

**EVALUATION OF THE COMPRESSIVE STRENGTH OF COCONUT SHELL
CONCRETE**

BY

FELIX, OSAHON NOAH

ENG1704096

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UNIVERSITY OF BENIN.

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CERTIFICATION

This is to certify that this work was carried out by Felix Osahon Noah, Mat No **ENG1704096** of the Department of Civil Engineering, Faculty of Engineering. University of Benin, Benin City, Edo state.

PROJECT SUPERVISOR

Name: ENGR. PROF. R. I. UMASABOR

Signature: Date:

HEAD OF DEPARTMENT

Name: ENGR. PROF. (Mrs) N. I. IHIMEKPEN

Signature: Date:

DEDICATION

I dedicate this project to the almighty God for guiding me to this point in my academic journey.

I would like to extend this dedication to my dear parents and my siblings, whose unwavering support and understanding have played a crucial role in guiding me along my academic journey. May the blessings of God always be with them, both now and in the future.

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ABSTRACT

This study evaluated the compressive strength of coconut shell concrete for concrete construction by partially replacing coarse aggregate with crushed coconut shells at varying levels (0%, 5%, 10%, and 15%). The primary aim was to determine the optimum replacement percentage that delivers satisfactory mechanical performance including compressive strength, split tensile strength, and flexural strength while promoting sustainability and reducing concrete weight. This investigation is driven by the need to recycle agricultural waste and improve the environmental footprint of conventional concrete in harsh service conditions.

A series of experiments were conducted on concrete mixes with replacement levels of 0%, 5%, 10%, and 15% by weight, prepared with a constant water-to-cement ratio of 0.48. Fresh concrete workability was assessed using slump tests, which indicated a reduction in slump as the percentage of coconut shell replacement increased. Hardened concrete specimens were cast in cube form and cured for 7, 14, and 28 days. Compressive strength tests were then carried out using a universal compression testing machine with a 2000 kN capacity. The failure load of each cube was recorded, and compressive strength was calculated using the formula: $\text{Strength} = (\text{Maximum Load})/(\text{Cross-sectional Area})$.

The results show that the control mix (0% replacement) achieved average compressive strengths of 21.09 N/mm² at 7 days, 23.90 N/mm² at 14 days, and 30.51 N/mm² at 28 days. Although increasing coconut shell content resulted in higher water absorption and a slight reduction in workability, the mix with 5% replacement maintained compressive strength values closest to the control, while meeting the target design characteristic strength (approximately 20 N/mm²). These findings indicate that a 5% replacement level provides the optimal balance between sustainability and mechanical performance, making coconut shell concrete a viable alternative for concrete applications.

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CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Concrete is the premier construction material around the world and is most widely used in all of construction works, including infrastructure, low- and high-rise buildings, and domestics. Conventional concrete is made up of cement, fine aggregate, coarse aggregate and water these materials are used globally for the production of concrete (Kolhapure et al., 2018). Structural concrete plays a most important role in the construction industry and has been widely used in all civil engineering structures (Hussein et al. 2012), because it can be molded into a variety of sizes and shapes and it also has the best resistance to water (Calkin 2009).

The majority of the aggregates are composed of materials like gravel, crushed stone, and sand. Concrete is strong, simple to make, and pliable enough to take on a variety of forms. In addition, it is inexpensive, reasonable, and rapidly combined. It is intended to enable dependable; superior fast-track construction. Structures built using the concrete unit of measurement are very resilient and ought to be built to withstand tornadoes, hurricanes, typhoons, and earthquakes.

Nowadays, the construction industry uses a lot of natural resources every year, including about 1 billion tons of water, 10–12 billion tons of stones for fine and coarse aggregates, and 1.5–2 billion tons of cement (Shafigh et al., 2013). This massive raw material consumption is depleting natural resources globally and has a major impact on the environment.

Muhammad and associates (2010). According to Silva et al. (2016), the world's total concrete production is growing daily, seriously harming the environment for the better.

For civil engineers, finding locally available materials that can be the best alternative to concrete is a major concern (Praveen et al., 2013). Finding aggregate for concrete and other alternatives to traditional aggregates is crucial since the building industry cannot survive without it. One of the most beneficial plants in the world is the coconut palm, which is the aggregate substitute employed in this study. Africa is one of the 92 nations in the world where coconuts are farmed. 51 billion coconut nuts are produced worldwide from 12 million hectares of land. Coconut shells can be used as a coarse aggregate in concrete, as they possess several properties which include:

- i. **Lightweight:** coconut shells are lightweight compared to traditional coarse aggregate like gravel or crushed stone. This property can help reduce the overall weight of the concrete, making it advantageous in certain applications where weight is a concern
- ii. **Porosity:** coconut shells have inherent porosity due to their natural structure; this can impact the water absorption characteristics of the concrete. Proper measures need to be taken to ensure that the concrete adequately retains moisture and does not excessively absorb water.
- iii. **Density:** Coconut shells have lower density compared to traditional coarse aggregate. The density affects the overall density a strength of the concrete. It is important to consider the appropriate mix design to achieve the design strength and density requirement.
- iv. **Size and shape:** Coconut shells are irregular in shape and vary in size. Their size and shape influence the workability of the concrete mix. The presence of coconut shells may require adjustments in the mix design to maintain suitable workability and ensure proper compaction

Others include: durability, mechanical properties

It is important to note that the properties of coconut shell concrete can vary depending on factors such as the species of coconut, age of the coconut shells, processing techniques, and mix proportions.

1.2 Statement of the problem

In order to minimize cost and maximize the use of agricultural wastes, coconut shell has been chosen as partial replace for coarse aggregates in the production of concrete. Also various test are carried to show the effective use of coconut shell concrete in the construction industry.

1.3 Aim and Objectives

The aim of the study is to evaluate the mechanical properties of coconut shell concrete with specific objectives which are to:

- i. To determine the optimum compressive strength of the coconut shell concrete with replacement 5%, 10%, 15% of the coarse aggregate by weight
- ii. To determine the water absorption rate of the coconut shell concrete with the following replacement
- iii. Determine the optimum density of the coconut shell concrete

1.4. Scope of Study

This study entails the study of the utility and efficacy of coconut shells as a coarse aggregate, optimum mechanical properties obtained at varying percentages of coconut shell in the concrete (5%, 10%, 15%) and as an alternative to natural aggregate in concrete. The study entails:

- i. Sieve analysis

- ii. Water absorption test
- iii. Compressive strength test and
- iv. Density Test

