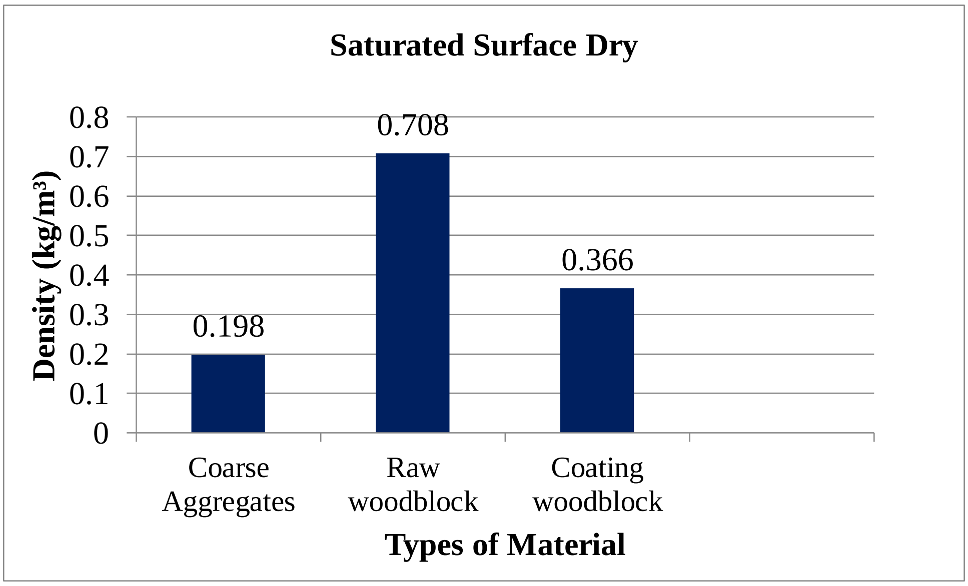

Figure 4.1 Graph of saturated surface dry

Figure 4.1 shows the results of the saturated surface dry for three material, coarse aggregates, raw woodblock and coating woodblock. From the graph, it show the raw woodblock has the highest value compare to coating woodblock within 93.44% because of water content in raw woodblock. Thus, the suit material to replace aggregate for this experiment is coating woodblock.

4.4 Water Absorption

The water absorption test is to determine the amount of water absorbed by the aggregates between their immersion and the first reading on the scale. All the mixes were subjected to water absorption test at the end of water curing period of 7 and 28 days. Table 4.1 show the results of initial and final water absorption at 7 days.

Table 4.1 Water absorption initial and final at 7 days

Sample	Water absorption initial	Water absorption final
P0	1.2	4.5
P1	3.4	5.6
P2	2.9	5.5

