PROPERTIES OF CONCRETE WITH PARTIAL RICE HUSK AS FINE AGGREGATE REPLACEMENT

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B. ENG (HONS.) CIVIL ENGINEERING

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ABSTRACT

This study aimed to determine properties of concrete with rice husk as partial replacement of fine aggregate or sand and to evaluate optimum ratio of rice husk in modified concrete. This study establishes the limit to determine the properties of rice husk ratio with ratio of 5 %, 10% and 15% from the basic concrete grade C25/30. There are 36 beams are provided with different ratio of replacement of sand with Rice Husk concrete in this study. The dimension size of beam is 150 mm of width, 150 mm of height and 750 mm of length. There are 36 cubes which dimension size of 150 mm width, 150 mm height and 150 mm length are provided to obtain the average results of the compressive strength. This study also aims 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 rice husk and to sustain good product performance and meet recycling goals. Observations from the tests performed were conducted in the laboratory where precise data were gathered and completely attained.

ABSTRAK

Kajian ini bertujuan untuk menentukan sifat-sifat konkrit dengan menjadikan sekam padi sebagai pengganti separa agregat halus atau pasir dan untuk menilai nisbah optimum sekam padi dalam konkrit yang diubahsuai. Kajian ini menetapkan had untuk menentukan sifat-sifat nisbah sekam padi dengan nisbah 5%, 10% dan 15% daripada gred asas konkrit C25 / 30. Terdapat 36 rasuk dihasilkan dengan kadar nisbah konkrit yang berbeza penggantian pasir dengan sekam padi dalam kajian ini. Saiz dimensi rasuk adalah 150 mm lebar, 150 mm ketinggian dan 750 mm panjang. Terdapat 36 kiub yang saiz dimensinya 150 mm lebar, 150 mm tinggi dan 150 mm panjang dihasilkan untuk mendapatkan keputusan purata kekuatan mampatan. Ini juga bertujuan untuk membantu menyumbang kepada industri dalam penjagaan alam sekitar, untuk menggalakkan kerajaan dalam mencari penyelesaian mengenai tapak pelupusan bahan sisa dan menjaga alam sekitar, untuk memberi pengetahuan baru kepada kontraktor dan pemaju tentang bagaimana untuk menambahbaik kaedah dalam industri pembinaan dan perkhidmatan dengan menggunakan sekam padi dan mengekalkan prestasi produk yang baik serta memenuhi matlamat kitar semula. Pemerhatian dari ujian yang dilakukan telah dijalankan di makmal di mana data yang tepat telah dikumpulkan dan tercapai.

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LIST OF SYMBOLS

%	Percentage
kg	Kilogram
mm	Millimetre
N	Newton
MPa	Mega Pascal
kN	Kilo Newton

LIST OF ABBREVIATIONS

ASTM	American Section of the International Association for Testing Materials
BS	British Standard
3R	Reduce, Reuse, Recycle
pH	Potential of Hydrogen

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

All through history, concrete as a building material has been broadly utilized and contributed significantly to the built environment. In its simplest form, concrete is a mixture of paste and aggregates. The paste is a composed of Portland cements and water which it coats the surface of the fine and coarse aggregates. As the basic civil engineering compound, the quality of concrete is determined by the quality of mix. The wide range of applications is not the only one that concrete offers, but also its durability, versatility, affordability and good strength. According to Obilade, I.O. (2014), concrete is the world's most consumed man made material (Naik, 2008).

Nowadays, due to the rapid construction development and increasing demand of houses, the demands of concrete are growing quickly and indirectly lead to the shortage of customary building materials. Cement, sand, brick and wood are currently becoming in short supply materials. Concrete is not only being used in building construction but also in bridges construction, road construction and others. According to Obilade, I.O. (2014), concrete production is not only a valuable source of societal development, but it is also a significant source of employment (Naik, 2008). The public and related industries had come into concern due to increasing demand of the construction materials. Although these materials and method have traditionally been considered "primitive" and therefore inferior to more highly processes materials in terms of safety, durability, performance, occupants health, and comfort with respect to environmental issue, consumption of environmental products and energy within the construction industry has created a significant demand for raw materials and for production thereby contributing to the many environmental problems associated with diverse ecosystem (Tomas U. Ganiron Jr, 2013).

The issue is not only the interminable lack of building materials but it also immense effect to environment. These days, solid waste management and pollution problems have been considered as a crucial issue for Malaysian government which is caused by industrial and agricultural wastes. As the consequence of alarming rate of waste generated and shortage of natural resources for construction material due to the increase in population and construction development in Malaysia, there are several strategies to overcome this issue. One of it is to reuse the waste by-product generated from agricultural and industrial production activities. The utilization of industrial and agricultural wastes to complement other conventional materials in construction gives both practical and prudent preferences. The waste by-product generated from agricultural and industrial production which can be found in Malaysia are such as rice husk, coconut shell, wood dust, glass wastes and etc. Sustainable construction materials can be remade by using this waste by-product while pollution problem and shortage of natural resources for building materials can also be overcome.

By reuse the waste by-product generated from agricultural and industrial production activities to decrease the environmental issues, Malaysia has a significant potential to achieve the objective of sustainable development.

1.2 PROBLEM STATEMENT

Rapid development in the construction industry these days was led by globalization and urbanization. Malaysia is well known as a developing country, increase in population growth, rising standards of living and increasing of urbanization which led to massive demand of construction materials. Due to the growth of population and the numerous construction activities nowadays, there is a lot of demand for these natural sources and they will be running low.

Concrete is generally utilized for the construction of most of the buildings. To meet out this rapid construction development, a massive quantity of concrete is required. For every concrete structure basically required tons of sand and gravel coated together with cement. Only some sands are suitable to use for making concrete. In fact, the properties of the sand utilized as a part of concrete can affect its quality. For example, desert sand generally not suitable to use for construction because the wind erosion of sand in the desert results in smooth and desert grains are too round which do not bind well. Furthermore, desert sand is mono-grained which means similar size. This sand is absolutely makes it unsuitable to use in concrete because concrete required sand which is small, intermediate, and coarser particles to prevent voids between grains to reduce the amount of water necessary. Generally, sand which is use for concrete was obtained by mined from land quarries and riverbeds. Natural sand is being extracted at an increasing rate due to growing global population which leads an expanding demand for building and housing. This action has caused the expansion of mining to coastal areas and dredging of the seafloor and indirectly increasing the possibility of flooding, affect the marine and river biodiversity, causing coastal and inland erosion, exacerbating the risk of drought and lowering the water table in some areas.

Agriculture is considered as a crucial sector to the economy of Malaysia. By advancing the agricultural sector, development was bringing to rural areas to reduce imbalance in urban rural development especially in the less developed states. In this case, the demand of food resources is absolutely increase due to the rapid growth of population in Malaysia. The massive development of plantation in Malaysia has generated substantial amount of agro-waste and big environmental concerns. Rice is considered as an important part of everyday Malaysian diet. In Malaysia, rice is one of the major food resource and also rice producers in the world. Besides producing rice, it also produces waste by-products such as rice husk. The rice husk is the outermost layer of the paddy grain which is separated from the rice grains during the milling process. Rice husk is a major by-product of the rice milling industry and also is an agro-waste that creates huge environmental problems due to its abundance by leaving it to rot down by itself which is dumped on landfills as well as dispose it by burning it in open fires which is emit large quantity of carbon dioxide to the atmosphere and it is not environmentally friendly at all.

In order to make efficient use of locally available materials, this study was conducted to apply rice husk as partial replacement for fine aggregate in concrete. As a sustainable material, the use of rice husk can eliminate waste disposal and support environmental protection.

1.3 OBJECTIVES

The objectives of this study are:

a) To determine properties of concrete with rice husk as partial replacement of fine aggregate or sand.
b) To evaluate optimum ratio of rice husk in modified concrete.

1.4 SCOPE OF PROJECT

The main focus of this project is to apply rice husk as partial replacement for fine aggregate in concrete. The replacement of fine aggregate with rice husk can reduce the production of sand further reduce natural sources from being running low and solve the disposal problem of numerous rice husks produced. Moreover, the production of carbon dioxide gas which is produced during burning the rice husk to dispose can be reduce to prevent from affecting global warming and greenhouse effect.

The parameters of the study are including the composition of rice husk, replacement ratio of fine aggregate with rice husk, compressive strength of concrete and flexural strength of concrete. This study establishes the limit to determine the properties of rice husk ratio with ratio of 5 %, 10% and 15% from the basic concrete grade C25/30. The concrete mix was using Composite Portland cement. The cube test and flexural test for concrete were tested within the range of 7, 14 and 28 days according to the curing period.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

In this chapter, there are literature reviews with evaluation of previous research. This chapter will mainly focus on concrete materials for this study.

2.1.1 The 3R Reduce, Reuse and Recycle Concept

Nowadays, a continuing waste production and over-consumption brings a problem for society. Many of waste production are not biodegradable and to break it down may take centuries. All items and materials have environmental effect from the extraction of raw materials for production to manufacture, distribution, use and disposal. There is a method that can be practice to minimize the volume of generated wastage, which is leading to reduction of waste production and over-consumption. The concept of 3R refers to reduce, reuse and recycle that is specifically in the context of consumption and production. This concept is a guidance proposed to making a sustainable life.

2.1.1.1 Reduce

Reducing is the most beneficial of the 3R. It is the best way to conserve and protect the environment. Consumers are recommended to reduce the waste by buying the items with less packaging, purchasing in bulk, and switching to reusable instead of single-use items. Manufacturing methods that require fewer resources can be adopt by businesses and create less waste. Moreover, this initiative indirectly reducing the expenses in purchases of financial incentive for consumers and businesses.

2.1.1.2 Reuse

In spite of effort to decrease the amount of waste produced, consumers and businesses still create considerable waste. Instead of throwing out items, consumers can discover new uses for them, which are can reduce the consumption of new resources. A lot of this waste can directly be reused to minimize the strain on the environment and municipal waste management. Learning to reuse items for a different use is crucial in waste management. For example, shoe boxes, coffee cans, drinking water bottle, milk containers and other types of containers can be used to store things or can become crafts projects and fun arts.

2.1.1.3 Recycle

A lot of items that were use every day such as plastic bag, newspaper, can and bottle are made out of materials that can be recycled. Recycling extracts out of the materials from the old ones and turns them into new products through a certain process. Consumer can help recycling by purchasing products that contain recycled materials such as toilet paper that made from recycled pulp which is the product should be environment friendly.

2.1.2 The Importance of 3R

Generally, the energy will be used for the process when manufacturers extracting resources and refining them to make products. This energy is generates by burning the fossil fuels. At the point when consumers discard those things away, they threw them to landfills which is generates the impact on the environment. By using the concept of reduce, reuse and recycle, it can help to reduce mankind's environmental footprint, conserve and preserve valuable resources indirectly protect the environment, reduce carbon dioxide emissions and energy use, and limits the amount of landfill space. This concept also can be an assistance to stop presenting hazardous waste concerns and promote a clean and healthy environment.

2.2 MATERIALS

2.2.1 Concrete

Concrete is one of the most essential construction materials. It is comparatively economical, simple to make, offers continuity and solidity, and will bond with different materials. It is acquired by mixing cementing materials, water and aggregates and sometimes admixtures in required extent. The mixture is placed in formwork and allowed to cure that will hardens into a rock-like mass known as concrete. Chemical reaction between water and cement caused the hardening and it continues for a long time and thus the concrete grows stronger with age.

The hardened concrete may also be considered as an artificial stone in which the voids of course aggregate is filled by fine aggregate and the voids of fine aggregates are filled with cement. In the concrete mix, cement and water form a paste called cement-water paste which in addition to filling the void of fine aggregate, coats the surface of fine and course aggregates and binds them together. The characteristics of concrete depend on the properties of its ingredients, on the proportions of mix, the method of compaction and other controls during placing, compacting and curing. Being careful in control of the process components are the key to make a strong, durable and uniform concrete such as high-performance concrete. These are the following:

i. **Cement.** Portland cement is the most commonly used cement in nowadays concrete that consists of compounds of calcium, silicon, aluminium, iron and oxygen.
ii. **Aggregate.** These are inert granular materials such as sand, gravel or crushed stone. Nevertheless, technology is broadening to include the use of recycle materials and synthetic products.

iii. **Water.** The water content, the minerals and chemical dissolved in it are crucial to achieving quality concrete.

iv. **Chemical admixtures.** These are the ingredients in concrete other than Portland cement, water and aggregates that are added to the mixture before or during mixing to adjust the specific performance of concrete.

Concrete has high compressive strength but low in tensile strength. In situations where tensile stresses are developed, the concrete is strengthened by steel bar which is called reinforced concrete. The concrete without reinforcement is called as plain cement concrete or simply as concrete. The process of making concrete is called concreting. Occasionally, the tensile stresses are taken care of by establish compressive stresses in the concrete so that the initial compression neutralizes the tensile stresses, which is known as prestressed concrete.

Concrete is not strong or tough as steel but it still is the most widely used in engineering materials. There are at least three main reasons for this situation. First, concrete possesses exceptional resistance to water. Unlike ordinary steel and wood, concrete has the ability to withstand the action of water without severe deterioration that makes it an ideal material for building structures to store and control water.

The second reason for the worldwide use of concrete is concrete can be formed into a variety of shapes and sizes. This is due to plastic consistency of concrete, which enables the concrete to flow into prefabricated formwork. After the concrete has hardened and solidified, the formwork can be removed and can be reuse for another time.

Then, the third reason is that it is usually the cheapest and most readily available material in construction industry. The main components for making concrete are aggregate, water and Portland cement, which are relatively inexpensive and commonly available in every place. Some of the considerations that prefer the use of concrete over steel as the construction material of choice are as follows:

i. **Maintenance**. Concrete does not corrode, needs no any surface treatment and its strength increases with time. Therefore, concrete structures require much less maintenance. On the other hand, steel is vulnerable to corrosion in offshore environments, which require surface treatment and maintenance cost.

ii. **Fire resistance.** The fire resistance of concrete is the most important aspect of safety. Since an adequate concrete cover on reinforcement is required for structural integrity in reinforced and prestressed concrete structures, the protection against failure due to excessive heat is provided at the same time.

iii. **Resistance to cyclic loading.** The fatigue strength of steel structures is greatly influenced by local stress fields in welded joints, corrosion pitting and sudden changes in geometry such as from thin web to thick frame connections. In most codes of practice, the allowable concrete stresses are limited to about 50 percent of the ultimate strength. Thus, the fatigue strength of concrete is generally not a problem.