1.5. Justification of study

In Nigeria, coconut shell is been thrown away when the white solid (solid albumen) is consumed, thereby increasing the mass of waste in our environment. Coconut shells are suitable for long-term use because of their high toughness, abrasion resistance, and good durability characteristics. This has led to the realization that natural resources will not be available to future generations. The qualities of the concretes were examined after several alternative waste materials and industrial byproducts, including fly ash, bottom ash, recycled aggregates, foundry sand, china clay sand, crumb rubber, and glass, were substituted with natural aggregate. A small number of studies have found that coconut shells, an agricultural byproduct, can also be used as aggregate in concrete in addition to the waste materials and industrial byproducts already mentioned. Nonetheless, this experiment demonstrates that waste coconut shells can be utilized as a coarse aggregate and a favor in the production of lightweight concrete. The outcome also demonstrates that, in comparison to traditional concrete, the resultant concrete has similar mechanical qualities. Several tests were conducted on the coconut shell when it was used as a coarse aggregate for concrete in order to demonstrate its suitability as a building material. These tests include workability and compressive strength tests, among others.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Concrete is a building material which is made up of broken stone or gravel, sand, cement and water. Concrete is one of the most widely used materials on the planet because of its versatility in using locally accessible ingredients, simplicity of shaping into any shape or size, and cost-effective manufacturing process. Concrete is manufactured in far greater quantities than any other substance created by humans. One ton is produced annually for each person on the earth. It is utilized in practically all significant construction projects due to its extreme versatility. Concrete uses aggregates for very particular reasons. Usually comprising between 60% and 75% of the volume of a concrete mixture, aggregates have a substantial economic influence because they are the least expensive of the components used in concrete. Research has been conducted to meet society's requirement for economical and safe garbage disposal. Utilizing waste products helps to keep the environment clean and conserves natural resources and landfill space. In addition to using massive amounts of drinking water, sand, and stone, the existing concrete construction method is deemed unsustainable since it uses two billion tons of Portland cement annually, which emits greenhouse gases that contribute to global warming. Rubber tires, e-waste, coconut shells, blast furnace slag, waste plastic, demolished concrete components, waste water, and other waste materials have all been the subject of experiments. Although construction waste recycling facilities are currently in place in many nations, they only partially address the waste issues. Depletion of aggregate deposits, ecological imbalance, and environmental degradation are all adverse effects of rising concrete demand. The ongoing use of aggregates for construction is no longer sustainable due to the potential for total depletion of aggregate resources. The conventional natural aggregate source is rapidly being depleted due to the construction

industry's rapid growth. Researchers have also focused more on using some agricultural wastes as building materials in recent years. Coconut shell (CS), one of the most prevalent agricultural solid wastes in many tropical nations, is one such substitute. Akshay et al. (2014) According to this study, crushed granite aggregate is less resistant to crushing, impact, and abrasion than coconut shell. Additionally, the coconut shell falls under the category of light-weight aggregate. 75% of global production is accounted for by the three major producers: India, the Philippines, and Indonesia. With an area of 1.9 million and an annual production of 2.74 million tons of copra equivalent, India is the third-largest producer of coconuts. South India accounts for 90% of India's total coconut production (www.foodmarketexchange.com). The enormous volume of this abandoned CS resource is still not being used economically, but it would be an intriguing subject for future research to consider using it as a building material, particularly in concrete, similar to other lightweight aggregates.

In this chapter, the numerous studies on lightweight concrete with great compressive strength are reviewed. Additionally, in order to analyze the strength, the usage of coconut shell as coarse aggregate in place of coarse aggregate is also studied. The abstract and conclusions of various authors in their literature is stated in this chapter for the study of strength characteristics of concrete. Tukiman et al. (2009) have investigated the combination of coconut shell and grained palm kernel to replace aggregate in concrete. They found that combination of coconut shell (maximum percentage) and few percentages of grained palm kernel shell have the potential for light weight aggregate in concrete. Also, the combination would reduce the material cost in construction due to the cheap and abundant availability of suitable agricultural waste for concrete preparation Amarnath Yerramala et al. (2012) Properties of concrete with coconut shells (CS) as aggregate replacement were studied. Control concrete with normal aggregate and CS

concrete with 10 - 20% coarse aggregate replacement with CS were prepared. Two mixes with CS and fly ash were also created to examine fly ash influence on CS substituted concretes. Properties including compressive strength, split tensile strength, water absorption and moisture migration were examined in the laboratory. The results showed that, density of the concretes reduces with rise in CS %. Workability decreased with increase in CS replacement. Compressive and split tensile strengths of CS concretes were lower than control concrete. Yogesh Narayan Sonawane et al. (2013) The paper analyzed compressive strength of concrete (M20-1:1.5:3) produced using coconut shell as substitute for conventional coarse aggregate with 0%, 25%, 50%, 100% partial replacement. Three sample cubes are prepared for M20 grade concrete mix for each case another aim of this paper is to spread awareness about use of coconut shell as construction material in civil engineering. It is concluded in this study that for M20 grade concrete cubes with 30% replacement of CS aggregates had supplied strength of 23 MPa at 28 days. At 28 days, M35 concrete cubes with 30% CS aggregate replacement had a strength of 42 MPa. At 28 days, M50 grade concrete cubes with 30% CS aggregate replacement achieved a strength of 51 MPa. According to Robert et al. (2017), Coconut Shell Concrete (CSC) may be utilized in rural regions and other locations with a lot of coconuts. It may also be utilized in situations where traditional aggregates are expensive. Moreover, a specific quantity of steel fiber is added to concrete to boost its strength and enhance its ductility, energy absorption, impact resistance, and fracture resistance. The appropriateness of partially substituting 10%, 20%, and 30% of coconut shell as coarse aggregate in grade M20 concrete as well as adding a certain quantity of steel fiber to the concrete has been investigated. The outcomes were similar to those of a traditional blend. Yashida et al. (2017) conducted an experimental study to examine the durability characteristics of concrete containing Coconut Shell (CS) aggregate. It was also

confirmed how the durability characteristics of CS aggregate concrete were affected by the partial replacement of cement with mineral admixtures such fly ash and ground granulated blast furnace slag (GGBFS). For the study, four concrete mixtures were taken into consideration. Control mix, 18.5% CS and 30% fly ash-replaced cement, 18.5% CS and 15% GGBFS-replaced cement, and 18.5% CS and 15% cement-replaced cement by weight. The aforementioned mixes' workability, compressive strength, flexural strength, and splitting tensile strength were contrasted with those of regular concrete. The results from the study are expected promote the use of coconut shell as a substitute for conventional coarse aggregates Dodda Nagarjun et al. (2017) The high cost of conventional building materials is a major factor affecting housing delivery in world. This has necessitate research into alternative materials of construction and analyzing flexural and compressive strength characteristics of concrete produced using crushed and sieved, granular coconut as substitute for conventional coarse aggregate with full replacement using M20, M15, M25 grade concrete. Amarnath et al. (2017) Properties of concrete with coconut shells (CS) as aggregate replacement were studied. Both CS concrete with 10–20% coarse aggregate replacement with CS and control concrete with regular aggregate were produced. Two mixes with CS and fly ash were also created to examine fly ash influence on CS substituted concretes. Constant water to cementitious ratio of 0.6 was maintained for all the concretes. Properties including compressive strength, split tensile strength, water absorption and moisture migration were examined in the laboratory.

Numerous research has studied the possibility of coconut shell as a sustainable option in concrete manufacturing.

The work by Ramamurthy et al. (2009), which examined the mechanical characteristics of concrete that partially substituted coconut shell for coarse aggregate, is noteworthy

among these investigations. According to their observations, coconut shell could be added up to a certain proportion without noticeably lowering compressive strength. Similarly, Ahmed et al. (2013) investigated how concrete's workability and durability were affected by the amount of coconut shell. Their study showed that adding coconut shell to concrete could improve some of its qualities, making it a desirable option for environmentally friendly building. Coconut shells have been emphasized by researchers like Sivakumar et al. (2017) as a sustainable substitute for coarse aggregates. This is in line with the more general objective of conserving natural resources and cutting waste. The use of grained palm kernel and coconut shell in place of aggregate in concrete has been studied by Tukiman Siti AminahBt et al. (2009). They discovered that the combination of a little percentage of grained palm kernel shell and the maximum percentage of coconut shell might result in light-weight aggregate for concrete. Due to the inexpensive and plentiful supply of acceptable agricultural waste for concrete preparation, the combination would also lower the cost of building materials. Prakash, Arunachalam, and Sivakumar (2017). Coconut shells are used as coarse materials in concrete. 5(2), 126–132, International Journal of Engineering and Technical Research. Kuruppu (2013). characteristics of concrete that substitutes coconut shells for aggregate. Civil, Environmental, and Construction Engineering International Conference (Vol. 50). Coconut shell concrete can increase compressive strength at lower replacement percentages, according to research by Tuan, Sam, and Soon (2017). Soon, Sam, and Tuan. (2017). The characteristics of concrete that contains coconut shell as a coarse aggregate are investigated experimentally. Forum for Materials Science, 890, 10–13. According to research by de Castro et al. (2015), coconut shell concrete offers better durability because of its reduced water absorption capacity and possible resistance to chemical attack. Otadoy, Castro, and Torres (2015). concrete's durability and