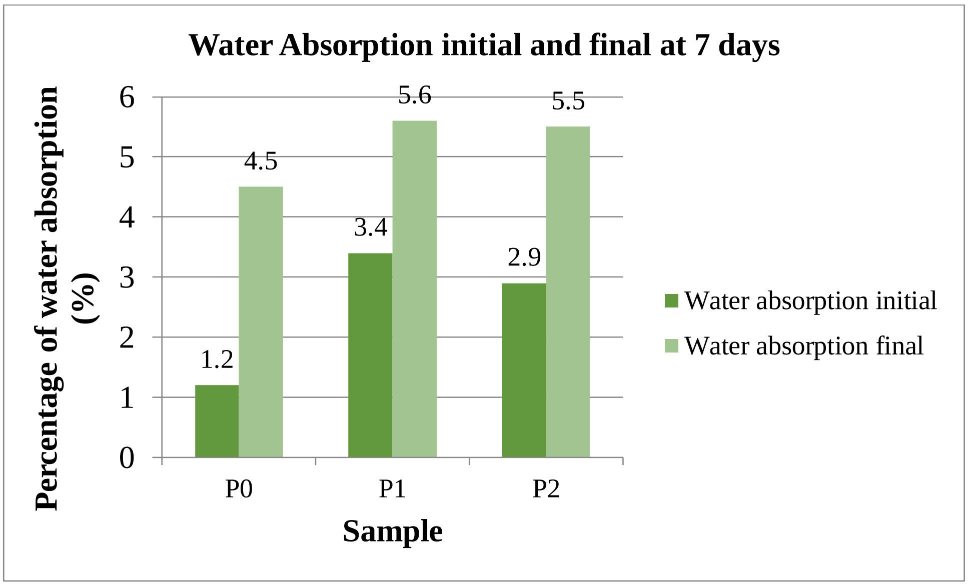

Figure 4.2 Graph of water absorption at 7 days

The results show in Table 4.1 and Figure 4.2 the water absorption for P1 greater than P0 and P2. The initial and final water absorption was significantly increase by P1 and P2 which was 14.7% and 18.5% at 7 days. The water absorption for P0 sample gained only a little water absorption because of it containing 0% of woodblock.

Table 4.2 Water absorption for initial and final at 28 days

Sample	Water Absorption Initial	Water Absorption Final
P0	0.4	4.2
P1	0.7	5.4
P2	0.3	4.7

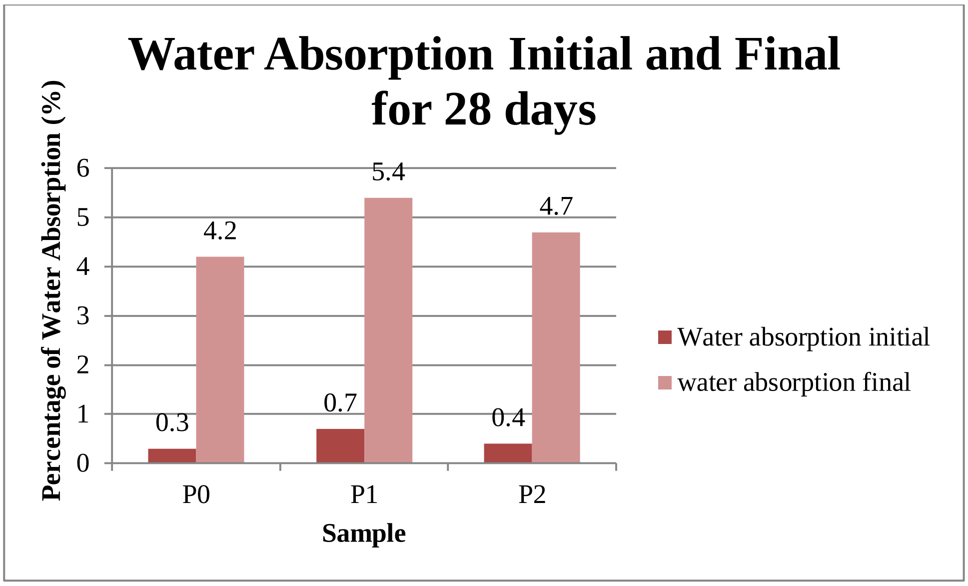

Figure 4.3 Graph of the water absorption at 28 day

The Table 4.2 and Graph 4.3 above show the results for 28 days initial and final water absorption. The results quite similar with 7 days of water absorption. The value of water absorption for P1 show the highest value compare with two another sample. The variation of water absorption for initial for P0, P1 and P2 were 0.3%, 0.7% and 0.4% follow by final water absorption 4.2%, 5.4% and 4.7%. The water absorption indicated the difference for P1 and P2 because of the sample containing of woodblock by 57.1% of water absorption. Besides that, the water absorption for P0 increased by 25% of water absorption for P2.

From both of the results, it can conclude that P1 have the highest percentage of water absorption. Therefore, P1 is unsuitable for replacing of coarse aggregates in concrete because it the absorption of water too high.

4.5 Compression Strength Test

The compression strength test is important to determine the strength of the hardened concrete. The cube specimens were cured and tested at the ages of 7 and 28 days for the compressive strength. The two method of curing was conducted in this test were water curing and air curing. The average results were acquired by test with three specimens for each age of curing. The results for compressive strength of the woodblock concrete cube were shown in Table 4.3 and the graph for compressive strength against curing ages was presented in Figure 4.4.