2.2.1.1 Types of Concrete

Based on unit weight, concrete can be classified into three categories. Concrete contain natural sand and gravel, generally weighing about 2400 kg/m^3 is called normal-weight concrete and it is the most commonly used concrete for structural purposes. For applications where a higher strength-to-weight ratio is desired, it is possible to reduce the unit weight of concrete by using natural or pyro-processed aggregates with lower bulk density. Lightweight concrete is used for concrete that weighs less than 1800 kg/m^3. Heavyweight concrete used for radiation shielding, which is a concrete was produced from high-density aggregates and basically weighs more than 3200 kg/m^3.

From standpoint of well-defined differences in the microstructure-property relationships, concrete is divide into three general categories based on compressive strength:

a) Low-strength concrete: less than 20 Mpa
b) Moderate-strength concrete: 20 to 40 Mpa
c) High-strength concrete: more than 40 Mpa

Table 2.1: Typical Proportion of Materials in Concrete Mixtures of Different Strength

	Low-Strength (kg/m^3)	Moderate-Strength (kg/m^3)	High-Strength (kg/m^3)
Cement	255	356	510
Water	178	178	178
Fine Aggregate	801	848	890
Course Aggregate	1169	1032	872
Cement Paste Proportion:			
Percent by mass	18	22.1	28.1
Percent by volume	26	29.3	34.3
Water/cement by mass	0.70	0.50	0.35
Strength, Mpa	18	30	60

Source: M.L. Gambhir (2009)

Typical proportions of materials for producing low-strength, moderate-strength and high-strength concrete mixtures with normal-weight aggregate are shown in Table 2.1. Moderate-strength concrete referred as ordinary or normal concrete, which is used for most structural work while high-strength concrete is used for special applications.

2.2.1.2 Properties of Concrete

Making concrete is not just a matter of mixing ingredients to produce a plastic mass but good concrete has to satisfy performance requirements in the plastic state and the hardened state. In the plastic state, the concrete should be workable and free from segregation and bleeding. Segregation is the separation of course aggregate and bleeding is the separation of cement paste from the main mass. The segregation and bleeding will result poor quality of concrete. In its hardened state, concrete should be strong, durable and impermeable and it also should have minimum dimensional changes.

Among the various properties of concrete, the compressive strength is considered to be the most essential and is taken as an index of its overall quality. Many other properties of concrete appear to be generally related to its compressive strength such as workability and durability.

2.2.1.3 Advantages of Concrete

As a construction material, concrete has the following advantages:

a) Concrete is economical in the long-term as compared to other engineering materials.
b) Concrete possesses a high compressive strength and the corrosive and weathering effects are minimal.
c) The fresh mixed concrete can be easily molded or formed into any shape or size according to specifications. The formwork can be reused for the same work, which is resulting in economy.
d) Concrete can be pumped and also can be laid in difficult positions.
e) Concrete is durable, fire resistant and requires very little maintenance.

2.2.1.4 Disadvantages of Concrete

The following are the disadvantages of concrete:

a) Concrete has low tensile strength and can cracks easily. Therefore, concrete is strengthened with steel bars.
b) Fresh concrete shrinks when drying and hardened concrete expands when wetting. Provision for construction joints have to be provided to avoid the cracks from occurs due to drying shrinkage and moisture movement.
c) Concrete expands and contracts with the changes in temperature. Therefore, expansion joints have to be provided to avoid the formation of cracks due to thermal movements.
d) Concrete is not entirely impermeable to moisture and contains soluble salts which may cause efflorescence.

2.2.1.5 Components of Concrete

Concrete is a composite material with variable properties. The ingredients mixing ratio of concrete is variable and determined by the properties of ingredients and mix design. Concrete is consisting of three main ingredients, which are cement, aggregates and water. Admixtures are added to adjust the concrete mixture for specific performance criteria.

i. Cement

Cement is a well-known as construction material and highly needed in construction works. There are many types of cements available in the market and each type is used under certain conditions due to its special properties. A mixture of cement and sand when mixed with water to form a paste is known as cement mortar while the composite product obtained by mixing cement, water and inert granular materials of sand and gravel is called cement concrete. The distinction property of concrete is its ability to harden under water.

The cement that is commonly used is Portland cement. It is necessary to understand the characteristics and behaviour of the ingredients in order to obtain a strong, durable and economical concrete mix. Portland cement is defined as hydraulic cement which means cement that not only hardens by reacting with water but also forms a water-resistance product. The function of cement is, first to bind the sand and course aggregates together and second is fill in the voids between sand and course aggregates particles to form a compact mass.

Cement is produce through the chemical combination of calcium, silicon, aluminium, iron and other ingredients. Common materials used to produce cement include limestone, shells, and chalk or marl combined with shale, clay, slate, blast furnace slag, silica sand, and iron ore. When these ingredients were heated at high temperatures, it forms a rock-like substance that is ground into the fine powder, which is called cement.

a) Portland Cement

Portland cement is the material that having adhesive and cohesive properties, which provide a binding medium for the discrete ingredients. It is obtained by burning together in a certain proportion, a mixture of naturally occurring argillaceous materials (containing alumina) and calcareous materials (containing calcium carbonate or lime) to a partial fusion at high temperature. The common argillaceous materials are clay, shale, slate and selected blast-furnace slag while the calcareous materials are limestone, chalk, oyster shells and marl. The basic components of the manufacturing process are shown in Figure 2.1.

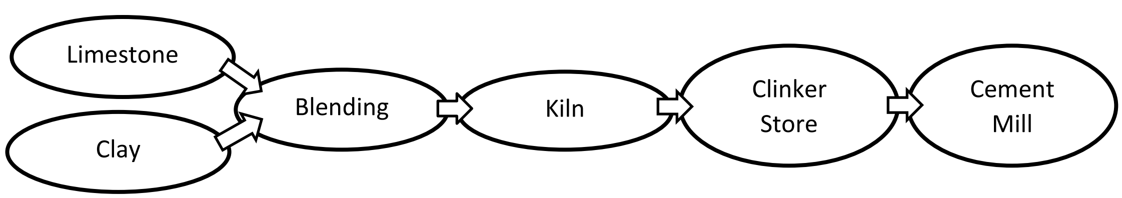

Figure 2.1: The basic components of the cement-manufacturing process

Source: M.L. Gambhir (2009)

The clinker that is the product that obtained on burning is cooled and ground to the required fineness to produce cement. Gypsum is also included into the final process in manufacturing to standardize concrete setting time. The amount of gypsum is about three per cent by weight of clinker. It is available in different type and each of it has its own distinct anti-corrosion or damage properties.

b) Special-purpose Cements

The special-purpose cements are manufactured for the specific performance requirements. The regularly used ones are as the following:

i. OPC-based cements
ii. Non-OPC cements

These cements have some further classifications and description.

a) OPC-based Cements

i. Rapid-hardening Portland cement

This cement is used where a rapid strength development is required. The rapid gain of strength is accompanied by a higher rate of heat during the hydration of cement. This may have advantages in cold weather concreting but a higher concrete temperature may lead to cracking due to following thermal contraction, and should not be used in mass concreting. It is recommended for prefabricated concrete construction, road repairs and in applications requiring early stripping of forms.

ii. Low-heat Portland cement

This cement has exceptional performances such as sulphate corrosion resistance, high final strength, good lasting properties, lower hydration heat, anti-seepage and also good resistance to rupture. It is cannot be used in cold weather conditions because it will retard the setting time than in ordinary weather. This cement is recommended for the use in mass concrete construction such as dam where the temperature is rise by the heat of hydration, which can become excessive.

iii. Sulphate-resisting cement

Sulphate-resisting cement is more resistant to the action of mineralized water containing sulphate than ordinary Portland cement, which is it is complete assurance against sulphate attack. It also slow the hardening and has lower heat of hydration. It is used in structures that are exposed to soil or ground waters where sulphate concentrations are higher than normal.

iv. Masonry cement

Masonry cement mortar is superior to lime mortar, lime-cement mortar and cement mortar. It combines the desirable properties of cement mortar relating to strength and setting and lime mortar relating to workability and water-retention. Thereby, a masonry cement produces a smooth, plastic, cohesive and strong yet workable mortar. The cracks due to shrinkage and temperature movement are considerable reduced.

v. White Portland cement

The process of manufacturing white cement is the same as ordinary Portland cement but the amount of iron oxide, which is liable for grayish color, is limited to less than one per cent. White Portland cement is used particularly for architectural purposes, such as precast curtain walls and facing panels, terrazzo surfaces, cement paint, tile grout and decorative concrete. Generally, white cement is ground finer than gray cement.

vi. Colored Portland cement

By mixing mineral pigments with ordinary cement, colored Portland cement may be obtained. The amount of coloring material may be different from 5 to 10 per cent. The strength of cement is affected if the percentage exceeds 10 per cent. The colored cements are broadly used for artificial marble, floors finishing, textured panel faces, window sill slabs, stair treads and many more.

vii. Hydrophobic cement

Hydrophobic cement is used in places where water is predominant. This type of cement contains some of the admixtures like napthalene soap, acidol and petrolatum (oxidised) along with others. These admixtures form a thin film layer over the cement grains. In initial stage, the setting of hydrophobic cement is slow because the admixtures surrounding as a thin film over the cement grains prevents the interaction with water. However, its strength after 28 days is equal to that of ordinary Portland cement. This cement can be used in cold weather conditions. Commonly, this cement is used in construction of spillways, dams and under water constructions.

viii. Air-entraining Portland cement

Air-entrained Portland cement is a special cement that can be used with good results for a various of conditions. It has been developed to produce concrete that is resistant to freeze-thaw action and to scaling caused by chemicals applied for severe frost and ice removal. In this cement, very small quantities of air-entraining materials are added as the clinker is being ground during manufacturing. Concrete that made with this cement contains tiny, well-distributed and completely separated air bubbles. The bubbles are so small that there may be millions of them in a cubic foot of concrete. The air bubbles provide space for freezing water to expand without damaging the concrete. The amount of water loss and the capillary/water-channel structure will be reducing by using this air-entrained cement in concrete.

ix. Expansive cement

Expansive cement does not shrink while hardening but expands slightly with time. This cement does not suffer any overall change in volume on drying. It can reduce or control the volume changes that occur during curing by using expansive cement. This cement is commonly used for grouting anchor bolts and grouting machine foundation.

x. Oil-well cement

Oil-well cement is used for cementing work in the drilling of oil wells where they are subject to pressures and high temperatures. This cement was produced by inter-grinding

Portland cement clinker, fly ash, gypsum and certain admixture which is retarder in suitable proportions. The retarder prevents quick setting and retains slurry in mobile condition to facilitate penetration to all fissures and cavities.

b) Non-OPC Cements

i. High-alumina cement

This cement is very reactive and produces very high early strength. At the age of 24 hours and even at six to eight hours, about eighty per cent of the ultimate strength was developed. It is also has an initial setting time that is about four hours and the final setting time that is about five hours. Generally, no additives are added to alumina cement. This cement is more workable than Portland cement if water-cement ratio is same. The strength will be affected by rise in temperature. Furthermore, this cement also resistant to chemical attack and suitable for under sea water applications.

ii. Magnesium phosphate cement

This cement has very high early strength and quick in setting. It is suitable for rapid patching mortar for road and aircraft run-ways, which can typically be re-opened in about 45 minutes. It has very good adhesion to a wide variety of aggregates. This cement has good water and freeze thaw resistance. It has high bond strength and low shrinkage rates.

ii. Aggregate

Aggregates are inert granular materials such as sand, gravel and crushed stone. Aggregates are generally cheaper than cement and deliver greater volume stability and durability to concrete. The aggregate is used especially for the purpose of providing bulk to the concrete. Aggregate need to be hard, strong, clean and free of absorbed chemicals or coatings of clay that could cause the deterioration of concrete to get a good concrete mix. The aggregate is frequently used in two or more sizes to increase the density of the concrete mix. Aggregate is set between 60 to 75 percentage of the total volume of concrete and commonly divide into two distinct categories which is fine aggregate and coarse aggregate.

Fine aggregate generally consist of natural sand or crushed stone that is the particles are passing through a 4.75 mm sieve. Sand is generally considered to have a lower size limit, which is about 0.07 mm. Then, coarse aggregate consist of crushed gravel or stone that is the particles are retained on the 4.75 mm sieve. Natural gravel and sand are usually dredged from a river, pit, lake or seabed. To produce crushed aggregate, quarry rock, boulders, cobbles or large-size gravel must be crush first. Other than that, recycled concrete is a viable resource of aggregate and it has been used in granular sub-bases, soil-cement and also in new concrete.

The particle-size distribution for aggregate is determined by grading. Grading limits and maximum aggregate size are specified because these properties affect the amount of aggregate used as well as cement and water requirements, workability and durability of concrete. In general, if the water-cement ratio is chosen correctly, a wide range in grading can be used without a major effect on strength. Particle shape and surface texture influence the properties of freshly mixed concrete more than the properties of hardened concrete. To produce workable concrete, angular, rough-textured and elongated particles require more water than smooth and rounded aggregate. Therefore, the cement content also must be increased to maintain the water-cement ratio. The amount of cement paste required for the mix can be affected by the void content between particles. To decrease the void content, the aggregate size must be large enough and improve the grading.

iii. Water

Water is the important ingredient, which are forms a paste that binds the fine and course aggregates together by mixed with cement. The concrete will be hardening through a process called hydration when water, aggregate and cement mix together. Hydration is a chemical reaction in which the major composite in cement form chemical bonds with water molecules and become hydrates. In order to prevent side reactions from occurring which may weaken the concrete, the water needs to be clean or otherwise interfere with the hydration process.

The role of water is important because the water/cement ratio is the most critical factor to produce the concrete. The grade of concrete, type of aggregates, the workability and durability will be influenced the water/cement ratio. The concrete strength will be reduce if too much water is added in concrete, while if too little water is added, the concrete will be unworkable. Concrete needs to be workable so that it may be consolidated and shaped into different forms.