compressive strength when coconut shell is used as a coarse aggregate. 745-751 in *Procedia Engineering*, 125. Alengaram et al. (2010) investigated the thermal characteristics of concrete made of coconut shells. According to their research, because coconut shell concrete has a reduced heat conductivity, it may provide better thermal insulation. Mahmud, Bahri, Jumaat, and Alengaram (2010). An analysis of coconut shell aggregate concrete's thermal characteristics. 1(1), 67-74; *La Revue de Mécanique Appliquée et Théorique*. Researchers like Raman et al. (2016) underline the necessity of stringent quality control techniques in obtaining and processing coconut shells to achieve optimal concrete performance. Raman, Sam, & Ibrahim, (2016). Enhancement of coconut shell quality as a concrete aggregate. *Cleaner Production Journal*, 112, 882-889.

Dhinakaran and Edwin (2018): This study examined the usage of coconut shells in concrete with an emphasis on the sustainable development of building materials. It emphasized coconut shell concrete's potential as an environmentally friendly building material and looked at its compressive strength and durability. In their 2018 study, Ismail, Al-Hashmi, and Al-Sulaimani examined the mechanical characteristics of coconut shell concrete, focusing on its modulus of elasticity, flexural strength, and compressive strength. The study offered information on the effects of varying coconut shell replacement percentages on concrete performance.

Sathyamoorthy and Sundarakannan (2014) evaluated the compressive strength, flexural strength, and durability of coconut shell concrete while examining how it behaved under various curing circumstances. The study shed light on the curing conditions needed to maximize the qualities of coconut shell concrete. Ghosh, Das, & Saha (2016): This study assessed the load-carrying ability of coconut shell concrete beams with an emphasis on structural concrete applications. It demonstrated the viability of using coconut shell concrete beams as structural elements by analyzing their flexural behavior and load-

deflection properties. The sustainability features of coconut shell concrete, particularly its capacity to lower carbon emissions, were investigated in Nair & Sathyan (2016). In keeping with international initiatives to slow down climate change, it covered the advantages of using coconut shells as an alternative aggregate for the environment.

Alengaram et al. (2009) evaluated the performance of coconut shell concrete in structural applications by examining the bond strength between the concrete and steel reinforcement. The results shed light on whether coconut shell concrete is suitable for usage in reinforced concrete constructions. Ismail & Al-Hashmi (2017): This study assessed the resilience of coconut shell concrete to sulfate attack and chloride ion penetration, with an emphasis on the material's endurance under harsh conditions. The study demonstrated how resilient coconut shell concrete can be in harsh environmental circumstances. Shiyamala et al. (2016): This work is noteworthy for its exploration of sustainable concrete by substituting a portion of the cement with powdered coconut shell. By using coconut shell powder as an additional cementitious material, the study sought to mitigate the environmental effects of conventional cement manufacture. According to their research, adding powdered coconut shell to concrete could improve its qualities while lowering the carbon footprint of cement manufacture.

A notable study investigating the use of coconut shell as a partial substitute for coarse aggregate in concrete was carried out by Sivakumar and Arulraj (2016). The mechanical characteristics and structural performance of concrete with different proportions of coconut shell aggregate were the main subjects of their study. The viability of using coconut shell as a sustainable substitute for traditional coarse aggregates in concrete mix designs was greatly aided by this study.

Hugar et al. (2016): This important study focused on assessing the strength characteristics of concrete that contained varying amounts of coconut shell as a partial substitute for coarse aggregate. The goal of the study was to ascertain the ideal proportion of coconut shell that could be added without sacrificing structural integrity through a battery of fifteen extensive tests, including assessments of compressive and flexural strength. For engineers and builders looking for sustainable building materials, this study offered useful information.

The strength and durability characteristics of concrete with coconut shell as an aggregate were examined by Krishnaraju et al. (2018). The purpose of this study was to ascertain how coconut shell affected important performance metrics such as resistance to chloride ingress, split tensile strength, and compressive strength. The results helped to clarify the possible advantages and difficulties of utilizing coconut shell in concrete.

Akinwumi et al. (2019): This study is a notable research endeavor that improved the quality of coconut shell concrete by substituting microsilica for some of the cement. The purpose of this study was to optimize the concrete mix by adding coconut shell as an aggregate and microsilica, a pozzolanic substance. The study provided a comprehensive viewpoint on enhancing coconut shell concrete by evaluating the effects of this combination on compressive strength, workability, and durability.

Aravindhya and Amarnath (2019): This study offered an experimental examination of the durability characteristics of concrete with coconut shell aggregate. The purpose of this study was to evaluate how resistant concrete using coconut shell aggregate was to environmental elements including sulfate exposure and chloride assault. The study helped to understand the long-term performance of coconut shell concrete in a variety of construction applications by carrying out thorough durability testing. Kumaravel et al.

(2019): This work, which carried out a comparative analysis on the partial substitution of coconut shell with coarse aggregate in concrete, makes a substantial contribution to the research. Finding the ideal replacement % to achieve the necessary concrete qualities was the goal of this study. Through the assessment of variables such as workability, compressive strength, and flexural strength, the research offered engineers and builders important recommendations. The use of coconut shell powder as a partial cement substitute in concrete was investigated by the authors of the 2019 study by Hameed and Sekar. This research aims to promote the sustainability of concrete by lowering cement content and using coconut shell powder as a supplemental element. The study investigated the impact on qualities such compressive strength, setting time, and water usage, revealing insights into sustainable concrete production processes. Srinivasan et al. (2020): A major research effort is the study by Srinivasan et al. (2020), which evaluated the mechanical properties of concrete with the partial replacement of fine aggregate with coconut shell. This research focuses on 20 improving concrete mix compositions by utilizing coconut shell as a fine aggregate replacement. By analyzing criteria such as compressive strength, tensile strength, and workability, the study contributed to understanding the possible benefits and problems of this substitute. Damodhara et al, (2014) in his research shows the qualities of coconut shell and coconut shell aggregate concrete is analyzed and the application of coconut shell aggregate in building is tested. When compared to conventional aggregate, the moisture content and water absorption were higher at 4.20 percent and 24%, respectively. Lightweight concrete (LWC) can be made by crushing this coconut shell and using it as a coarse aggregate. In addition to being utilized in places where coconuts are plentiful and in rural areas, Coconut Shell Concrete (CSC) can also be used in places where traditional aggregates are expensive. According to Yogesh et al. (2016), who examined a number of variables, the smooth

surface on one side of the coconut shell gives concrete a greater workability. Concrete's setting strength will not be impacted by the presence of sugar in the CS as long as it is not in the form of free sugar. The shell's strong tissue prevents it from breaking down readily and keeps it solid waste for years. According to Apeksha et al. (2015) in this journal, coconut shells have the added benefit of having a high lignin concentration. In comparison to other agricultural waste, coconut shell absorbs less moisture because of its low cellulose content, which also increases the weather resistance of the composites. Concrete constructed with coconut shell has superior workability due to its smooth surface on one side and the fact that coconut shells are naturally occurring because they are not biodegradable. When creating concrete hollow blocks, it serves as an alternative to aggregates. In contemporary construction, lightweight aggregate concrete, or LWAC, is a crucial and adaptable component. Because of its better thermal insulating qualities and reduced density, it has become more and more popular. As demonstrated by the numerous remarkable lightweight concrete (LWC) constructions found worldwide, many architects, engineers, and contractors are aware of the inherent economies and advantages provided by this material. Although lightweight concrete is usually 25–35% lighter than regular concrete, it nevertheless offers strengths that are comparable. Because structural LWC reduces self-weight, improves seismic structural response, and lowers foundation costs, it provides design freedom and cost benefits. Pre-cast concrete components that are lightweight can save money on placement and transportation. Natural lightweight aggregates include pumice, scoria, and other volcanic-derived minerals. Man-made lightweight aggregates include expanded blast furnace slag, vermiculite, and clinker, which are byproducts of industrial processes. Lightweight aggregate's primary attribute is its high porosity, which contributes to its low specific gravity. Even though commercial lightweight aggregate has been used extensively in the