Table 4.3 Results of the compressive strength water curing

Sample	Strength for 7 days (N/mm²)	Strength for 28 days (N/mm²)
P0	23.49	24.27
P1	15.09	16.10
P2	17.39	19.83

The compressive strength of concrete specimens was increased with age of curing. At the 7th day, the compressive strength of P0 concrete was attained 23.49 N/mm^2, which was the highest among of the others. The result shows that the early strength of the P2 concrete which was 15.7 % higher than P1. The results for P1 and P2 represent of 3% and 6% of woodblock in concrete. From this results it show that P2 has the highly strength compared to P1, even though the P1 contain 3% of woodblock. At the 28th day, the compressive strength of P0 was attained 24.27 N/mm^2, which was also the highest among of the others. The P0 gain the highest results because it a normal concrete. The result presents that strength of P2 concrete at 28 days was 23.2% higher than P1.

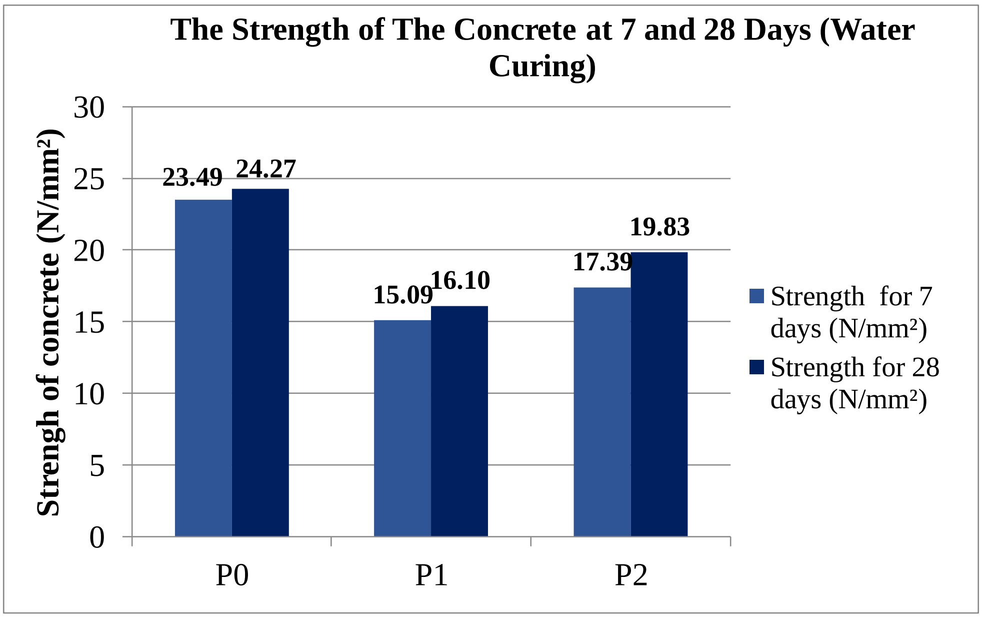

Figure 4.4 Graph of compressive strength at 7 and 28 days (water curing)

In compressive strength result, all the concrete was not passed the design grade of 25 N/mm^2.On the other hand, the result shows that the compressive strength of woodblock concrete was decreased at 3% but increased at 6%. The highest compressive strength at 28 days was occurred at P0 concrete. Therefore, it can be concluded that the optimum percentage of woodblock replacement in concrete was 6%.

Table 4.4 Results of compressive strength for air curing

Sample	Strength for 7 days (N/mm²)	Strength for 28 days (N/mm²)
P0	24.80	25.22
P1	21.68	22.97
P2	24.47	24.75

Furthermore, in Table 4.4 and Figure 4.5 the show the consistent results for the compressive strength using air curing method. The highest strength was attained 24.80 N/mm^2 at 7 days and 25.22 N/mm^2 at 28 days it represents for P0. The comparison strength between P1 and P2 was 12.9% at 7 days, while for 28 days the difference was 7.7%. There was slightly difference about these two concrete. On the other hand, P2 still show the high results compare with P1. Thus, P2 achieved the optimum strength for air curing. Thandavamoorthy T.S. (2015) was found that the maximum value was obtained at 15% replacement level with a result greater than that of the control concrete. For all the other percentage levels, compressive strength was lower than that of the control concrete. This is because the absorption water occurred in the woodblock concrete.