Concrete is susceptible to cracking and shrinkage if water/cement ratio is high. Shrinkage leads to micro-cracks, which are zones of weakness. Excess water will squeeze out of the paste by the weight of the aggregate and the cement paste itself once the fresh concrete is placed. The water bleeds out onto the surface when there is a large excess of water. The usual way to achieve a high strength and high quality concrete is by using a low water/cement ratio, but it does not guarantee that the resulting concrete is always appropriate for concrete countertops. The result of good concrete is come from good mix design and a low water/cement ratio is just one part of a good mix design.

iv. Admixtures

Admixtures are the chemical compounds in concrete other than cement, aggregates and water that are added to the concrete mix immediately before or during mixing to modify the specific properties of concrete. The use of admixtures should not affect the performance of the concrete and should offer an improvement not economically achievable by adjusting the proportions of cement, aggregates and water.

The admixtures have formulated chemical composition and special chemical action that are used to modify certain properties of concrete. They are used essentially to modify the performance of hardened concrete, to ensure the quality of concrete, to reduce the cost of concrete construction and to overcome certain emergencies during concreting operations. The rate of hydration or setting times, workability, dispersion and air-entrainment are the properties that commonly are modified.

The admixture is generally added in a small quantity. To ensure proper quantity of the admixture in concrete, a degree of control must be exercised. Most admixtures are supplied in ready-to-use liquid form. The effectiveness of admixtures depends on several factors including water content, type and quantity of cement, mixing time and temperature of the concrete and air.

2.2.2 Rice Husk

Rice is the seed of the grass species *Oryza sativa* that is one of the most essential commercial food crops. It is grown on almost every continent of the world and large part of the world's population relies on rice as a staple food, especially in Asia. Asia is known as waterlogged tropical areas, which is dominated the production of rice, where rice is the only food crop that can be grown during the rainy season. Therefore, rice is unique unlike other crops that cannot survive in wet environment. Rice production is expected to grow from year to year due to the global demand.

When the harvest season coming, rice from the field was being threshed and harvested to produce the paddy rice. After that, paddy rice moves through the crucial process in post-production of rice, which is milling process. The purpose of a rice milling process is to remove the by-product of rice such as bran layers, rice husk, rice germ and broken kernels, and then produce an edible rice kernel that is free of impurities.

Rice husk is the outermost layer that is covers the rice grain. Rice husk was often considered as waste product. However, rice husk is a potential material, which is for value addition. The usages of rice husk are many either in its raw form or in ash form. Commercially, rice husk, which is grounded with broken rice was being used as animal feed. Furthermore, rice husk can be burned and being used as fuel to power steam engines. Some rice mills generally use this way to dispose the rice husk. By burning the rice husk will result ash and can be used as fertilizer. Other application of rice husk are as fillers and aggregates for concrete and board production. However, most rice husk is simply disposed and causing an environmental problem.

2.3 PREVIOUS STUDIES

2.3.1 Research 1: Experimental Study on Rice Husk as Fine Aggregates in Concrete (Obilade, I.O., Department of Civil Engineering, Osun State Polytechnic, Iree, Nigeria, 2014)

This study was conducted on the effect of weight replacement and volume replacement of fine aggregate with rice husk. The test was conducted based on the workability, compressive strength and bulk density of concrete. Rice husk was being used to replace sand by weight and by volume respectively with 0%, 5%, 10%, 15%, 20% and 25% of the percentage replacement. The mix proportions of concrete that being used was 1:2:4.

2.3.1.1 Methods & Results

i. Compacting Factor Test

To determine the workability of concrete, compacting factor test was carried out on fresh concrete. The results that obtained from the compacting factor test on fresh concrete samples given in Table 2.2.

Table 2.2: Compacting Factor of Rice Husk Concrete

Replacement (%)	0	5	10	15	20	25
Weight Batch	0.91	0.90	0.89	0.89	0.88	0.87
Volume Batch	0.94	0.93	0.93	0.92	0.91	0.91

The compacting factor of both mixes decreased with increase in the percentage replacement of sand by rice husk. This is due to the increase in the quantity of rice husk, thereby requiring more water to make the specimens workable. The workability of the volume-batched concrete is higher than weight-batched concrete. Since sand is denser than rice husk, replacement by an equal mass of rice husk leads to a larger increase in volume than replacement by an equal volume of sand. More water would be required if the quantity of rice husk increase.

ii. Compressive Test

Cubic specimens of concrete with size 150 x 150 x 150 mm were cast for all measurements. The concrete was mixed, placed and compacted in three layers. The samples were demoulded after 24 hours and kept in a curing tank for 7, 14 and 28 days as required. The sample was weighed before being put in the compressive test machine. The results of the compressive strength tests of weight-batched rice husk concrete cubes and volume-batched rice husk concrete cubes are shown in Tables 2.3 and 2.4. The effects of replacement of sand with rice husk on compressive strengths of weight-batched rice husk concrete cubes and volume-batched rice husk concrete cubes are shown in Figures 2.3 and 2.4 respectively.

Table 2.3: Compressive Strengths of Weight-Batched Rice Husk Concrete

Rice Husk Replacement (%)	Compressive Strength(N/mm^2)		
	7 days	14 days	28 days
0	14.72	16.66	22.15
5	12.09	15.84	17.62
10	8.08	11.10	15.31
15	6.36	7.68	14.76
20	5.53	8.14	13.98
25	4.68	6.23	12.62

Table 2.4: Compressive Strengths of Volume-Batched Rice Husk Concrete

Rice Husk Replacement (%)	Compressive Strength(N/mm^2)		
	7 days	14 days	28 days
0	14.91	17.03	23.08
5	12.13	16.64	19.36
10	9.32	13.91	17.37
15	8.80	11.48	15.68
20	7.60	9.81	14.69
25	7.33	8.82	14.47

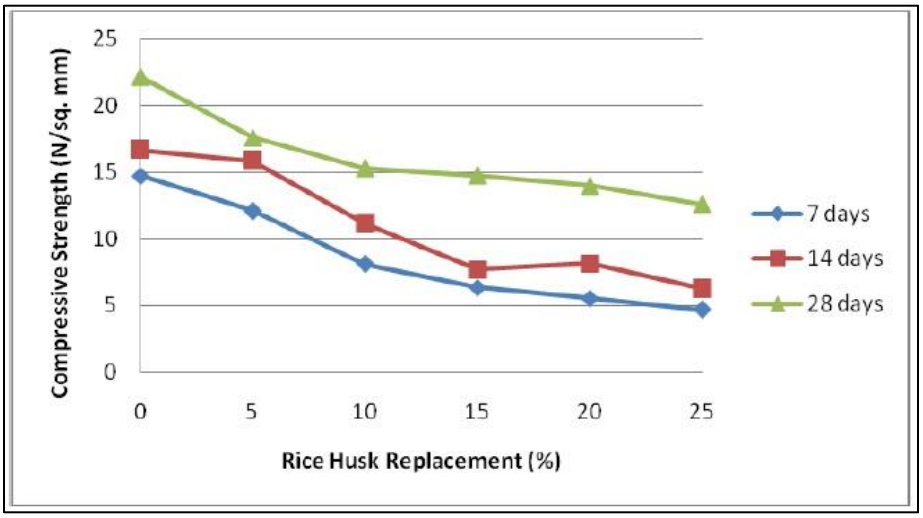

Figure 2.2: Compressive Strengths of Weight-Batched Rice Husk Concrete

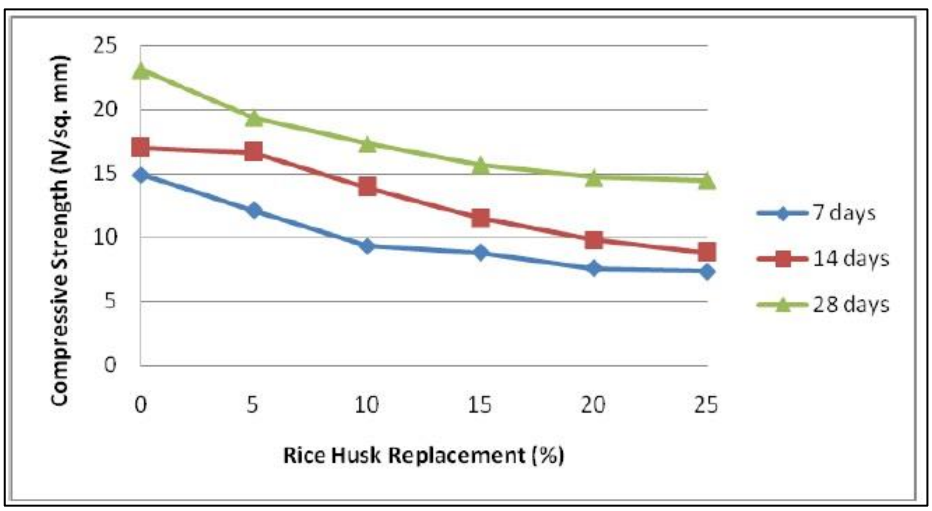

Figure 2.3: Compressive Strengths of Volume-Batched Rice Husk Concrete

It can be observed that the compressive strength decreased as the rice husk content increased. The compressive strength is maximum at 0% replacement by rice husk and minimum at 25% replacement. As rice husk content increases, thus requiring more cement paste to bond effectively with the husks. Since the cement content remains the same, the bonding is inadequate. The compressive strength reduces as a consequence of the increase in percentage of sand.

The 28 days strength for 5% and 10% replacement in the weight-batched rice husk concrete were above the specified value of 15N/mm^2 for Grade 15 lightweight concrete (BS 8110, 1997) as shown in Table 2.5. The 28 day strength for 5%, 10% and 15% replacement in the volume-batched rice husk concrete were above the specified value of 15N/mm^2 for Grade 15 lightweight concrete (BS 8110, 1997) as shown in Table 2.5.

Table 2.5: Recommended grade of concrete

Grade	Characteristic strength	Concrete class
7 10	7.0 10.0	Plain concrete
15	15.0	Reinforced concrete with lightweight aggregate
20 25	20.0 25.0	Reinforced concrete with dense aggregate
30	30.0	Concrete with post tensioned tendons
40 50 60	40.0 50.0 60.0	Concrete with pre tensioned tendons

Source: BS 8110 (1997)

2.3.1.2 Bulk Densities of Concrete Cubes

The bulk densities of weight-batched rice husk concrete and volume-batched rice husk concrete are presented in Tables 2.6 and 2.7 respectively. The variations of density of concrete with rice husk content are shown in Figures 2.4 and 2.5 respectively.

Table 2.6: Bulk Densities of Weight-Batched Rice Husk Concrete

Rice Husk Replacement (%)	Bulk Density (g/cm^3)		
	7 days	14 days	28 days
0	2.31	2.35	2.40
5	2.19	2.21	2.28
10	2.01	2.15	2.25
15	1.98	2.10	2.19
20	1.96	2.05	2.11
25	1.87	1.99	2.01

Table 2.7: Bulk Densities of Volume-Batched Rice Husk Concrete

Rice Husk Replacement (%)	Bulk Density (g/cm^3)		
	7 days	14 days	28 days
0	2.34	2.38	2.43
5	2.31	2.33	2.37
10	2.27	2.28	2.31
15	2.23	2.26	2.29
20	2.18	2.20	2.23
25	2.07	2.09	2.16

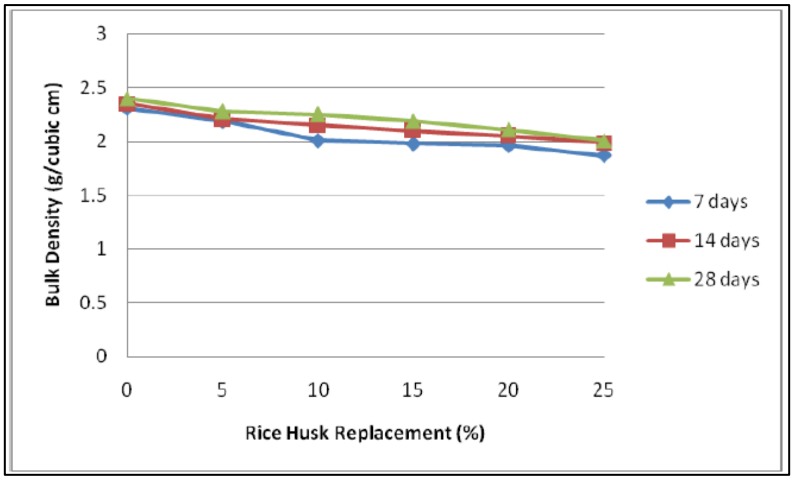

Figure 2.4: Bulk Densities of Weight-Batched Rice Husk Concrete

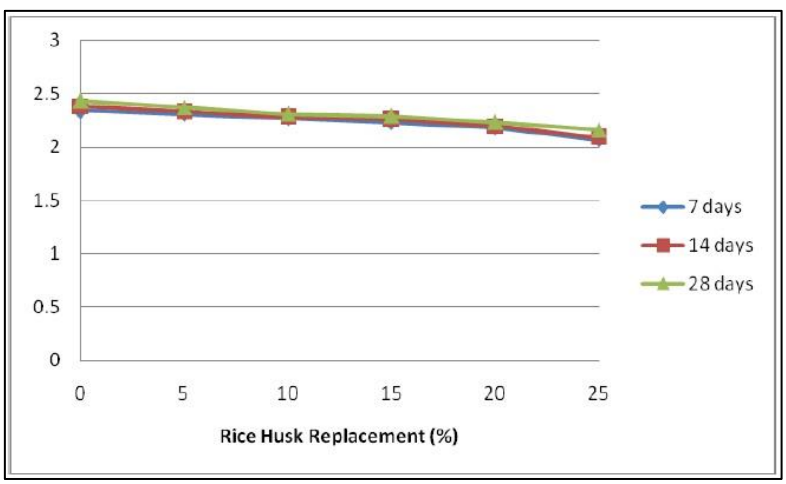

Figure 2.5: Bulk Densities of Volume-Batched Rice Husk Concrete

It can be observed that in both mixes, the density of concrete reduced as percentage content of rice husk increased. However, the densities of both mixes increased with age of curing. The maximum densities occurred at no replacement while minimum densities occurred at 25% rice husk replacement. The minimum 28-day densities of weight-batched rice husk concrete and volume-batched rice husk concrete are $2.01 g/cm^3$ and $2.16 g/cm^3$ respectively.