production of LWC, using waste materials as lightweight aggregates in concrete can have more positive effects on the environment and the economy. The use of aggregates made from solid waste materials and/or by-products is becoming more and more prevalent due to environmental issues. According to Rajeevan et al. (2015), coconut shells are more resistant to abrasion, impact, and crushing than traditional aggregate. Therefore, there is no need to treat the coconut shell before using it as an aggregate. According to Kakade et al. (2015), as long as the concrete is not sugar-free, the presence of sugar in the shell has no effect on the concrete's setting or strength, and the typical increase in strength shows that the aggregate does not degrade once it is encapsulated into the concrete matrix. Because of the increased porosity in its shell structure, the aggregate of coconut shells also absorbs more water. When compared to crushed stone aggregate, the aggregate impact value of coconut shell aggregates is significantly lower, indicating that the aggregates have good shock absorbance. According to the study's findings, concrete production costs can be lowered by up to 48%. The density of coconut shell falls between 550 and 650 kg/m³, which is within the range allowed for lightweight aggregate. According to Dewanshu et al. (2014), coconut shell is classified as a light-weight aggregate. After drying, the coconut shell contains cellulose, lignin, pentosans, and ash. In order to determine whether coconut shell concrete is suitable as a lightweight aggregate, this study will optimize the concrete's key mechanical qualities—namely, its compressive, flexural, splitting tensile, and impact resistance—for varying percentages of coconut shell. In order to assess the feasibility from a structural perspective, the bonding characteristic of coconut shell is also investigated.

2.1. Materials used

Local suppliers provided the constituent materials used in this study. These ingredients, which comprise cement, coarse and fine aggregate, coconut shells, and water, are needed for a number of experiments.

2.1.1. Coconut shell as coarse aggregate:

Coconut Shell

One of the most beneficial plants in the world is the coconut palm. In 92 nations worldwide, coconuts are farmed. On an area of 12 million hectares, 51 billion coconut nuts are produced worldwide. Coconut shells that had previously been split in two were gathered from a nearby temple, let to air dry for five days at a temperature of about 25 to 30 degrees Celsius, had their fiber and husk removed, and were then hand smashed into tiny chips with a hammer before being sieved through a 12.5 mm sieve. Coconut shells were used in place of coarse aggregate after the material passed through a 12.5 mm sieve. The material that was retained on the 12.5mm sieve was thrown away. At saturated surface dry conditions, the material's specific gravity was 1.33 and the water absorption of the coconut shells was 8%. Wood and cement may not mix well because of the sugar in wood. To calculate the amount of sugar in coconut shells, 15 since the aggregates are made of wood The maximum hydration temperature, the time required to reach the maximum temperature, the ratio of the setting times of the coconut shell fines-cement mixture, neat cement, and inhibitory index are the criteria that typically establish the compatibility requirements for the coconut shells cement composite. The reduction in heat output during the exothermic chemical process of cement hydration is known as the inhibitory effect. Using samples of coconut shell fines with cement and plain cement, the compatibility of coconut shells with cement was examined in terms of normal consistency, initial and final setting times, compressive strength, and hydration.

The recently abandoned shells were gathered from nearby oil mills and dried and cured either by hand or with a small crusher; the lengths were limited to 12 mm and the crushed edges were sharp and jagged. On concave faces, the shell's surface texture was rather smooth, but on convex faces, it was rough. Saturated surface dry (SSD) conditions were utilized for the coconut shell aggregates.

2.1.2. Coarse aggregate (granite/gravel)

These are normal aggregates used in making structural concrete. Because of their advantages, concrete is now a crucial consumable in the building sector. As coarse aggregate, regular crushed blue granite up to 20 mm in size was utilized. The coarse aggregate's specific gravity, fineness modulus, and water absorption capacity are the three characteristics we are testing. However, when more of these materials are used, the natural resources tend to be depleted, which is why this study was conducted.

2.1.3. Fine Aggregate:

Well graded river sand with a diameter of 4.75 mm was used as fine aggregate. The sandy material was dried by air and sieved to get rid of any foreign particles before mixing. We are doing tests on fine aggregate are Water Absorption Capacity, Specific Gravity and Fineness Modulus of fine aggregate.

2.1.4. Other Concrete Mix Constituents (Cement):

Ordinary Portland cement of C53 grade conforming to both the requirements of IS: 12269 and ASTM C 642-82 type-I was used. Normal consistency, initial and final setting times, cement's compressive strength, specific gravity, and fineness are the various cement test types that we are performing. The typical concrete can be constructed in accordance with IS10262-82 (MIX DESIGN CODE) based on the test findings. At last, concrete of M30 grade is designed. For mixing and curing, the University's potable water

was utilized. In order to achieve complete compaction of the concrete without segregation or undue laitance, specimens were cast. A table vibrator was used to produce compaction. The weights of the ingredients determine their proportions. By performing a number of workability tests, the water cement ratio is determined. Because coconut shell absorbs a lot of water, they were soaked in water for a full day before being mixed. Based on their testing setup, it was determined that with 10% replacement, the concrete achieved 18.91 n/mm², which is somewhat less than the minimum 20N/MM² that is required for usage as structural concrete. As the replacement % rose, the strength dropped. More cement was needed for a good bond because the surface area of the coconut shell increased as it grew. Strength was decreased and no further bonding occurred since the cement content remained unchanged. According to Parag et al. (2014), oil palm shell is a waste product from the agriculture industry that is widely accessible. Its goal is to analyze the compressive strength properties of concrete made with partially substituted crushed, granular coconut for traditional coarse aggregate. The purpose of the experimental program was to determine the feasibility of using CS as CA in concrete as well as the ideal mix fraction for using CS as coarse aggregate. According to experimental investigation, coconut shell can lower material costs and is more suited as a light-weight, low-strength aggregate in the manufacturing of concrete. Osei Daniel Yaw et al. (2013) According to his journal, there is a chance that coconut shell might be used in place of traditional aggregate in both traditional and lightweight reinforced concrete. Concrete made from coconut shells helps preserve resources. Amarnath Yerramala et al. (2012) investigated the transport characteristics of concrete that substituted coconut shell (CS) for coarse aggregate, as well as the strength of doing so. They came to the conclusion that as the CS percentage rose, the concrete's densities reduced and that the strength gain over seven days grew along with the matching 28-day curing strength.

Maninder et al. (2012) talked about a number of factors in their journal. Concrete with coconut shell aggregates was found to have the sufficient strength needed for structural concrete. There is no need for pre-treatment because the coconut shell-cement composite is suitable. Coconut shell concrete has a high level of impact resistance. Coconut shells have a strong capacity to absorb and retain moisture.