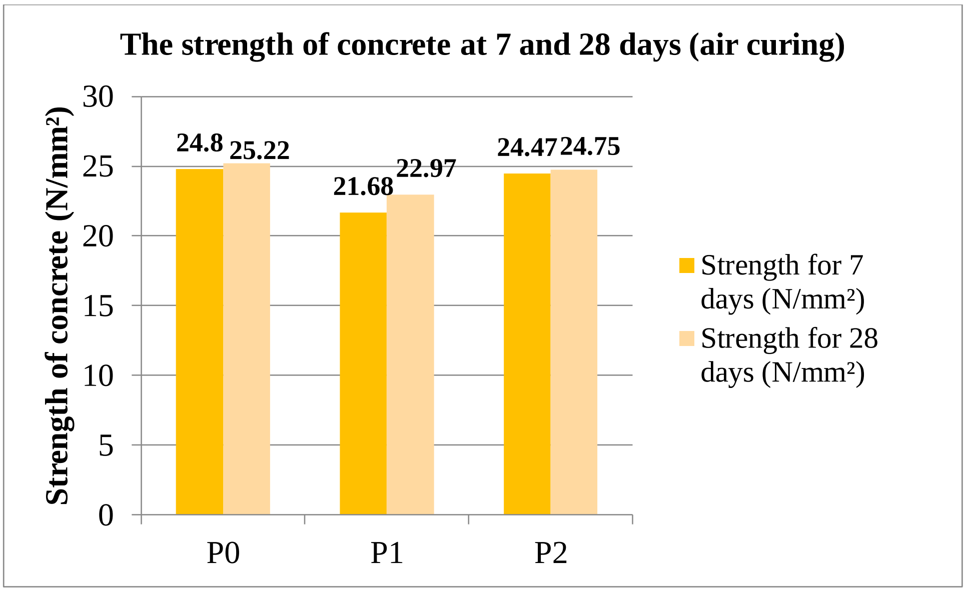

Figure 4.5 Graph of compressive strength at 7 and 28 days (air curing)

4.6 The comparison compressive strength for air curing and water curing

Based on the Figure 4.6 and Figure 4.7 below shows the compressive strength for air curing and water curing. At 7 days the comparison of air and water curing for P0 the strength 5.28%, followed by P1 30% decreased and for P2 the strength was increased 28.9%. From the analysis, it clearly shows the water curing had a lower strength. Besides that, the comparison strength between the two method of curing at 28 days quite similar with 7 days. It can be seen the strength for P0, P1 and P2 falling off at 3.77%, 29.9% and 19.8%. Overall results it show the P0 had the highest strength for 7 and 28 days. Meanwhile, for the concrete that containing woodblock which are P1 and P2 the highest strength at P2.

It was found that the compressive strength water curing lower than air curing as shown in the graph. This is because, it may appear that air-cured specimens are stronger than wet-cured, due to the effect that excess water in the pore system has with the specific tests commonly employed for testing strength properties. Modestau S. (2014) stated that pore excess in the concrete influence the strength.