It can be observed that the rate at which densities decreased with increase in the percentage replacement is higher for the weight-batched rice husk concrete than for volume-batched rice husk concrete. Replacement of sand by equal weight of rice husk leads to larger increase of rice husk in the mix since sand is heavier than rice husk. This leads to an increase in volume without increase in weight which reduces the density.

2.3.1.3 Conclusion

From the investigations carried out, there exists a high potential for the use of rice husk as fine aggregate in the production of lightly reinforced concrete. Weight-batched rice husk concrete and volume-batched rice husk concrete show similar result in the variation of bulk density, workability and compressive strength. Loss of bulk density, workability and compressive strength is higher for weight-batched rice husk concrete than volume-batched rice husk concrete.

2.3.2 Research 2: Partially Replacement of Fine Aggregate by Rice Husk & Egg shells in Concrete (Sathanantham.T, Dinesh.N, Ramesh Kumar.R, Arunachalam, Chandra Sekar, Gowtham.P, Department of Civil Engineering, Jay Shriram Group of Institutions, Avinashipalayam, Tirupur, Tamilnadu, India, 2014)

This study was conducted to investigate the effect of rice husk and egg shells on physical properties of concrete. Egg shells and rice husk were being used to replace sand with 0%, 10%, 20%, 30%, 40% and 50% of the percentage replacement. Concrete grade M_{25} was being used for this study.

2.3.2.1 Methods & Results

i. Split Tensile Strength Test

For this test, 3 columns were made for each and every proportion. The concrete structures were immersed in water after being made. The columns were tested for 7, 14 and 28 days and weighted all of it before being tested. The results are shown in Table 2.8 and Figure 2.6 below.

Table 2.8: Split Tensile Strength Test

EG & RH added %	7 days N/mm^2	14 days N/mm^2	28 days N/mm^2
0	0.62	1.34	2.36
10	0.94	1.5	1.76
20	0.72	1.06	1.43
30	0.37	0.49	1.2
40	0.34	0.42	0.99
50	0.14	0.16	0.21

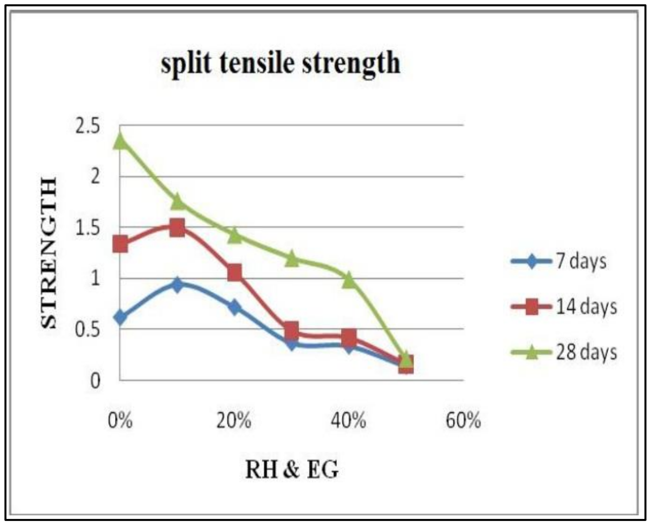

Figure 2.6: Split Tensile Strength Test

ii. Compaction Test

3 cubes were being made for each and every proportion. All cubes were being immersed in water and being tested for 7, 14 and 28 days. Before tested, all cubes are weighted. The results are shown in Table 2.9 and Figure 2.7 below.

Table 2.9: Compaction Test

EG & RH added %	7 days N/mm^2	14 days N/mm^2	28 days N/mm^2
0	14.97	22.03	24
10	13.78	20.11	22.33
20	15.33	22.33	24.32
30	14.21	16.89	21.42
40	8.78	9.55	14.16
50	2.78	3.06	9.67

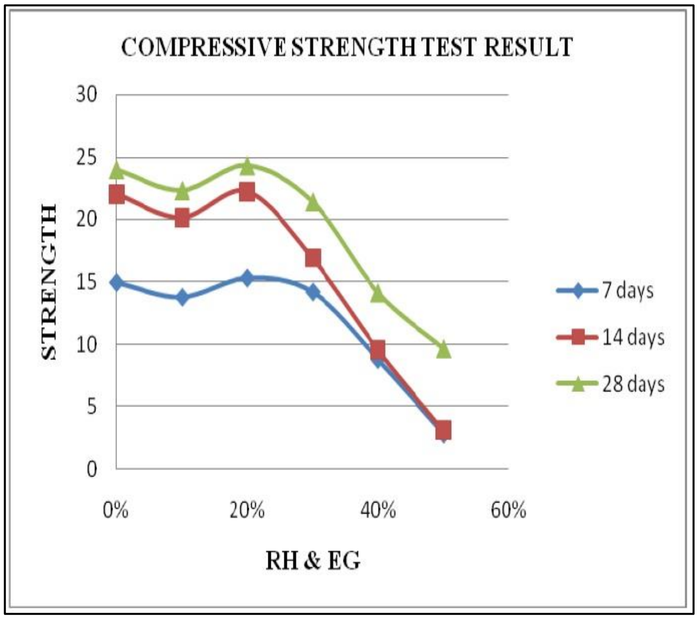

Figure 2.7: Compaction Test

iii. Flexural Test

For each and every proportion, 3 beams were being made for this test and then being immersed in water. The beams were weighted before being tested. All beams were being tested for 7, 14 and 28 days. The results are shown in Table 2.10 and Figure 2.8 below.

Table 2.10: Flexural Test

EG & RH added %	7 days N/mm^2	14 days N/mm^2	28 days N/mm^2
0	1.6	2.2	2.86
10	0.53	1.12	1.82
20	0.8	1.2	2.01
30	0.4	0.44	1.68
40	0.29	0.36	1.47
50	0.16	0.29	0.99

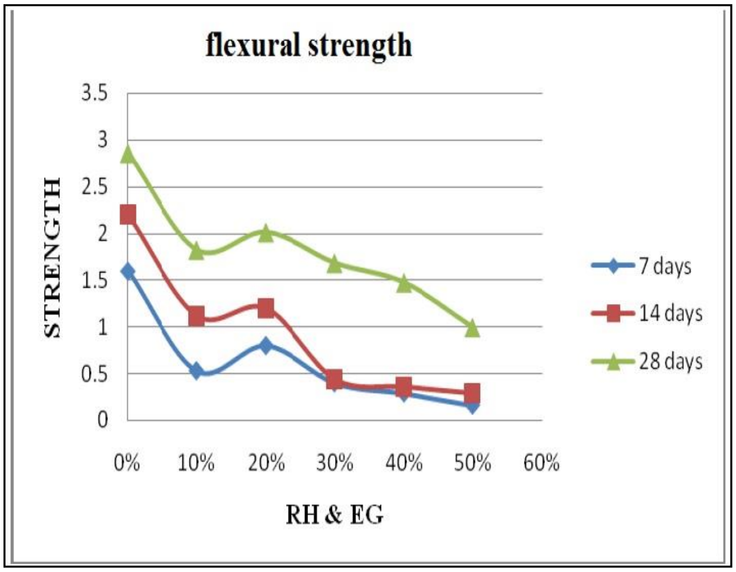

Figure 2.8: Flexural Test

2.3.2.2 Conclusion

Based on the analysis in the experimental work that being carried out, the tensile strength and flexural strength of concrete was decreased with increasing the percentage of egg shells and rice husk. The tensile strength was decreased from 2.36 N/mm^2 to 0.21 N/mm^2 with increasing egg shells and rice husk from 0% to 50%. The compressive strength of concrete meet the required strength with 20% of the egg shells and rice husk at the same time weight of the cubes were reduced up to 2 kg to 2.8 kg.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter describes the methodological aspects used in collecting, analyzing and evaluating the data. Methodology refers to various sequential steps in studying a problem with certain objective in view. It describes the methods and process applied in the entire subject of the study. It is the way to study systematically about the research problem.

In order to complete the report, various methods will be applied. The data will be collected from many sources. Most of the information will be gathered through the articles, journals and websites. Under this chapter, it includes introduction, methodology flow chart, materials preparation, concrete mix design, the principles of parameter used and tests conducted. The main objective of this chapter is to explain various methods for testing and materials used for data collection, analysis and evaluation. They are discussed in detail in this chapter.

3.2 METHODOLOGY FLOW CHART

The methodology or process can be shown in the figure below:

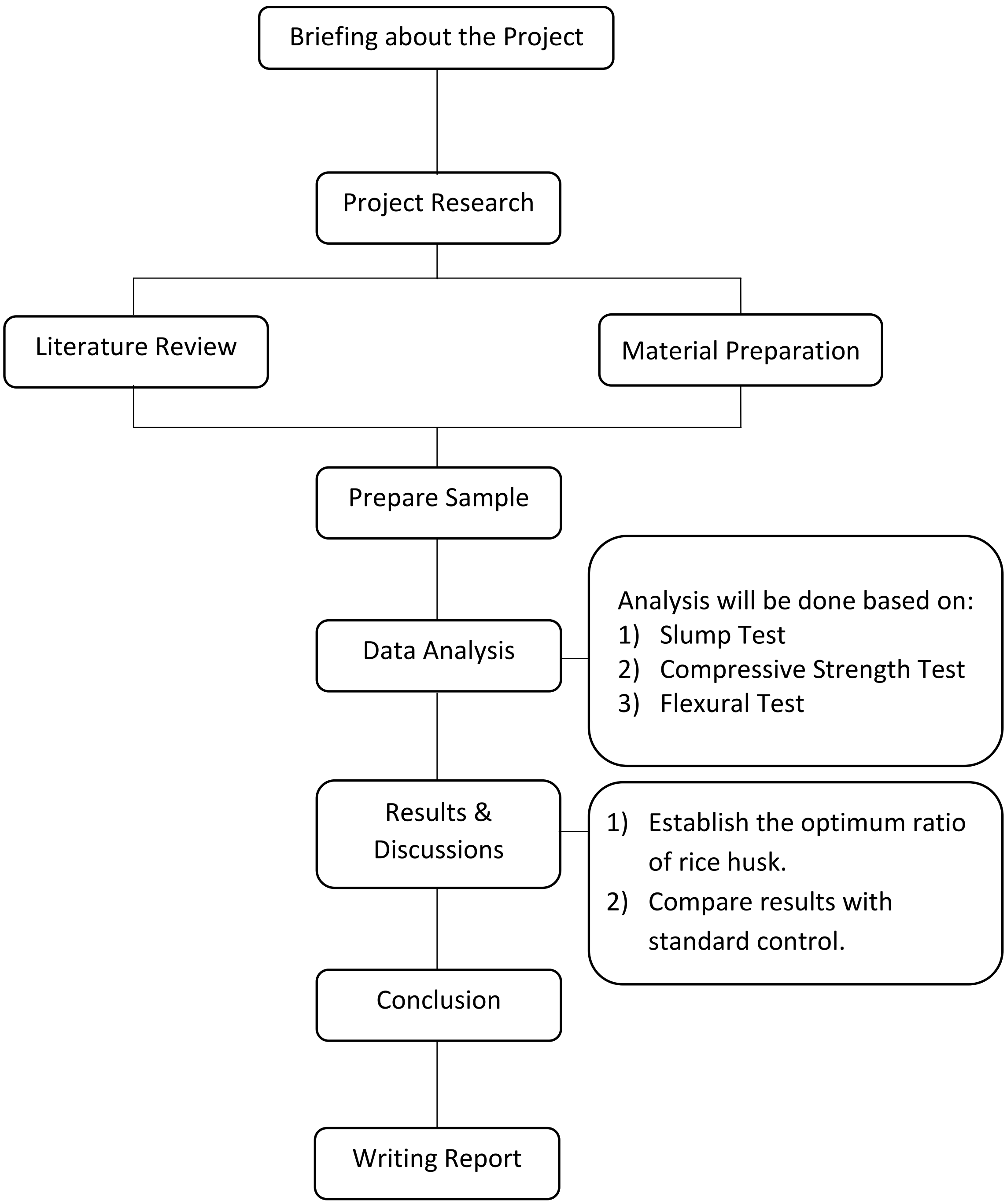

Figure 3.1: Methodology Flow Chart

3.3 MATERIALS PREPARATION

Materials used for this study are listed below.

3.3.1 Cement

Composite Portland cement was used in this study which is commonly used for construction building. The cement was stored away from air moisture in the concrete laboratory to ensure the cement was in good condition during the experimental period.

3.3.2 Coarse Aggregate

For this study, granite was used in concrete mixing. Granite is formed naturally from stone that was quarried and crushed to produce various sizes of aggregate. Commonly, it is used in construction industry as coarse aggregate. The aggregate used was cleaned and dried before concrete mixing.

3.3.3 Fine Aggregate

The fine aggregate that used for concrete mixing in this study was mining sand. Mining sand was selected because it easier to obtain and it was free from clay, organic material and chemical compared to river sand. The mining sand was checked to ensure that it was free from other organic materials inside before used it.

3.3.4 Water

Tap water was chosen for the concrete mixing and curing process in this study. Water is considered as an important ingredient that required for concrete mixing. The pH value and impurities in the water may affect the compressive strength and setting time of the concrete. The quality of tap water that being used satisfied the requirements for concrete mixing.

3.3.5 Rice Husk

The rice husk sample was collected from local rice mill. The amounts of collected rice husk samples were approximately 14 kilograms. The rice husk samples were dried in oven for 24 hours to avoid deterioration due to moisture content.

3.4 CONCRETE MIX DESIGN

Concrete mix design may be defines as the process of selecting the appropriate materials of concrete and determining their relative proportions with the materials of producing concrete as economical as possible. The purpose is to ensure the most optimum proportions of the component materials to fulfill the requirement of the structure being built. The other purposes of concrete mix design are to achieve the desired workability in the plastic stage, minimum strength in hardened stage, durability in the given environment conditions and produce concrete as economically as possible.

The design mix is being used widely in variety of important structures due to better strength, reduced variability, leaner mixed with consequent economy as well as greater assurance of resultant quality. Table 3.1 shows the calculated mix design for this study.