Experiments

The set of tests and number of samples utilized to measure the mechanical and bond properties of coconut shell concrete are shown in previous studies that are comparable to the goals of this study. By assessing slump, densities, and compressive strength, the investigations on the impact of cement content and wood-cement ratio on Coconut Shell Concrete also examined the impact of water-cement ratio on workability. In order to investigate the flexural and splitting tensile strengths as well as the impact resistance of coconut shell concrete, the effects of free water–cement ratios of 0.42 and 0.44 were taken into consideration for one mix. One of the most crucial elements of structural reinforced concrete is the strength of the bond between the steel reinforcement and the concrete matrix. One of the basic presumptions of reinforced concrete is the existence of a complete link between the concrete and steel reinforcement. In order to ascertain the binding strength of coconut shell concrete, a study was conducted using pull-out tests on both normal and deformed steel bars.

Studies on cement content

According to reports, light-weight concrete has a cement composition of 285–510 kg/m³. Using coconut shell as a coarse aggregate was suggested as a way to accomplish the goal of producing structural concrete. To achieve the goal, several trial mixes were created utilizing weigh batches with cement levels ranging from 300 to 510 kg/m³ and by

modifying the ratios of fine aggregate to coarse aggregate (coconut shell). The ratio of cement to water ranged from 0.72 (300 kg/m³) to 0.42 (510 kg/m³). Eleven mixes, numbered M1 through M11, were chosen from the 33 trial mixes that were previously prepared.

Studies on water–cement ratio

Given that the characteristics of various coconut-cement concrete composites differ, it is challenging to determine the ideal water-to-cement ratio for each type of composite. It has been discovered that the strength of the coconut-cement concrete composites decreases when the water-to-cement ratio rises. Water-to-cement ratios of 0.38, 0.42, and 0.48 have been taken into consideration in this investigation.

Mechanical properties

In accordance with BS EN 516:2006, the compressive strength of 100 mm cubes was tested. The flexural, splitting tensile, and impact resistance of Coconut Shell Concrete were investigated using Mix CS8 (1:1.47:0.65:0.42). In order to examine its impact, the water-to-cement ratio was also raised by 0.02. For the chosen mix, Tables 6 and 7.3.4.1 provide the 28-day flexural and splitting tensile strengths as well as the impact resistance of Coconut Shell Concrete.

Mix ratio (cement: fine aggregate: CS: water-cement)	Compressive strength (N/mm²)	Flexural strength (N/mm²)	Split tensile strength (N/mm²)
1:1.47:0.65:0.42	26.70	4.68	2.70
1:1.47:0.65:0.44	25.95	4.26	2.38

Cement content

In order to meet ASTM's structural LWC requirements, the minimum 28-day compressive strength must be more than 17 N/mm². The coconut shell concrete mixes M9, M10, and M11 meet this requirement. Between 480 and 510 kg/m³ of cement are needed to satisfy this minimum requirement.

Compressive strength

Compressive strength of LWAC depends on both the strength of the matrix and the particle tensile strength of the aggregate. Once more, rather than the water-to-cement ratio, the compressive strength of LWC is often correlated with the cement content at a specific slump and air content. The difficulty in figuring out how much of the overall mix water is absorbed by the aggregate and, thus, unavailable for reaction with the cement is the cause of this. But in this investigation, the water-to-cement ratio was adjusted to achieve the required workability while using coconut shell coarse aggregates in saturated surface dry (SSD) conditions.

CHAPTER THREE

MATERIALS AND METHODOLOGY

3.1 General

The various materials used and the procedures followed in carrying out the activities related with this project are discussed here one after the other. This chapter contains a of discussion the nature, type, sources, properties and preparation of materials used; the processes of casting concrete and various field and laboratory tests performed.

3.2 Materials

- The following are the materials used for this study:
- Ordinary Portland Cement (OPC).
- Fine Aggregates (sharp sand).
- Coarse Aggregates (crushed granite stones) ½ inch.
- Clean Water.
- Coconut shells.

They are each discussed below.

3.2.1 Cement

Generally, in construction, cement is a binder or binding agent that binds other materials together by setting, hardening, and adhering to them. Cement is typically used to bind sand and gravel together rather than by itself. Cement has a density of 1.45g/cm³. Masonry mortar is made of cement, fine aggregates, and either sand or gravel. Hydration is a chemical reaction that happens when water is introduced to cement and the ingredients are combined to create cement paste. Over time, the mixture hardens and gets firmer.

Ordinary Portland cement was used during this study. This belongs to the class of cement named *hydraulic*. In the presence of water, cement reacts chemically (hydration) to form hydrates that are not soluble in water.

Cement is mostly used in the production of mortar and concrete, the bonding of natural or artificial aggregates to form a strong building material that is durable in the face of normal environmental effects.



This was gotten from a depot at Isihor, Ugbowo, Benin city.

Fig 3.1 sample of cement

3.2.2 Fine Aggregates (Sand)

Fine aggregates are essentially any natural sand particles worn from the land through the mining process. The size of fine aggregate is defined as 4.75mm or smaller, include things such as sand, silt and clay. In the words of Microsoft Encarta, 2009, “generally composed of quartz (silica), sand is a loose, incoherent mass of mineral components in a coarsely granular state with trace amounts of mica, feldspar, magnetite, and other refractory minerals. It is the result of rocks breaking down mechanically and chemically as a result of abrasion and weathering”. It is widely distributed as a surface deposit in arid areas, on the banks of lakes and the sea, and along river systems. In general, fine aggregate particles are smaller than 6.4 mm (.25 in) in size, and coarse aggregate particles are larger than 6.4 mm (.25 in) (Microsoft Encarta, 2009). This was gotten along Isihor, Benin city at a cement depot.

3.2.3 Coarse Aggregates (Granite Chippings)

Coarse aggregate are irregular in shape, shattered stones or circular gravels that occur naturally and are utilized to produce concrete. Broken pieces of hard rock, such as granite, limestone, or river gravel, are found in coarse aggregate for structural concrete.

Granite chippings are crushed igneous rock having definite and recognizable crystal formation and texture. It's composed of feldspar and quartz, with little amount of mica and minor accessory minerals. The specific gravity of granite ranges from 2.63 to 2.75. Its crushing strength is from 1050 to 14,000 kg per sq cm (15,000 to 20,000 lb per sq in). Granite stronger than other types of stone such as sandstone, limestone, and marble and is therefore more difficult to quarry. It is an important building stone, the best grades being extremely resistant to weathering ((Microsoft Encarta, 2009). This was gotten at the same depot the cement and fine aggregate were gotten from.



Fig 3.2, sample of coarse aggregate

3.2.4 Water

Water is the name given to the liquid state of the hydrogen-oxygen compound H_2O . To make durable concrete, pure water as defined above is required. Water and cementitious materials react to form cementing medium or paste by the process of hydration. Water was gotten from the civil engineering lab, University of Benin.

3.2.5 Coconut Shell

Coconut shells are used in the production of activated carbon due to their hardness and high carbon content. To find their ideal strength in comparison to conventional concrete, the coconut shell is used in this investigation as a partial substitute for coarse aggregation. After being sun-dried for 20 days, the coconut shells were hand crushed into the appropriate sizes. By mass, the coconut shell substituted traditional aggregate by 5%, 10%, 15%, and 20%, respectively, and the impact on the concrete's density and compressive strength was noted. The coconut shell was gotten from New Benin market, Benin City Edo State.

3.3 Machines and Equipment used during test

1. Concrete Mixer.
2. Sieve.
3. Oven.
4. Digital Weighing balance.
5. Shovel.
6. Hand trowel.
7. Cube moulds.
8. Headpan.
9. Measuring cylinder.
10. Vibrating table.
12. Bucket.

3.4 Experimental Procedures

The following are the experimental procedures of how the experiment was carried out:

- I. Sampling of materials.
- II. Preparation of concrete mix design (Grade 20 Concrete was used).
- III. Sieve analysis/particle size distribution test.
- IV. Workability Test.
- V. Casting of control mix.
- VI. Casting of cubes with the addition of percentages of coconut shell.
- VII. Water absorption Test for the cubes.
- VIII. Compressive strength test on the cubes.