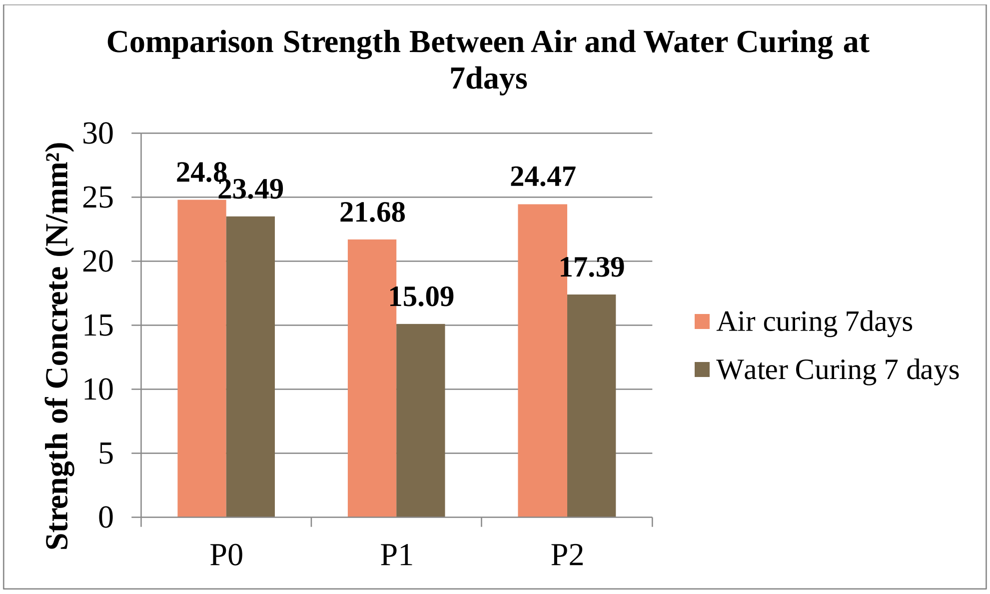

Figure 4.6 Comparison graph for air and water curing at 7 days

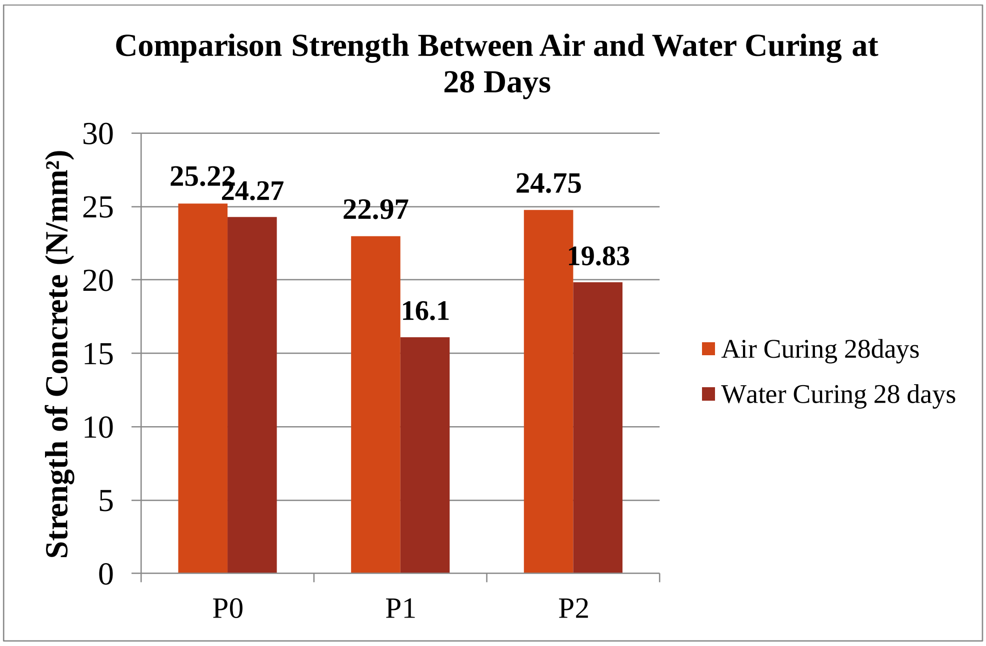

Figure 4.7 Comparison graph for air and water curing at 28 days

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter present the conclusion of the research based on the objectives listed in this study. The objectives of the research were to determine the properties of raw and coating woodblock as replacement material and to determine the initial and final water absorption of concrete using woodblock as partially coarse aggregates. The outcomes of the experimental test were able to the concrete contains woodblock as aggregates to accommodate the load and the strength of concrete. Other than that, some recommendations were suggested for future research.

5.2 Conclusion

Based on the results and discussion obtained within the previous chapter, many conclusions are often drawn for this research. There are three objective need to be fulfilled in order to conduct this research which are the saturated surface dry of material, the water absorption in concrete and last but not least comparison of strength for three types of concrete. First, the coating woodblock suit as replacement aggregate in concrete because it do not absorb too much water compare to raw woodblock. Raw woodblock absorb too high water and will affect the concrete.