Table 3.1: Concrete Mix Design

Percentage Replacement, (%)	Water, kg	Cement, kg	Aggregate		Rice Husk, kg
			Fine, kg	Course, kg	
0	35	61	188.14	160.27	0
5	35	61	178.43	160.27	2.34
10	35	61	169.04	160.27	4.67
15	35	61	159.65	160.27	7.01

3.5 THE PRINCIPLES OF PARAMETER USED

There are a few of parameters used in this study for testing the concrete. The parameters that are involved as follows:

i. Compressive Strength

Under a gradually applied load, a given material can sustain without fracture, which is can be defined as the maximum compressive stress, in other words compressive strength. Compressive strength is an important value for design of structures.

ii. Density

Density of concrete depending on the amount and density of the aggregate, entrained air, water and cement content. Density is simply a mass to volume ratio. Perhaps the easiest and most accurate way to calculate the concrete density is to measure some into a container of known volume and weighing it.

iii. Workability

Workability is a measure of the ease with which a fresh concrete can be handled and placed. It is indicative of the wetness of the concrete mixture.

3.6 TESTS CONDUCTED

Concrete used in construction industry has to meet strict regulations and quality standard. As these standards are often compulsory, there are several of test must be conduct to evaluate and ensure the quality of concrete. Slump test, Compressive strength test and Flexural strength test were done in this study to determine the properties of the concrete samples.

3.6.1 Slump Test

Slump test was conducted to measure the workability of concrete. According to Gambhir, 2004, workability can be defined as the property of fresh concrete which determines the ease in handling, placed, consolidating and compacting and the degree to which it is resists segregation. The apparatus of slump test consists of slump cone, base plate, tamping rod and measuring scale. Internal surface of the cone should be cleaned properly. Then, the base plate should be placed on a horizontal and smooth surface. Filled the cone with fresh mixed concrete in 3 layers. Tamped 25 times by using tamping rod for each layers. After filling is completed and concrete is leveled, slowly lifted the cone in the vertical direction. Placed the cone besides the slump concrete and placed the tamping rod over the cone to measure the slump. The decrease in the height of the center of the slump concrete is called slump and is noted with measuring scale.

The slump consists of three types which are collapse slump, shear slump and true slump. True slump can be characterized as the general drop of the concrete mass evenly without visible signs of deterioration or disintegration. Then, concrete completely collapse due to the mix is too wet and considered to be harsh and lean for a collapse slump. For a shear slump, the top portion of the concrete slips sideways and shears off. The slump is called a shear slump if half of the cone slides down an inclined plane. This type of slump indicates deficient in cohesion of the concrete mix and leads to segregation and bleeding. A fresh concrete sample should be taken and the test is repeated if achieved a shear or collapse slump.

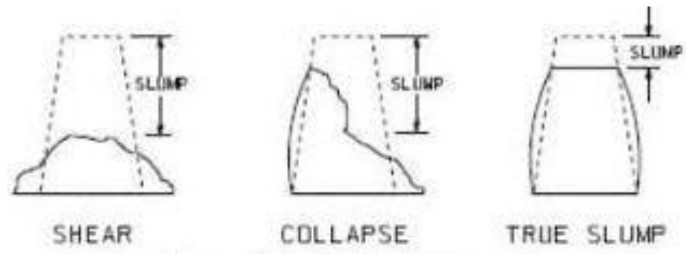

Figure 3.2: Types of Concrete Slumps

Source: M.L. Gambhir (2009)

3.6.2 Compressive Strength Test

The objective of this test is to determine the compressive strength of concrete. Strength of concrete is directly related to the structure of cement paste, which is gives an overall picture of the quality of concrete. Compressive strength testing machine which located in concrete laboratory was used to conduct this test. This test was conducted with the standard dimension of 150 mm x 150 mm x 150 mm. By using oil, lubricate the inside of the cube moulds thoroughly to avoid from adhere to the moulds. Fresh concrete was poured into the moulds and properly compacted by using vibration table to prevent from having any voids. Then, the moulds are kept for 24 hours for concrete setting. After 24 hours, the moulds were removed and the specimens were put into the water tank for curing process.

These specimens were tested by compressive strength testing machine after 7, 14 and 28 days curing. The load was applied slowly and continuously increased until the resistance of the specimens to the increased load breaks down and cannot sustained anymore. The results were noted and the maximum load that is applied to the specimens was being recorded to bring out in the report.

Figure 3.3: Compressive Strength Test

3.6.3 Flexural Strength Test

Flexural strength test is used to determine the flexural modulus or flexural strength of a material. Generally, three core stresses were presented, which is tensile, compressive and shear when a specimen was placed under flexural loading. Therefore, the flexural properties of a specimen are the result of the combined effect of all three stresses as well as the geometry of the specimen and the rate the load is applied.

For flexural strength test, beam specimens of dimension 150 mm x 150 mm x 750 mm were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing place where in they were allowed to cure for 7, 14 and 28 days. These flexural strength specimens were tested under four point load machine, which is the machine consist of two supports and two loading points. The load is normally increased & failure load is noted at cracking of beam specimen. In each category, three beams were tested and their average value is reported.

Figure 3.4: Flexural Strength Test

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

The emissions results for the each test are presented in this chapter. The results are presented in table and graph form. The results displayed include slump height, maximum load, maximum compressive strength and maximum flexural strength. These results are utilized to determine properties of concrete with rice husk as partial replacement of fine aggregate or sand and evaluate optimum ratio of rice husk in modified concrete. The results generated at this stage of the study formed a set of data of modified concrete that was further used in the analysis and comparison with control concrete.

4.2 SLUMP TEST

The slump test is a method used to determine the consistency of concrete. The consistency or stiffness of the concrete shows the fluidity of the concrete indicating how much water has been used in the mix, and is often measured by concrete slump. Table 4.1 and Figure 4.1 shown variation in slump for 0%, 5%, 10% and 15% of mix proportion replacement of sand with Rice Husk concrete.

Table 4.1: Slump Test

Percentage Replacement, (%)	Slump Height, (mm)
0	64
5	57
10	53
15	43

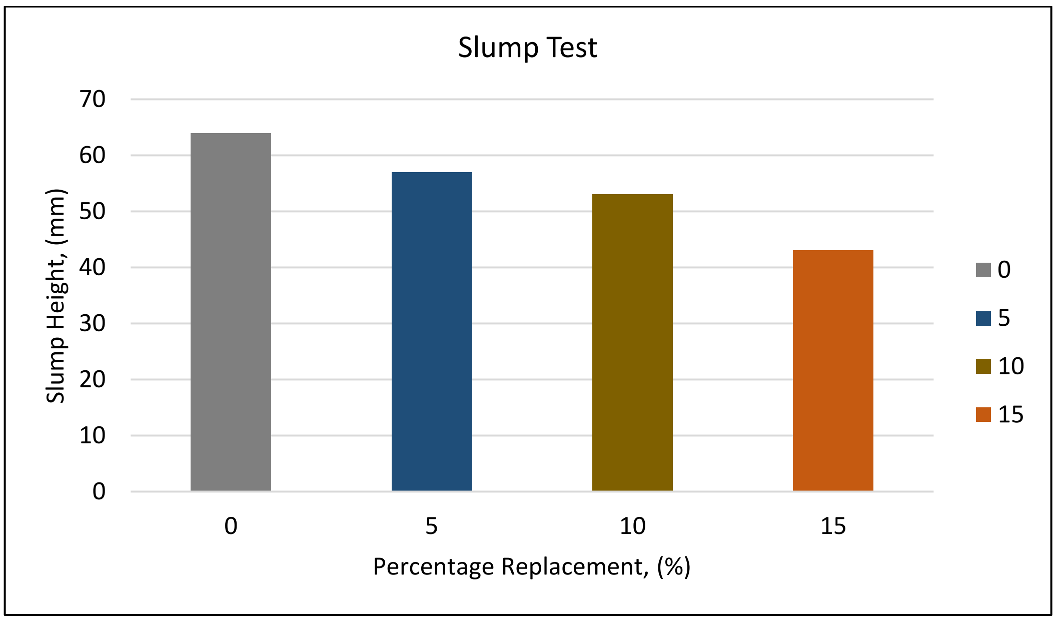

Figure 4.1: Slump Test for all mix proportion

Figure 4.1 shown the decreasing value of slump height from 0% replacement mix proportion to 15% replacement mix proportion. The reason of this reduction maybe because of the characteristic of the rice husk, which was water absorbing. It can be seen that the highest value was 64 mm, which goes to 0% replacement mix proportion while the lowest value was 43 mm that obtained from 15% replacement mix proportion. The concrete mixture and the ratios of ingredients affect the workability of the concrete's final strength (water/cement ratio). In terms of workability, the higher the slump value, the higher the amount of water and as a result the mixture is more fluid for working the concrete and finishing. Therefore, 0% replacement mix proportion was found to be the highest workability among the other mix proportion.

4.3 COMPRESSIVE STRENGTH TEST

Compressive Strength Test indicates the major compressive strength which was carried out according to ASTM C-39. The sample cubes with the dimension of 150 mm x 150 mm x 150 mm were tested. The sample cubes were cured in water and tested for compressive strength at the curing age of 7, 14 and 28 days. The compressive strength average was taken from the result of three sample cubes. Table 4.2, Table 4.3 and Table 4.4 show the result of average compressive strength of the different Rice Husk replacement sample cubes with curing period of 7, 14 and 28 days. The effects of replacement of sand with Rice Husk on average compressive strengths of the different Rice Husk replacement sample cubes with curing period of 7, 14 and 28 days are shown in Figures 4.2, Figure 4.3 and Figure 4.4 respectively.

Table 4.2: Compressive Strength Test for 7 days curing period

Percentage Replacement, (%)	Load, (kN)	Compressive Strength, (Mpa)
0	542.023	24.090
5	317.037	14.090
10	216.192	9.609
15	166.381	7.394

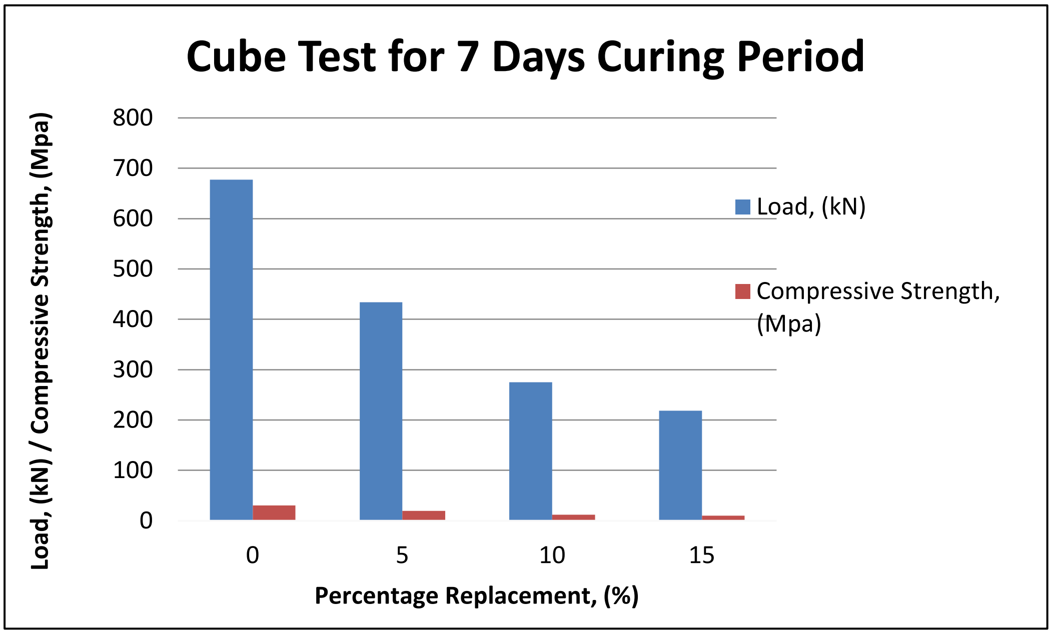

Figure 4.2: Compressive Strength Test for 7 days curing period

Table 4.3: Compressive Strength Test for 14 days curing period

Percentage Replacement, (%)	Load, (kN)	Compressive Strength, (Mpa)
0	677.482	30.110
5	433.902	19.284
10	275.283	12.234
15	218.712	9.721

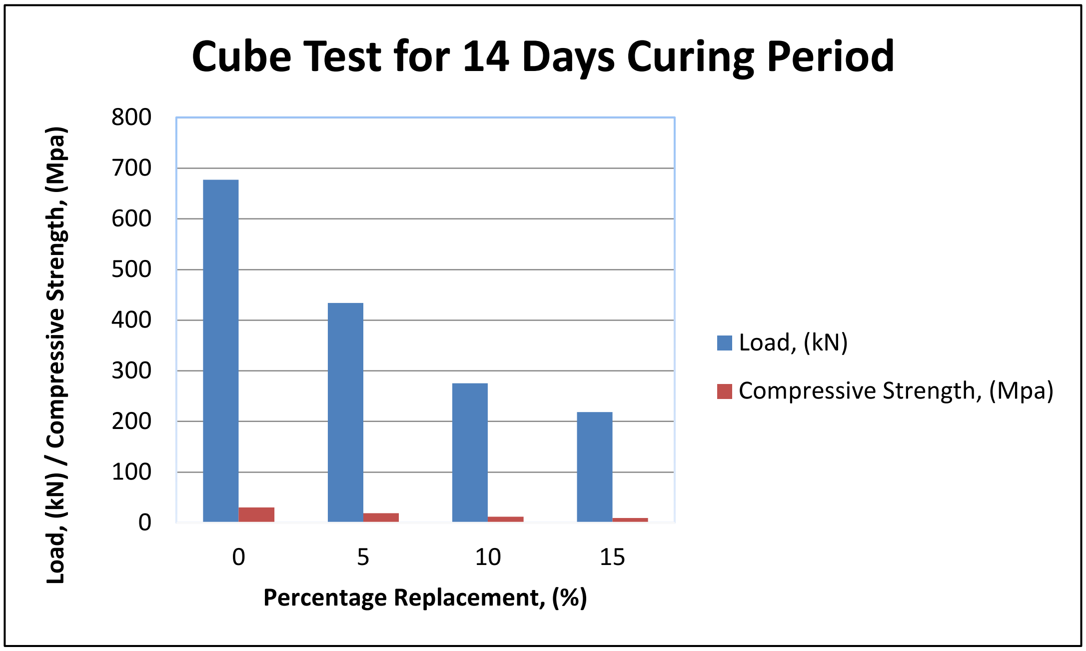

Figure 4.3: Compressive Strength Test for 14 days curing period

Table 4.4: Compressive Strength Test for 28 days curing period

Percentage Replacement, (%)	Load, (kN)	Compressive Strength, (Mpa)
0	746.589	33.182
5	530.515	23.579
10	338.718	15.054
15	275.330	12.237