3.4.1 Sampling of materials

The various materials that were needed for the experiment were gotten and sampled in the laboratory. i.e Cement, Sharp sand, Granit and Coconut shells.

3.4.2 Preparation of concrete mix Design

The calculated mix ratio from the concrete mix design was obtained to be 1: 1.5 :3.

The mix was designed to achieve a strength of 20Mpa after 28 days for the control mix (low strength concrete)

Water	Cement	Fine aggregate	Coarse aggregate
1	0.348	0.522	1.044

3.4.3 Sieve analysis/particle size distribution test

This is a test showing the range of particle size of an aggregate to obtain the normal size of particle and its suitability as aggregate through the evaluation value of the coefficient of uniformity (cu) obtained from the particle size distribution curve drawn from the result of the sieve analysis test.

Particle size distribution was carried out for the fine aggregate and coarse aggregates using the apparatus below:

- i. Sieve shaker
- ii. Sieve of various size
- iii. A weighing balance sensitivity to 0.1g

3.4.3.1 Experimental procedure

- i. The sieves to be used were cleaned and each of them weighed to 0.1g(W).
- ii. The sieve was arranged in decreasing order of size of sieve openings.
- iii. A representative sample of the aggregate to be analysed was taken and broken into individual particle using fingers.
- iv. A small quantity of the dried aggregate (about 500g) was weighed and put into the top sieve.
- v. The aggregate was then sieved through the stack of sieve by hand shaking using a motion of horizontal circular movement and was done for about thirty minutes.
- vi. Each sieve and its content were weighed to 0.1g (W₂)
- vii. The weight of the aggregate retained on each sieve (W₂-W₁) was determined Σ (W₂-W₁) was checked against the original soil weight.

3.4.4 Workability Test

Workability describes the relative ease or difficulty of placing and consolidating concrete in the form. Workability is often defined as the amount of mechanical work required for full compaction of the concrete without segregation. Workability can be measured using the slump test and the compaction factor test.

Slump test was carried out in conformity with B.S 1881 part 2, 1970

3.4.5 Casting of control mix

Before the replacement of cement with coconut shell was done, a trial mix was prepared to get the strength of the pure concrete as to compare it against the strength of that which had coconut shell in it.

3.4.5.1 Experimental procedure

- i. The concrete was prepared using the mix ratio obtained from the mix design.
- ii. Each sample (cement, fine aggregate, coarse aggregate) required were set out on the lab.
- iii. The numerous weights of each sample were multiplied by the dimension of the cube moulds i.e 0.1m x 0.1m x 0.1m. There was an addition of 5% to each sample as a regard to losses that might occur during mixing and transfer of sample from weighing pan to mixer and from the mixer to the moulds.
- iv. The first weighed sample was the cement, followed by the fine aggregate then the coarse aggregate.
- v. Mixing was done before water was added before the final mixing was done
- vi. The wooden moulds were oiled using engine oil as well fastened before the concrete was poured into it.

- vii. The moulds were placed on the vibrating table so that compaction could be achieved before been kept for 24 hours so that setting and hardening can take place.
- viii. After 24hrs the cubes were demoulded and cured respectively according to their required time.

3.4.6 Casting of cubes with the addition of Coconut Shells

This was the most essential part of the whole experiment were the partial replacement of Coarse aggregate was done by using Coconut shells. The procedure is quite similar to that of the control mix, but with some slight adjustments.

3.4.6.1 Experimental Procedure

- i. The concrete is prepared using the weight of each sample obtained from the mix design chart.
- ii. The samples are weighed in similar fashion just as for the control mix but, in this instance, the weight of coarse aggregate were multiplied by 0.05, 0.10, 0.15 and 0.20 to account for the 5%, 10%, 15% respectively.
- iii. For the first mix, the weight of coarse aggregate is multiplied by 0.05 to account for the 5% replacement. The obtained weight is subtracted from the initial weight of coarse aggregate and will be the weight for the coconut shell to be measured and added to the concrete mix.
- iv. Similarly, this is done for 10% and 15%.
- v. After the Coconut shell is added to the rest samples, mixing is done on the mixer before the addition of water.
- vi. The moulds are oiled and casting of the cubes is carried out.

vii. The cubes are being demoulded after 24hrs and cured according to their respective category.

3.4.7 Curing of cubes

The cubes were cured in a curing tank (water curing) for the stipulated period of time as stated in the study. Below were how the cubes were cured, the number of cubes and the days for their curing.

S/N	Duration of curing in days	Method of curing	No of cubes	Test carried out on the cubes
1.	7	Wet	3	Water absorption test + Compressive strength test
2.	14	Wet	3	Water absorption test + Compressive strength test
3.	21	Wet	3	Water absorption test + Compressive strength test
4.	28	Wet	3	Water absorption test + Compressive strength test

3.4.8 Water Absorption test

Concrete cubes of dimensions 100mm x 100mm x 100mm were cured for 28days, these specimens were then oven dried for 24 hours at 100°C. Their weight was measured and recorded (W1), the specimen is now placed in water for 24hours and their weight is taken as (W2). The percentage absorption was calculated from

$$\text{Absorption (\%)} = \frac{W_2 - W_1}{W_1} \times 100$$

3.4.8. Bulk Density Test

This test was performed to determine the weight that would fill a unit volume and was conducted in accordance with BS 812:2 (1995). The density is determined as Mass of concrete Cube/Volume of concrete cube

3.4.9 Compressive Strength Test

The compressive strength test for concrete was carried on all cubes. Three cubes were crushed on every crushing day and the average compressive strength was recorded.

Procedure

- i. The compression test machine was turned on with gauge set to zero.
- ii. The cube sample was taken one at a time and was set at the middle of the machine, the top screw was lowered to hold the cube in place firmly.
- iii. After it was held in place, the compression machine was turned on and it started exerting compressive force on the cube sample till it crushed it.
- iv. The failure load is recorded immediately after failure of the cube.
- v. A total of 3 cubes were crushed and the average recorded

$$\text{Compressive Strength} = \frac{\text{Failure load}}{\text{Cross section Area of cube}}$$

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 INTRODUCTION

4.1.1 COMPRESSIVE STRENGTH TEST

In order to determine the compressive strength of concrete cubes, a universal compression testing machine with a 2000 KN capability was employed. A pivotal aspect of the compressive strength test is the determination of the type of failure that occurs. Concrete typically fails through crushing, which is the anticipated outcome. However, the test may sometimes reveal unexpected modes of failure, such as splitting or shear. Recording and analyzing the failure mode provides valuable insights into the concrete's behavior under stress.

Following the test, the recorded data serves as the basis for calculating the compressive strength of the concrete specimen. This calculation is performed by dividing the maximum applied load by the specimen's cross-sectional area. The formula is straightforward:

$$\text{Compressive Strength (KN/ } mm^2) = \frac{\text{Maximum Load (KN)}}{\text{Cross Sectional Area (} mm^2)}$$

Compressive Strength at 0% Replacement with **water** = 0.48
cement

Table 4.1: Average Compressive Strength Obtained after 7 days of Curing, with coconut shell replacement of 0%, 5%, 10%, and 15%.

Replacement %	Sample No	Weight (Kg)	Density (Kg/m³)	Failure load (KN)	Compressive Strength (N/mm²)	Average strength (N/mm²)
0%	1	2.577	2577	190	19	19
	2	2.610	2610	210	21	
	3	2.504	2504	170	17	
5%	1	2.524	2524	200	20	15.5
	2	2.493	2493	145	14.5	
	3	2.635	2635	120	12	
10%	1	2.474	2286	180	18	15.3
	2	2.234	2491	160	16	
	3	2.407	2399	120	16	
15%	1	2.286	2286	90	9	11
	2	2.491	2491	130	13	
	3	2.399	2399	110	11	

Table 4.2: Average Compressive Strength Obtained after 14 days of Curing, with coconut shell replacement of 0%, 5%, 10%, and 15%.