Second objective, the absorption of water in concrete was determined by the three type of material fill in concrete. The materials were coarse aggregates, raw wood block and coating woodblock. The woodblocks as a partially replacement of coarse aggregates in concrete. The percentage used for woodblock was 3% and 6%. Based on the results, it show the 3% if woodblock in concrete have the highest water absorption in concrete at 7 and 28 days period of curing compare to 0% and 6% of woodblock. It means the 6% of woodblock have the optimum water absorption for the concrete that containing woodblock.

The strength of woodblock concrete was determined by compressive strength test. The compressive strength test result for the woodblock concrete has shown that even though the sample has been design by using grade 25 N/mm^2, but it tend to be lower in strength as at 7 and 28 days of curing day. Only for normal concrete the strength value was nearly for grade 25 which were 23.49 N/mm^2 at 7 days and 24.27 N/mm^2 at 28 days. However, for concrete that containing woodblock the strength was lower and had not achieved the design grade.

Last but not least, the two method of curing for this research was air curing and water curing. In this research, the air curing show the good results compare to water curing. This is because it may appear that air-cured specimens are stronger than wet-cured, due to the effect that excess water in the pore system has with the specific tests commonly employed for testing strength properties.

As a conclusion, the woodblocks concrete have lower in strength. The good water absorption for woodblock concrete is P2 which is contain 6% of woodblock. Furthermore, based on the both results of compressive strength and water absorption test, the 6% of woodblock was the best result to replace the aggregates.

5.3 Recommendation

From the results analysis, discussion, and observation that are done through this analysis, there are some recommendations that may improve the additional study on this topic:

i. The coating woodblock is suitable to replace coarse aggregates
ii. It is recommended that any studies by amendment in form and size of woodblock to reduce the effect flaky shapes, smooth surface and build the stronger bonding between concrete and aggregates.
iii. Other than that, method of curing influenced the strength of the concrete. The comparison air curing and water curing have many different in term of strength. The observation regarding of the curing method has to review to implement the potency of woodblock concrete.
iv. Increase the percentage of woodblock to find the strength of the concrete.
v. The number of samples also should be increased in order to achieve the consistency and more accurate result.

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Appendix A: Raw Data of Saturated Surface Dry (SSD)

Types of material	Before oven (kg)	After 24 hours (kg)	After soak 24 hours (kg)	SSD
Aggregates	1.003	0.988	1.174	1.005
Raw woodblock	1.007	0.935	1.410	1.282
Coating woodblock	1.005	0.956	1.28	1.104

APPENDIX B: Raw Data of Water Absorption Initial and Final

<u>0% of woodblock</u>

7 days	W/A after 7days curing	W/A after oven 2 days	W/A after 2 hours cold	W/A after 30 minutes	W/A after 3 days	W/A initial	W/A final
3	2.392	2.256	2.258	2.332	2.383	0.034	0.056
9	2.418	2.275	2.277	2.355	2.405	0.035	0.057
15	2.528	2.290	2.292	2.369	2.417	0.034	0.055

28 days	W/A after 28days curing	W/A after oven 2 days	W/A after 2 hours cold	W/A after 30 minutes	W/A after 3 days	W/A initial	W/A final
6	2.407	2.307	2.312	2.315	2.382	0.003	0.033
12	2.358	2.138	2.165	2.167	2.290	0.014	0.071
14	2.418	2.218	2.226	2.229	2.35	0.005	0.060

<u>3% of woodblock</u>

7 Days	W/A after 7days curing	W/A after oven 2 days	W/A after 2 hours cold	W/A after 30 minutes	W/A after 3 days	W/A initial	W/A Final
4	2.232	2.040	2.041	2.067	2.160	0.013	0.059
12	2.243	2.128	2.129	2.154	2.223	0.012	0.045
14	2.246	2.169	2.171	2.191	2.240	0.010	0.033