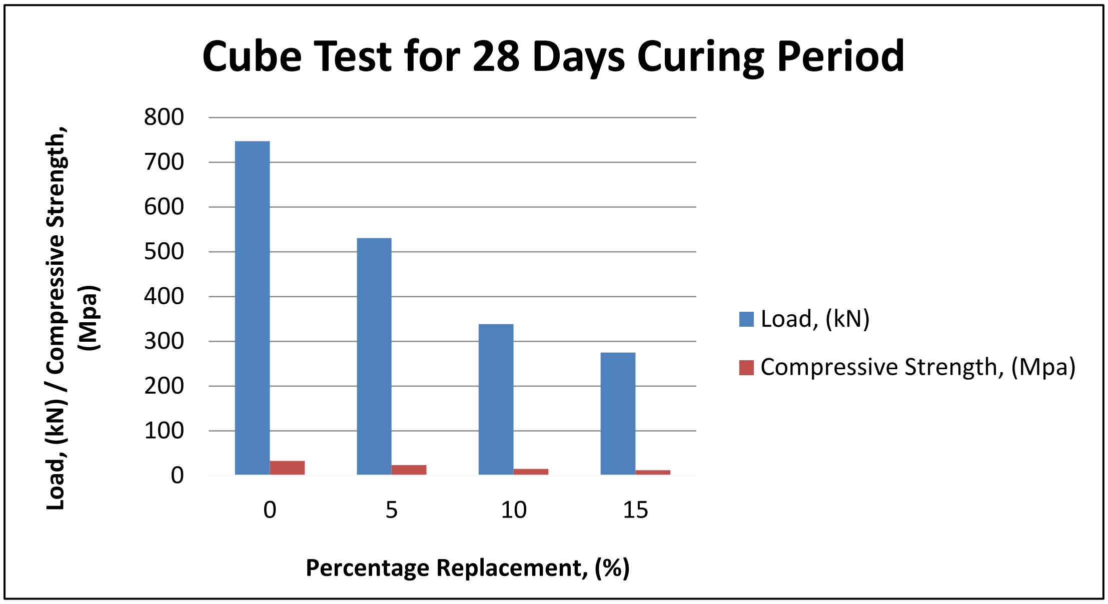

Figure 4.4: Compressive Strength Test for 28 days curing period

The test results indicate that Rice Husk addition caused a decrease in load and compressive strength of the concrete depending upon the Rise Husk content. It can be clearly observed that a clear downward trend in both load and compressive strength for all graph of 7, 14 and 28 days curing period. The load and compressive strength was highest at 0% replacement of sand with Rice Husk concrete, 542.023 kN and 24.090 Mpa respectively and minimum at 15% replacement of sand, which the load and compressive strength were obtained to be 166.381 kN and 7.394 Mpa respectively for 7 days curing period. At 14 days curing period, the highest load and compressive strength goes to 0% replacement of sand with Rice Husk concrete, which found to be 677.482 kN and 30.110 Mpa while the lowest value goes to 15% replacement of sand with Rice Husk concrete, which the load was 218.712 kN and compressive strength was 9.721 Mpa. Then, for 28 days curing period presented the highest value of load and compressive strength, 746.589 kN and 33.182 Mpa, respectively at 0% replacement of sand with Rice Husk concrete. Conversely, the lowest value of load, 275.330 kN and compressive strength, 12.237 Mpa goes to 15% replacement of sand with Rice Husk concrete at 28 days curing period.

This reduction in load and compressive strength may be attributed to the pore structure induced by Rice Husk addition. As Rice Husk content increases, the specific area increases, thus requiring more cement paste to bond effectively with the Rice Husks. Since the cement content remains the same, the bonding is therefore inadequate. The load and compressive strength reduces as a consequence of the increase in percentage of Rice Husk. It can be observed that the 28 day curing period compressive strength for 5% and 10% replacement of sand with Rice Husk concrete were above the specified value of 15 Mpa, which are 23.579 Mpa and 15.054 Mpa respectively. Therefore, the concrete produced in this study can be classified as lightweight concrete (BS 8110, 1997) as shown in Table 4.5.

Table 4.5: Recommended grade of concrete

Grade	Characteristic strength, Mpa	Concrete class
7	7.0	Plain concrete
10	10.0	
15	15.0	Reinforced concrete with lightweight aggregate
20	20.0	Reinforced concrete with dense
25	25.0	aggregate
30	30.0	Concrete with post tensioned tendons
40	40.0	
50	50.0	Concrete with pre tensioned tendons
60	60.0	

Source: BS 8110 (1997)

After the examination of many specifications, it has been noted that compressive strength is the most important property of concrete. However, this may not always be correct as workability and bond are also of great significant. The maximum load results reported in Table 4.6 and Figure 4.5 while maximum compressive strength results shown in

Table 4.7 and Figure 4.6 that presented in the form of graphical variation, where in the maximum load and compressive strength were plotted against the curing period.

Table 4.6: Maximum Load of Compressive Strength Test in kN

Curing Period, (Day)	Percentage Replacement, (%)			
	0	5	10	15
7	542.023	317.037	216.192	166.381
14	677.482	433.902	275.283	218.712
28	746.589	530.515	338.718	275.330

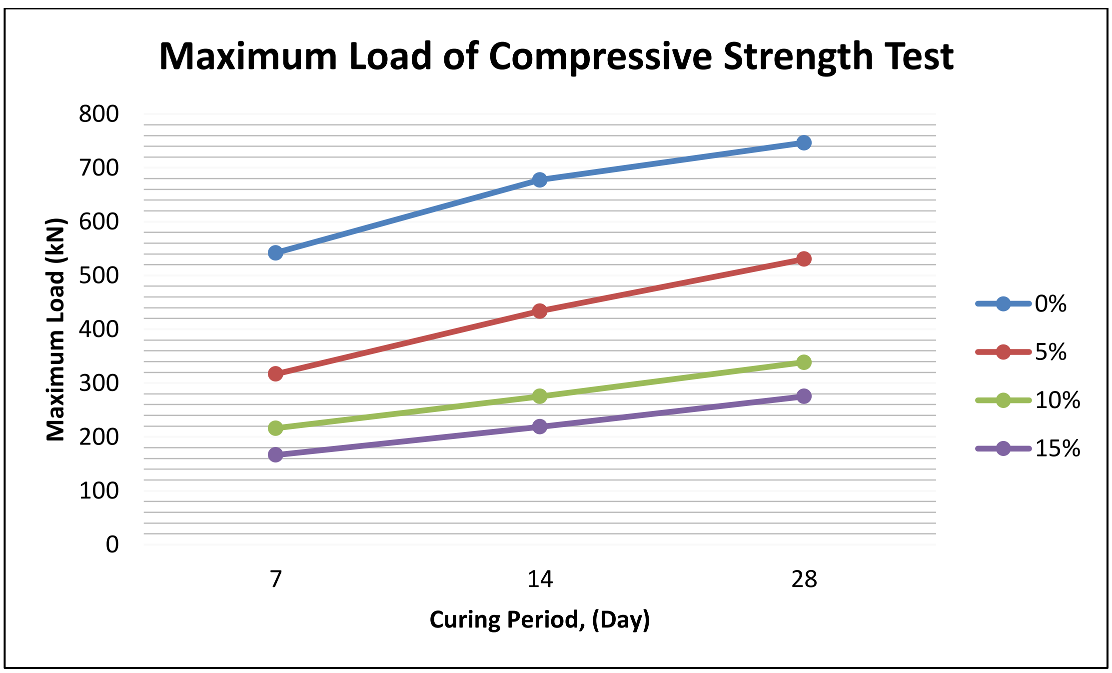

Figure 4.5: Maximum Load of Compressive Strength Test in kN

Table 4.7: Maximum Compressive Strength of Compressive Strength Test in Mpa

Curing Period, (Day)	Percentage Replacement, (%)			
	0	5	10	15
7	24.090	14.090	9.609	7.394
14	30.110	19.284	12.234	9.721
28	33.182	23.579	15.054	12.237

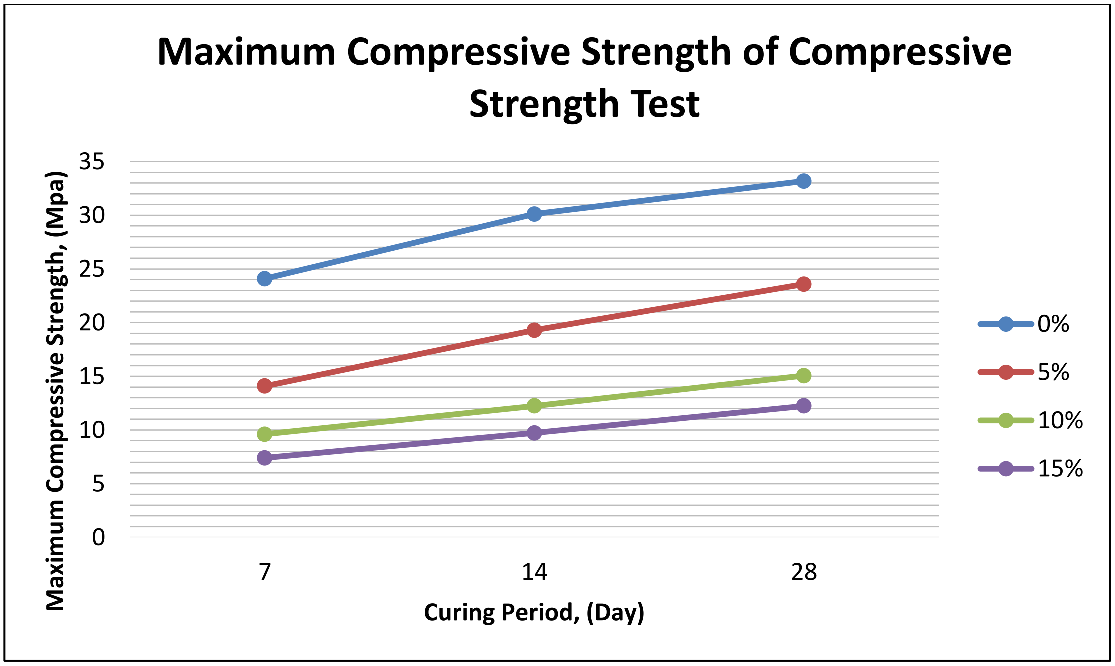

Figure 4.6: Maximum Compressive Strength of Compressive Strength Test in Mpa

Table 4.6 and Figure 4.5_display the maximum load for all four different mix proportions over curing period of 7 days, 14 days and 28 day under water curing. Meanwhile, Table 4.7 and Figure 4.6 display the maximum compressive strength for all four different mix proportions over curing period of 7 days, 14 days and 28 day under water curing. From the figures, it is clear that as the curing period advanced, the maximum load and compressive strength increased. All mix proportion shown the same pattern for both maximum load and compressive graph, which was found to be gradually increased from day 7 to day 28 of curing period. It can be clearly observed that the specimen of 0% replacement of sand with Rice Husk concrete has highest value for both maximum load and compressive strength among all three mix proportions, followed by 5%, 10% and 15% of mix proportion at 28 days curing period, which the maximum load was found to be 746.589 kN and maximum compressive strength was 33.182 Mpa. Meanwhile, the specimen of 15% replacement of sand with Rice Husk concrete of 28 days curing period obtained the lowest maximum load of 275.330 kN and the lowest compressive strength of 12.237 Mpa among all mix proportions.

4.4 FLEXURAL TEST

The tests for flexural strength of concrete were conducted for different rice husk ratio with ratio of 5 %, 10% and 15% replacement of sand with Rice Husk concrete from the basic concrete grade C25/30 at the curing period of 7 days, 14 days and 28 days. The results are compiled in the given below. Table 4.8 and Figure 4.7 shows the effects of rice husk on flexural strength of 0% replacement of sand with Rice Husk concrete (Control concrete).

Table 4.8: Flexural Test for Control concrete

Curing Period, (Day)	Load, (kN)	Flexural Strength, (Mpa)
7	24.53	5.452
14	28.12	6.249
28	26.32	5.820

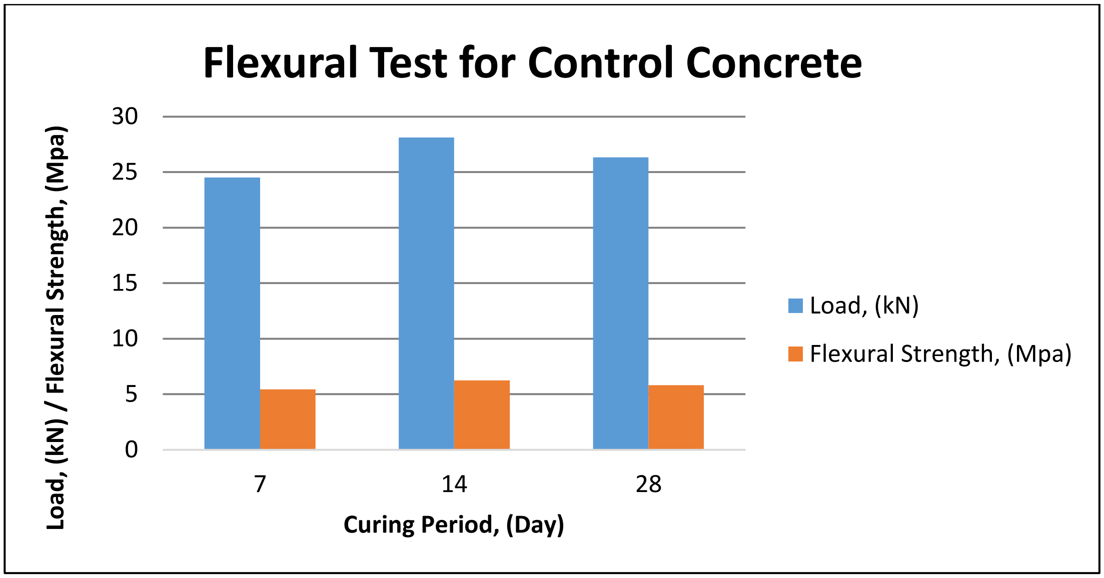

Figure 4.7: Flexural Test for Control concrete

The result showed the load and flexural strength of test for control concrete between the 7 days and 28 days of curing period. It can be seen that both increased from day 7 to day 14 of curing period and then dropped slightly from day 14 to day 28 of curing period. At 7 days curing period, it shown the lowest of load and flexural strength value obtained among the other curing period, which the load and compressive strength were 24.53 kN and 5.452 Mpa, respectively. The highest value of load and compressive strength goes to 14 days curing period, 28.12 kN and 6.249 Mpa, respectively.