Replacement %	Sample No	Weight (Kg)	Density (Kg/m³)	Failure load (KN)	Compressive Strength (N/mm²)	Average strength (N/mm²)
0%	1	2.623	2623	165.03	16.503	19.128
	2	2.634	2634	211.36	21.136	
	3	2.611	2611	177.44	19.744	
5%	1	2.623	2623	114.76	11.476	16.4
	2	2.649	2649	189.93	18.993	
	3	2.606	2606	187.32	18.732	
10%	1	2.441	2441	128.26	12.826	10.118
	2	2.591	2591	63.2	6.32	
	3	2.311	2311	112.05	11.205	
15%	1	2.464	2464	122.46	12.246	13.51
	2	2.471	2471	129.25	12.925	
	3	2.482	2482	153.69	15.369	

Table 4.3: Average Compressive Strength Obtained after 28 days of Curing, with coconut shell replacement of 0%, 5%, 10%, and 15%.

Replacement %	Sample No	Weight (Kg)	Density (Kg/m³)	Failure load (KN)	Compressive Strength (N/mm²)	Average strength (N/mm²)
0%	1	2.730	2730	250.03	25.003	24.697
	2	2.695	2695	230.69	23.069	
	3	2.770	2770	260.18	26.018	
5%	1	2.705	2705	190.35	19.035	20.678
	2	2.619	2619	230.01	23.010	
	3	2.784	2784	199.89	19.989	
10%	1	2.598	2598	200.8	20.08	19.722
	2	2.625	2625	199.85	19.985	
	3	2.577	2577	191.01	19.101	
15%	1	2.511	2511	132.86	13.286	15.16
	2	2.501	2501	172.35	17.235	
	3	2.485	2485	149.58	14.958	

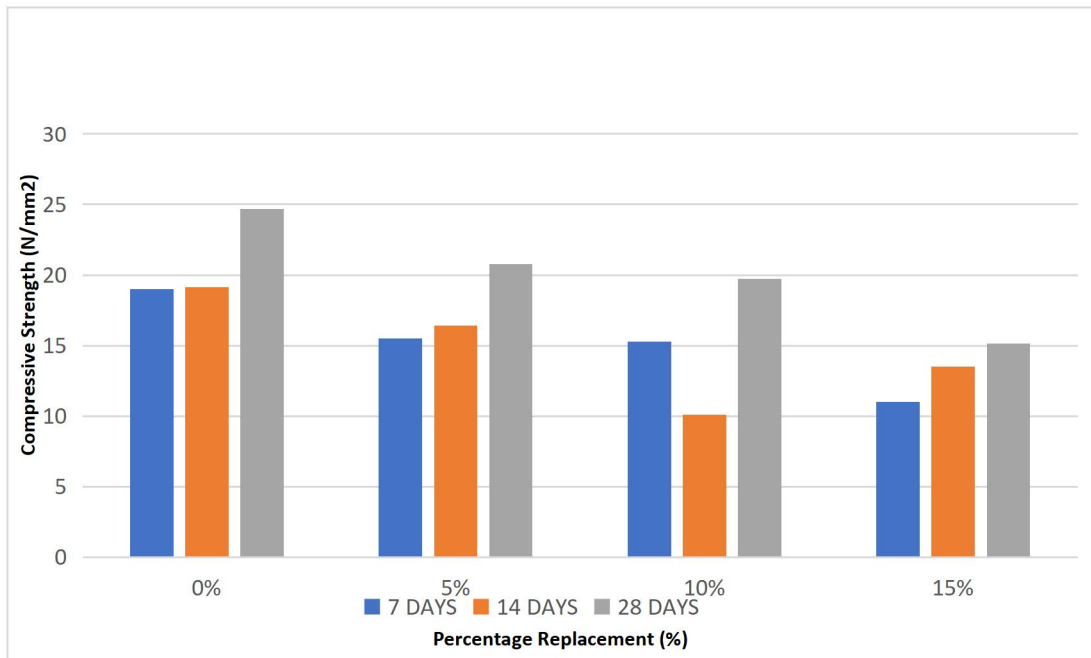


Figure 4.1: Graph showing Average Compressive Strength for various Proportion

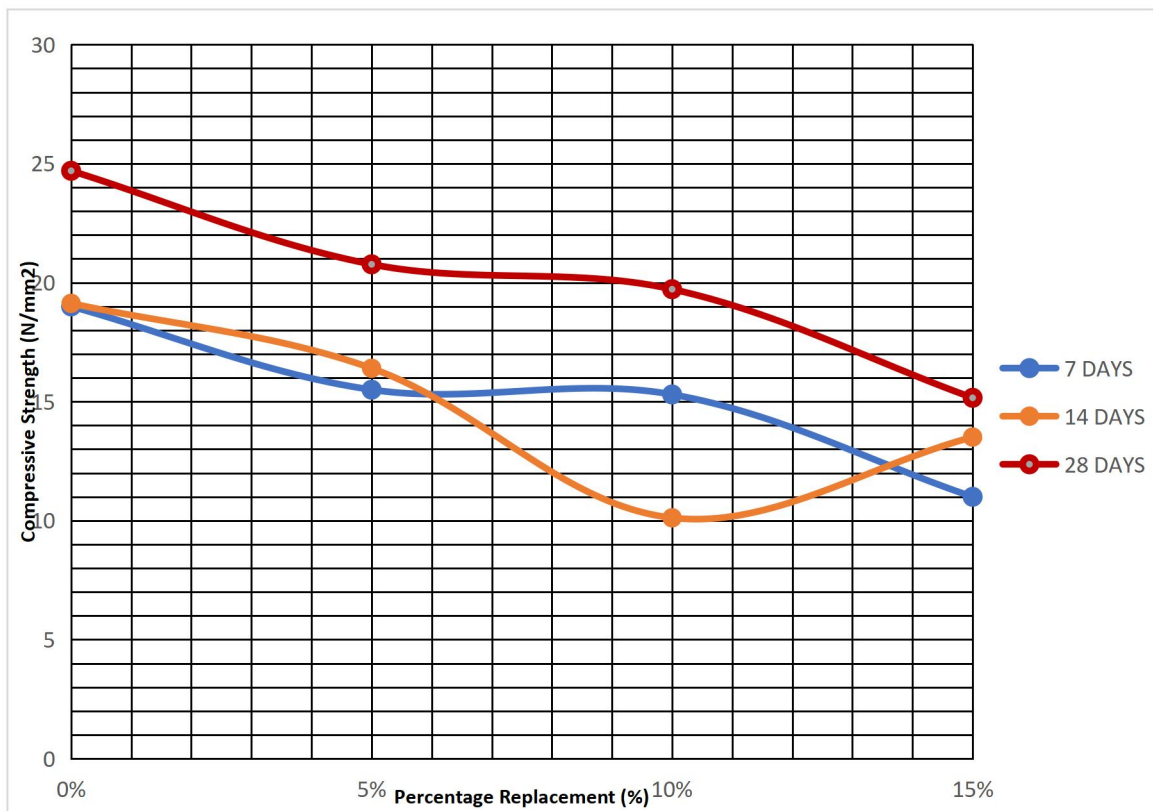


Figure 4.2: Graph showing Average Compressive Strength for various Proportion

4.2 DISCUSSION OF THE COMPRESSION RESULT

From the results obtained and represented on Fig 4.3, the optimum strength was obtained when the coarse aggregate was replaced by 5% with the coconut shell. However, all other percentage replacement gave values that conform to the expected design characteristic design of the concrete (20 N/mm²).