28 days	W/A after 28days curing	W/A after oven 2 days	W/A after 2 hours cold	W/A after 30 minutes	W/A after 3 days	W/A initial	W/A final
5	2.168	2.049	2.052	2.055	2.156	0.003	0.052
9	2.384	2.259	2.271	2.273	2.370	0.006	0.049
11	2.235	2.137	2.139	2.142	2.256	0.002	0.056

<u>6% of woodblock</u>

7 days	W/A after 7days curing	W/A after oven 2 days	W/A after 2 hours cold	W/A after 30 minutes	W/A after 3 days	W/A initial	W/A final
1	2.193	2.092	2.093	2.148	2.175	0.027	0.040
6	2.25	2.152	2.154	2.204	2.238	0.024	0.040
11	2.111	1.986	1.988	2.055	2.155	0.035	0.085

28 days	W/A after 28 days	W/A after oven 2 days	W/A after 2 hours cold	W/A after 30 minutes	W/A after 3 days	W/A initial	W/A final
10	2.312	2.194	2.197	2.2	2.285	0.003	0.041
14	2.274	2.15	2.152	2.157	2.25	0.003	0.047
15	2.225	2.017	2.020	2.025	2.125	0.004	0.054

APPENDIX C: Raw Data of Water Curing Compression Test

7 days of water curing

0% of woodblock

No. Sample	Before curing (kg)	After curing 7 days (kg)	Stress (N/mm^2)
7	2.391	2.412	23.44
8	2.382	2.403	24.73
11	2.357	2.375	21.29

3% of woodblock

No. Sample	Before curing (kg)	After curing 7 days (kg)	Stress (N/mm^2)
1	2.130	2.161	16.37
3	2.151	2.177	13.26
7	2.175	2.204	15.64

6% of woodblock

No. Sample	Before curing (kg)	After curing 7 days (kg)	Stress(N/mm^2)
4	2.064	2.111	17.80
7	2.112	2.153	20.11
8	2.127	2.165	14.26

28 days of water curing

<u>0% of woodblock</u>

No. Sample	Before curing (kg)	After curing 28 days (kg)	Stress /N/mm^2)
2	2.300	2.322	24.30
10	2.432	2.454	23.50
13	2.368	2.836	22.02

<u>3% of woodblock</u>

No. Sample	Before curing (kg)	After curing 28 days (kg)	Stress (N/mm^2)
6	2.227	2.275	15.45
8	2.213	2.248	19.93
10	2.235	2.227	16.75

<u>6% of woodblock</u>

No. Sample	Before curing (kg)	After curing 28days (kg)	Stress (N/mm^2)
9	2.176	2.230	16.80
12	2.203	2.247	22.90
13	2.146	2.197	19.80

APPENDIX D: Raw Data of Air Curing Compression Test

7 days of air curing

<u>0% of woodblock</u>

No. Sample	Before curing (kg)	After curing (kg)	Compression (N/mm^2)
1	2.239	2.316	25.67
2	2.345	2.333	25.23
3	2.339	2.326	23.5

<u>3% of woodblock</u>

No. Sample	Before curing (kg)	After curing (kg)	Compression (N/mm^2)
1	2.509	2.503	19.08
2	2.435	2.425	20.45
3	2.286	2.279	25.50

<u>6% of woodblock</u>

No. Sample	Before curing (kg)	After curing (kg)	Compression (N/mm^2)
2	2.136	2.132	23.9
3	2.246	2.24	24.60
6	2.346	2.196	24.9

28 days for air curing

0% of wood block

No. Sample	Before curing (kg)	After curing (kg)	Compression (N/mm^2)
4	2.310	2.292	24.26
5	2.333	2.314	25.10
6	2.358	2.337	26.30

3% of woodblock

No. Sample	Before curing (kg)	After curing (kg)	Compression (N/mm^2)
4	2.404	2.497	23.5
5	2.306	2.395	20.6
6	2.202	2.294	24.80

6% of woodblock

No. Sample	Before curing (kg)	After curing (kg)	Compression (N/mm^2)
1	2.235	2.257	25.13
4	2.267	2.241	24.57
5	2.252	2.336	24.55