The other variations of effects of concrete with rice husk content on flexural strength were shown in Table 4.9, 4.10, 4.11 and Figures 4.8, 4.9 and 4.10, respectively for 5%, 10% and 15% replacement of sand with Rice Husk concrete on 7, 14 and 28 days curing period.

Table 4.9: Flexural Test for 5% of Rice Husk Concrete

Curing Period, (Day)	Load, (kN)	Flexural Strength, (Mpa)
7	23.35	5.188
14	28.05	6.233
28	34.145	7.588

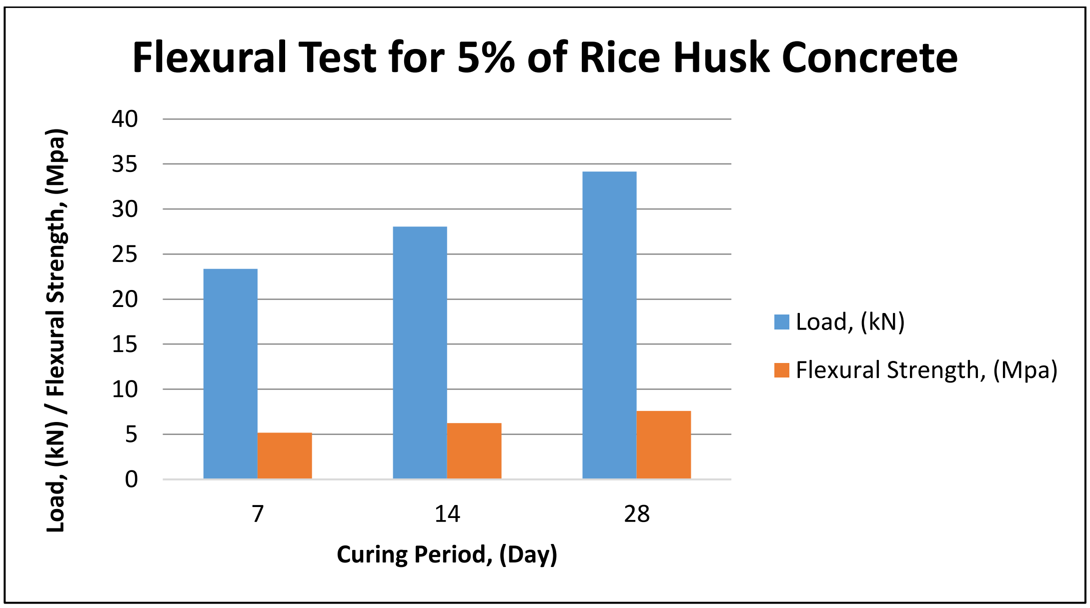

Figure 4.8: Flexural Test for 5% of Rice Husk Concrete

Table 4.10: Flexural Test for 10% of Rice Husk concrete

Curing Period, (Day)	Load, (kN)	Flexural Strength, (Mpa)
7	15.14	3.365
14	19.06	4.235
28	20.53	4.561

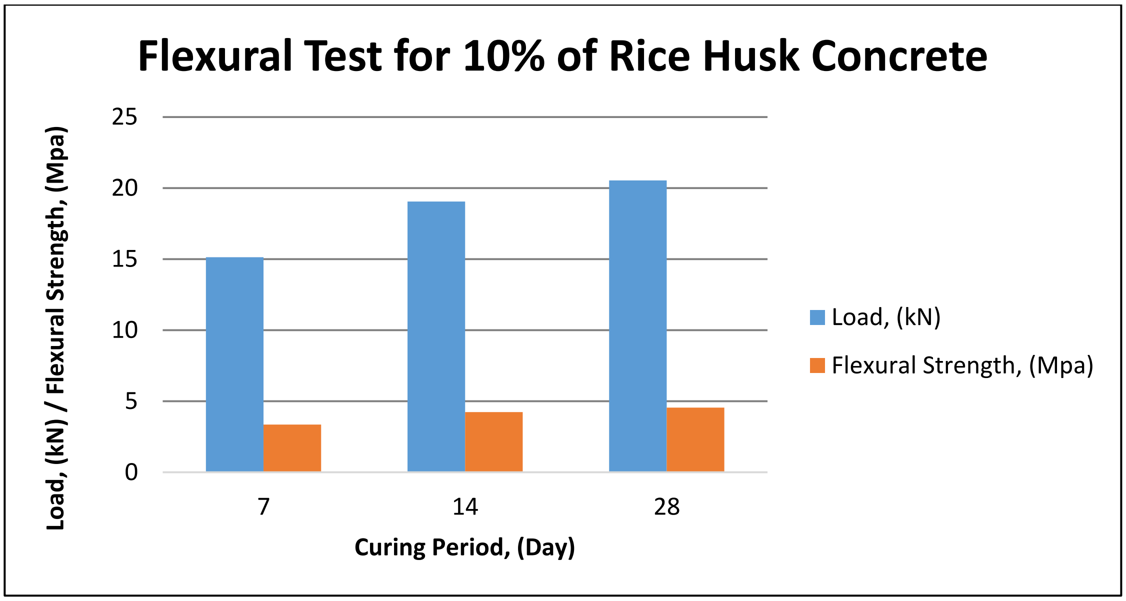

Figure 4.9: Flexural Test for 10% of Rice Husk concrete

Table 4.11: Flexural Test for 15% of Rice Husk concrete

Curing Period, (Day)	Load, (kN)	Flexural Strength, (Mpa)
7	11.64	2.586
14	13.95	3.099
28	21.47	4.772

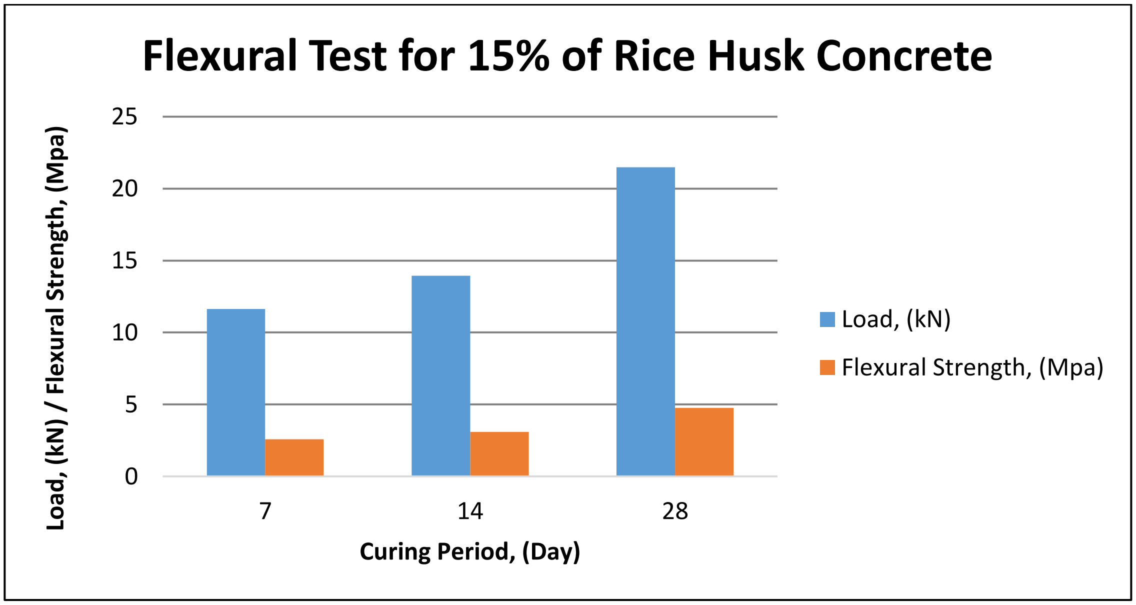

Figure 4.10: Flexural Test for 15% of Rice Husk concrete

Generally, the flexural strength increase with increasing curing period for all mix proportions. It can be observed that in these three mix proportion, the load and flexural strength were increased reasonably. The results shown that the specimen 5%, 10% and 15% replacement of sand with Rice Husk concrete were found to be the highest value of load and flexural strength at 28 days curing period. Conversely, the lowest value of load and flexural strength goes to 7 days curing period for these three mix proportion. At Table 4.9 and Figure 4.8, load and flexural strength at 28 days curing period were found to be 34.145 kN and 7.588 Mpa, respectively for 5% replacement of sand with Rice Husk concrete.

Then, at Table 4.10 and Figure 4.9 shown the highest value of load, 20.53 kN and flexural strength, 4.561 Mpa obtained from 28 days curing period for 10% replacement of sand with Rice Husk concrete. Last but not least, from Table 4.11 and Figure 4.10, it can be seen that for 10% replacement of sand with Rice Husk concrete, 28 days curing period presented the highest value of load that was 21.47 kN while the flexural strength was 4.772 Mpa.

The maximum load results obtained in Table 4.12 and Figure 4.11 while maximum flexural strength results shown in Table 4.13 and Figure 4.12 that revealed in the form of graphical variation, where in the maximum load and flexural strength were plotted against the curing period.

Table 4.12: Maximum Load of Flexural Test in kN

Curing Period, (Day)	Percentage Replacement, (%)			
	0	5	10	15
7	24.53	23.35	15.14	11.64
14	28.12	28.05	19.06	13.95
28	26.32	34.15	20.53	21.47

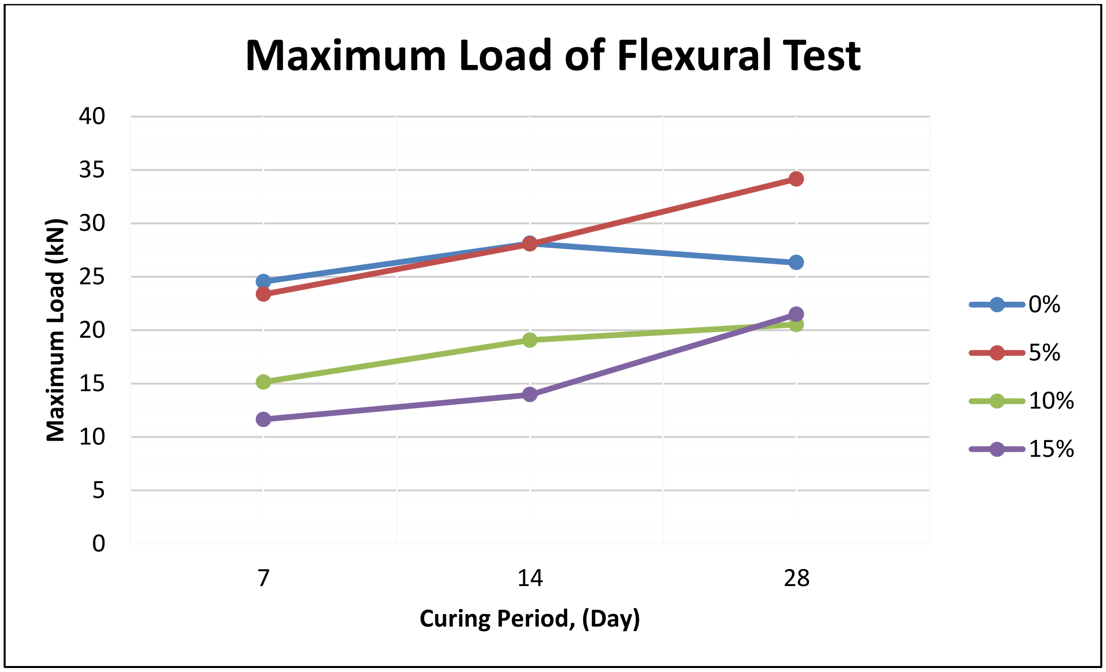

Figure 4.11: Maximum Load of Flexural Test in kN

Table 4.12 and Figure 4.11 shown maximum load for all mix proportion. From the graph, it can be seen that 0% replacement of sand with Rice Husk concrete maximum load was increased from day 7 to day 14 of curing period and it decreased at day 28. For the other mix proportion, the maximum load was gradually increased properly until day 28 of curing period. At 28 days curing period, it goes to specimen 5% replacement of sand with Rice Husk concrete, which was the highest maximum load, 34.15 kN among the other mix proportion. Meanwhile, specimen 10% replacement of sand with Rice Husk concrete was reported to be the lowest maximum load, 20.53 kN.

Table 4.13: Maximum Flexural Strength of Flexural Test in Mpa

Curing Period, (Day)	Percentage Replacement, (%)			
	0	5	10	15
7	5.452	5.188	3.365	2.586
14	6.249	6.233	4.235	3.099
28	5.820	7.588	4.561	4.772

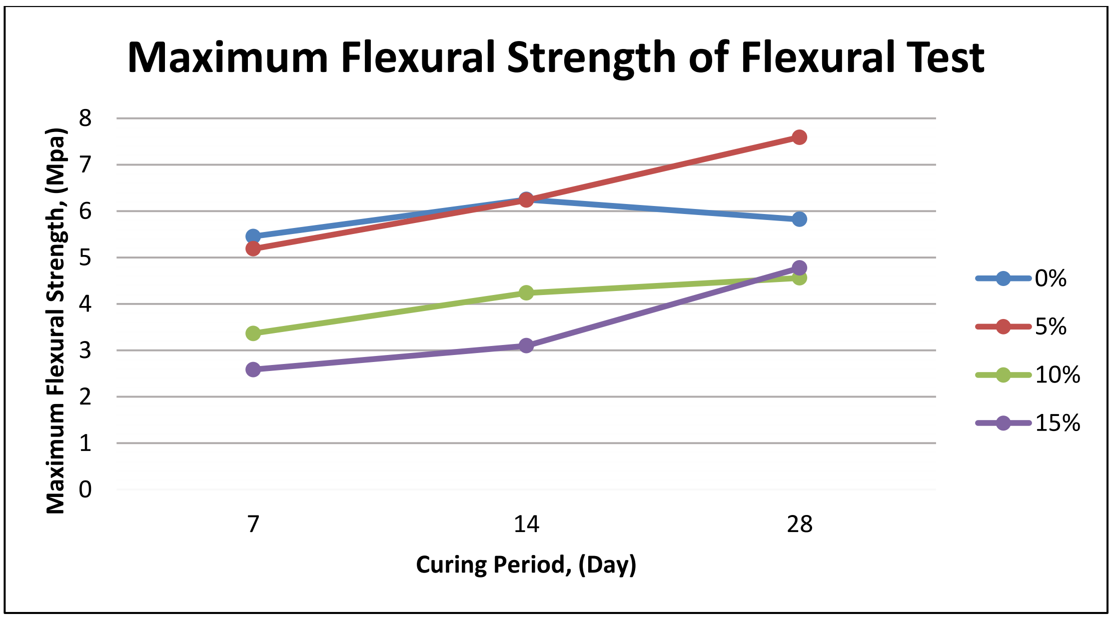

Figure 4.12: Maximum Flexural Strength of Flexural Test in Mpa

The experimental results of the maximum flexural strength for all mix proportion are presented in Tables 4.13 and graphically were shown in Figure 4.12. It can be seen from the graph on Figure 4.12 that the specimens of 0% replacement of sand with Rice Husk concrete was slightly increased to day 14 of curing period and then it decreased from day 14 to day 28. The result should be continuous increase until day 28 to get the true maximum strength. The reason for this reduction maybe because of the cement used for this mix proportion. The cement used for this mix proportion was the old cement that available in laboratory, which was exposed to the air for a long time. For other three mix proportion of 5%, 10% and 15%, the cement used was the new cement that arrived from factory at that moment. Maybe the condition of cement effect the strength of this mix proportion and caused the reduction of flexural strength. From the results, it is noticed that the specimen of 5% and 15% replacement of sand with Rice Husk concrete increased until day 28 with same pattern. Meanwhile, the specimen of 10% replacement of sand with Rice Husk concrete also increased from day 7 to day 14 and slightly increased to day 28. At day 28, 5% replacement of sand with Rice Husk concrete mix proportion presented the highest maximum flexural strength value, 7.588 Mpa, and the lowest strength value presented by 10% replacement of sand with Rice Husk concrete mix proportion, 4.561 Mpa.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

In the previous chapter, the results of the study were tabled and the findings of the study were discussed in detail. This chapter provides the conclusions of the study and the proposed recommendations for future study. The study covers the replacement of fine aggregate with rice husk in concrete. Main tasks of this study were to determine properties of concrete with rice husk as partial replacement of fine aggregate and evaluate optimum ratio of rice husk in modified concrete.

5.2 CONCLUSIONS

The potential application of this study is to reduce the production of sand further reduce natural sources from being running low, solve the disposal problem of numerous rice husks produced and thereby reducing carbon dioxide gas which is produced during burning the rice husk to dispose it. Such a goal is desirable from the point of view of combating greenhouse effect and global warming.

This study provides a further environmental benefit by using agro-waste material. This will lead to a reduction in the stockpile of such waste material, thus decreasing their impact on the environment and easing the problems associated with the disposal of waste material to landfill. Economic benefits should also be felt by construction industry from lower production cost due to the ready availability and low cost of industrial waste material.

The following conclusions can be drawn from this study:

i. This study showed that the compressive strengths of the specimen 10% and 15% of mix proportion at days 28 are 15.054 Mpa and 12.237 Mpa, respectively, which have a very high potential to treats as lightweight concrete since the value of compressive strengths are within 15-10 Mpa according to BS 8110, 1997. Meanwhile, the specimen 5% of mix proportion at days 28 was found to be 23.579 Mpa, which not practically defined as lightweight concrete.
ii. The results of compressive and flexural tests showed that the optimum ratio for this study was found to be the specimen 15% replacement of sand with Rice Husk concrete due to the results of compressive and flexural strengths at day 28 curing period, which classified as lightweight concrete.

From the investigations carried out, there exists a high potential for the use of rice husk as fine aggregate in the production of lightweight concrete. It can be concluded that Rice Husk can be successfully used in the lightweight concrete as fine aggregate replacement. Therefore, the development of existing knowledge and identification of waste materials to be used in making concrete will provide a valuable contribution in the environmental sustainability of the industry.

5.3 RECOMMENDATIONS FOR FUTURE STUDY

Further researches and advancement on this topic maybe done and the recommendations are provided and offered to broaden the knowledge of using partial Rice Husk as fine aggregate replacement in concrete. In order to improve this study, the concrete materials such as cement must be in good condition. Otherwise, the quality of concrete and the results of test will be affected.

In addition, the study should be added more sample percentages of partial Rice Husk as fine aggregate replacement for getting better and accurate strength results in improving the study. Other than that, it is also recommended to investigate the strength of concrete mixes at longer curing period to develop the desire result and set the percentages of partial Rice Husk between 10% - 20% to get the ideal optimum ratio

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APPENDIX A

CONCRETE MIX DESIGN

Stage	Item	Reference & calculation	Value
1	1.1 Characteristic Strength	Specified	**G30** N/mm^2 at **28** days Proportion Defective **5 %**
	1.2 Standard Deviation	Figure 3	**5** N/mm^2
	1.3 Margin	C1 or Specified	(k=1.64) 1.64 x **5** = **8.2**N/mm^2
	1.4 Target mean strength	C2	**30** + **8.20** = **38.20** N/mm^2
	1.5 Cement type	Specified	**PCC**
	1.6 Aggregate type: Coarse		**Crushed**
	Aggregate type: Fine		**Crushed**
	1.7 Free water/cement ratio	Table 2, Fig 4	**0.58** use the lower value
	1.8 Max. free-water cement ratio	Specified	**0.65**
2	2.1 Slump or V-B	Specified	Slump **10-30 mm**
	2.2 Maximum aggregate size	Specified	**20 mm**
	2.3 Free-water content	Table 3	**190 kg/m^2**
3	3.1 Cement content	C3	**190** ÷ **0.58** = **327.59 kg/m^2**
	3.2 Maximum cement content	Specified	______**Kg/m^2**
	3.3 Minimum cement content	Specified	**275 kg/m^2** – use if greater than item 3.1 and calculate 3.4
	3.4 Modified free-water/cement ratio		______
4	4.1 Relative density of aggregate (SSD)	Fig 5	**2.7** known/assumed
	4.2 Concrete density	C4	**2435 kg/m^2**
	4.3 Total aggregate content		**2435** – **327.52** = **1917.41** kg/m^2
5	5.1 Grading of fine aggregate	BS 882	Zoom ____ - ____ -
	5.2 Proportion of fine aggregate	Fig 6	______**Per cent**
	5.3 Fine aggregate content	C5	**1917.41** X **0.53** = **1016.23kg/m^2**
	5.4 Coarse aggregate content	C5	**1917.41**- **1016.23**= **901.18kg/m^2**

Quantities	Cement (Kg)	Water (Kg)	Fine aggregate (Kg)	coarse aggregate (Kg)
Per m^3 (to nearest 5 kg)	**330**	**190**	**1020**	**905**
Per trial mix of **0.18225** m^3	**61**	**35**	**189**	**165**

APPENDIX B

FLEXURAL STRENGTH OF CONTROL CONCRETE

Curing Period	7 Days			14 Days			28 Days		
Sample	Load (kN)	Compressive Strength (Mpa)		Load (kN)	Compressive Strength (Mpa)		Load (kN)	Compressive Strength (Mpa)	
		Reading	Calculated		Reading	Calculated		Reading	Calculated
S1	23.61	10.627	5.247	29.35	5.871	6.522	25.40	11.433	5.644
S2	24.94	11.226	5.542	26.37	5.275	5.860	24.93	11.221	5.540
S3	25.05	11.273	5.567	28.64	5.729	6.364	28.24	12.709	6.276
Average	24.53	11.042	5.452	28.12	5.625	6.249	26.32	11.788	5.820

APPENDIX C

FLEXURAL STRENGTH OF 5% OF RICE HUSK CONCRETE

Curing Period	7 Days			14 Days			28 Days		
Sample	Load (kN)	Compressive Strength (Mpa)		Load (kN)	Compressive Strength (Mpa)		Load (kN)	Compressive Strength (Mpa)	
		Reading	Calculated		Reading	Calculated		Reading	Calculated
S1	26.52	11.934	5.893	28.83	12.976	6.407	-	-	-
S2	22.74	10.236	5.053	26.38	11.872	5.862	34.93	10.479	7.762
S3	20.78	9.354	4.618	28.94	13.024	6.431	33.36	10.008	7.413
Average	23.35	10.508	5.188	28.05	12.624	6.233	34.145	10.244	7.588

APPENDIX D

FLEXURAL STRENGTH OF 10% OF RICE HUSK CONCRETE

Curing Period	7 Days			14 Days			28 Days		
Sample	Load (kN)	Compressive Strength (Mpa)		Load (kN)	Compressive Strength (Mpa)		Load (kN)	Compressive Strength (Mpa)	
		Reading	Calculated		Reading	Calculated		Reading	Calculated
S1	18.54	8.345	4.120	17.55	7.899	3.900	10.79	16.873	2.398
S2	13.77	6.197	3.060	18.45	8.305	4.100	25.75	40.238	5.722
S3	13.12	5.906	2.916	21.17	9.530	4.704	25.04	39.137	5.564
Average	15.14	6.816	3.365	19.06	8.578	4.235	20.53	32.083	4.561

APPENDIX E

FLEXURAL STRENGTH OF 15% OF RICE HUSK CONCRETE

Curing Period	7 Days			14 Days			28 Days		
Sample	Load (kN)	Compressive Strength (Mpa)		Load (kN)	Compressive Strength (Mpa)		Load (kN)	Compressive Strength (Mpa)	
		Reading	Calculated		Reading	Calculated		Reading	Calculated
S1	9.77	4.399	2.171	17.16	7.723	3.813	23.52	36.752	5.227
S2	9.78	4.404	2.173	13.23	5.956	2.940	19.86	31.031	4.413
S3	15.36	6.915	3.413	11.45	5.155	2.544	21.04	32.877	4.676
Average	11.64	5.239	2.586	13.95	6.278	3.099	21.47	33.553	4.772

APPENDIX F

COMPRESSIVE STRENGTH OF CONTROL CONCRETE

Curing Period	7 Days			14 Days			28 Days		
Sample	Load (kN)	Compressive Strength (Mpa)		Load (kN)	Compressive Strength (Mpa)		Load (kN)	Compressive Strength (Mpa)	
		Reading	Calculated		Reading	Calculated		Reading	Calculated
S1	568.045	25.246	25.246	683.077	30.359	30.359	797.016	35.423	35.423
S2	541.696	24.075	24.075	651.375	28.950	28.950	723.590	32.160	32.160
S3	516.328	22.948	22.948	697.995	31.022	31.022	719.161	31.963	31.963
Average	542.023	24.090	24.090	677.482	30.110	30.110	746.589	33.182	33.182

APPENDIX G

COMPRESSIVE STRENGTH OF 5% OF RICE HUSK CONCRETE

Curing Period	**7 Days**			**14 Days**			**28 Days**		
Sample	**Load (kN)**	**Compressive Strength (Mpa)**		**Load (kN)**	**Compressive Strength (Mpa)**		**Load (kN)**	**Compressive Strength (Mpa)**	
		Reading	**Calculated**		**Reading**	**Calculated**		**Reading**	**Calculated**
S1	309.857	13.771	13.771	436.487	19.399	19.399	562.719	25.010	25.010
S2	363.662	16.163	16.163	411.446	18.286	18.286	536.370	23.839	23.839
S3	277.593	12.337	12.337	453.772	20.168	20.168	492.455	21.887	21.887
Average	317.037	14.090	14.090	433.902	19.284	19.284	530.515	23.579	23.579

APPENDIX H

COMPRESSIVE STRENGTH OF 10% OF RICE HUSK CONCRETE

Curing Period	7 Days			14 Days			28 Days		
Sample	Load (kN)	Compressive Strength (Mpa)		Load (kN)	Compressive Strength (Mpa)		Load (kN)	Compressive Strength (Mpa)	
		Reading	Calculated		Reading	Calculated		Reading	Calculated
S1	214.204	9.542	9.520	288.410	12.818	12.818	345.118	15.339	15.339
S2	215.547	9.530	9.580	262.515	11.667	11.667	328.822	14.614	14.614
S3	218.825	9.726	9.726	274.924	12.219	12.219	342.215	15.210	15.210
Average	216.192	9.599	9.609	275.283	12.234	12.234	338.718	15.054	15.054

APPENDIX I

COMPRESSIVE STRENGTH OF 15% OF RICE HUSK CONCRETE

Curing Period	**7 Days**			**14 Days**			**28 Days**		
Sample	**Load (kN)**	**Compressive Strength (Mpa)**		**Load (kN)**	**Compressive Strength (Mpa)**		**Load (kN)**	**Compressive Strength (Mpa)**	
		Reading	**Calculated**		**Reading**	**Calculated**		**Reading**	**Calculated**
S1	162.456	7.220	7.220	216.858	9.638	9.638	273.519	12.156	12.156
S2	167.341	7.437	7.437	218.590	9.715	9.715	270.428	12.019	12.019
S3	169.345	7.530	7.526	220.698	9.809	9.809	282.042	12.535	12.535
Average	166.381	7.396	7.394	218.712	9.721	9.721	275.330	12.237	12.237

APPENDIX J

PICTURES OF THIS STUDY

PREPARATION OF SAMPLE (RICE HUSK)

Sample collected

Washed sample

Dried using oven

Sieved sample (Passing 4.75 mm)

CONTINUED

PREPARATION OF SAMPLE (PRISM)

Materials collected

Concreting work

Oiled mould

Poured & vibrated

Concreting done

Cured sample

Curing by using wet gunny sacks

CONTINUED

SLUMP TEST RESULTS

Slump Control: 64 mm

Slump 5% Replacement: 54 mm

Slump 10% Replacement: 53 mm

Slump 15% Replacement: 43 mm

CONTINUED

COMPRESSIVE STRENGTH TEST

Sample preparation

Curing method

Test conducted

Data collected

CONTINUED

FLEXURAL STRENGTH TEST

Flexural Strength Test Machine **Set up the specimen**

Test conducted **Data collected**