Table 4.4: Result from Sieve Analysis for fine aggregate Total Mass of sand tested = 100.00g

SIEVE SIZE (MM)	MASS RETAINED (G)	PERCENTAGE RETAINED (%)	CUMULATIVE PERCENTAGE RETAINED (%)	PERCENTAGE PASSING (%)
2.36	0.30	1.26	0.11	96.21
2.00	0.15	0.15	2.71	94.22
1.18	2.26	6.627	9.408	90.59
600	19.28	31.66	41.068	58.93
425	6.68	18.96	41.068	58.93
300	10.73	22.92	82.948	17.05
212	21.90	12.05	94.998	5.00
150	3.95	0.69	95.688	4.31
75	3.97	1.52	97.208	2.79
Pan	1.25	0.269	95.477	1.5

$$\text{Retained\%} = \frac{\text{Mass retained Total}}{\text{Mass tested}} \times 100$$

Cumulative % Retained = % retained + the succeeding % retained

% passing = 100 – Cumulative % Retained % loss < 0.5

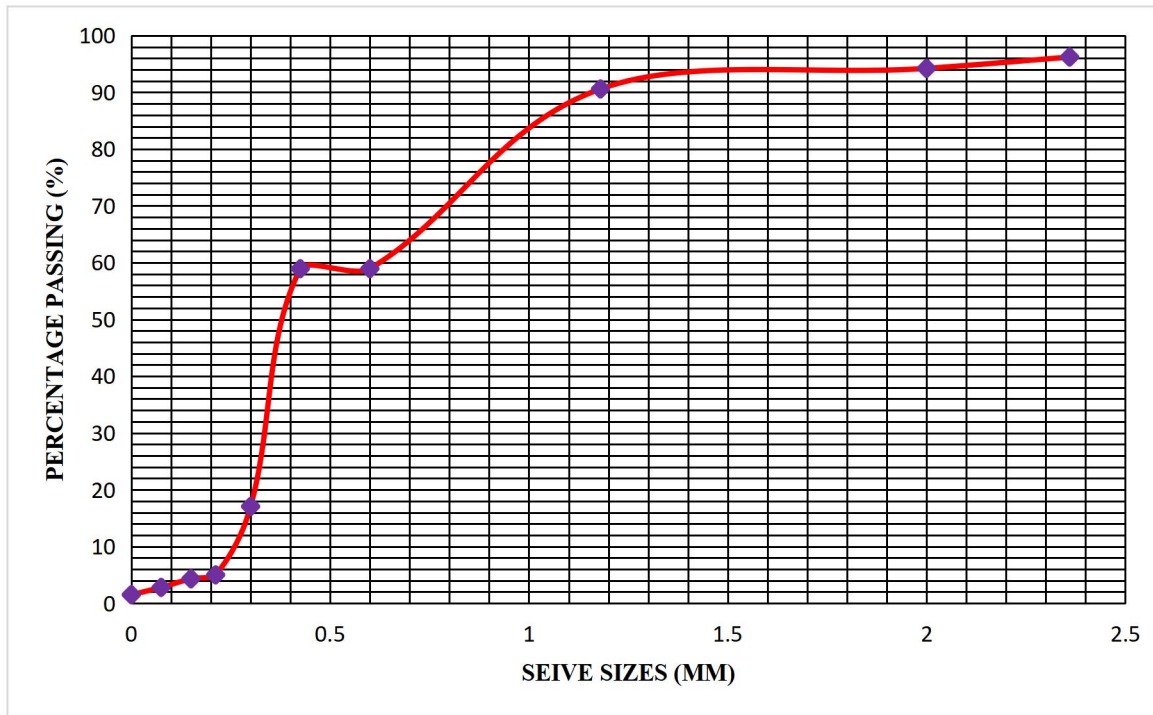
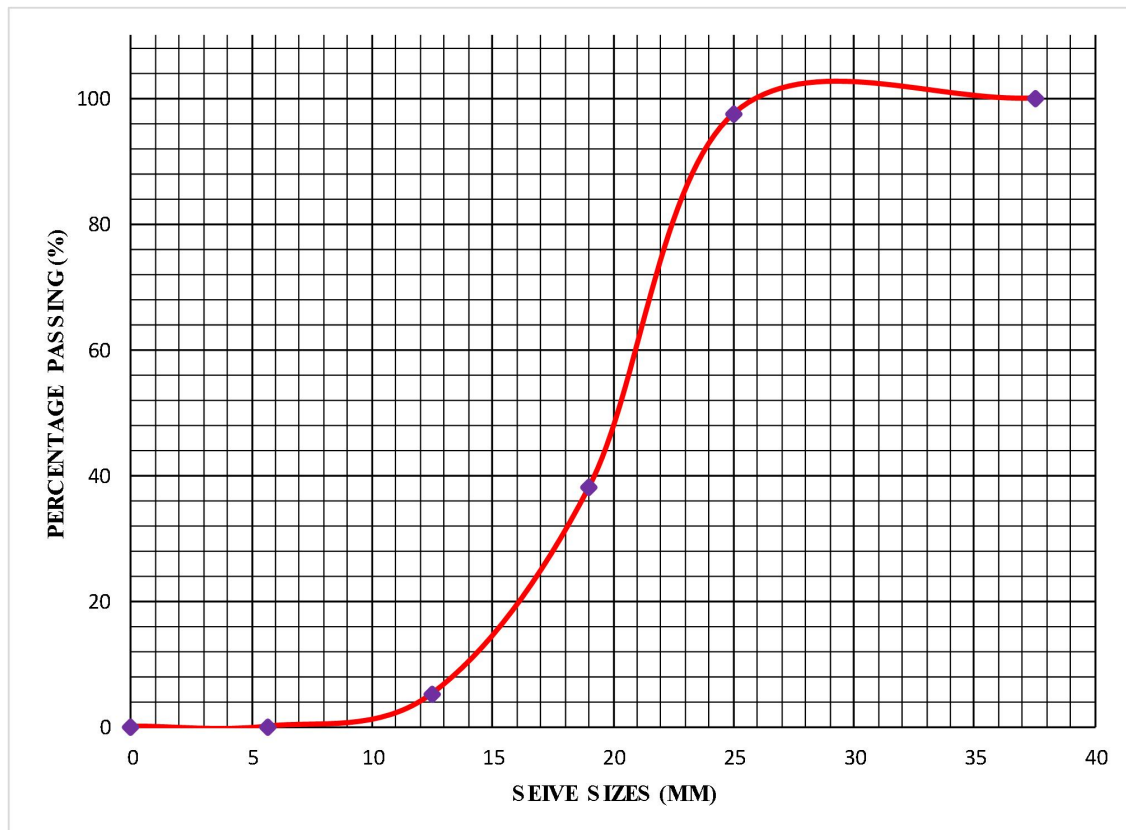


Fig 4.3: Graph showing the variation of % passing with respect to different sieve sizes.

Table 4.5: Result from Sieve Analysis for coconut shell aggregate (3000g)

Sieve Size (mm)	Mass Retained (g)	Mass passing (g)	Percentage Passing (%)
37.5	0	3000	100
25	73.5	2926.5	97.55
19	1783.8	1142.7	38.09
12.5	985.5	157.2	5.24
5.7	156.9	0.3	0.01
Pan	1.2	0.1	0.00



F

Fig 4.4: Graph showing the variation of % passing of the Coconut Shell aggregate

Table 4.6: Results from Slump test

Sample No	Slump 1 (mm)	Slump 2 (mm)	Slump 3 (mm)	Average Slump (mm)
0%	10	11	10	10.3
5%	12	15	16	14.3
10%	11	13	14	12.6
15%	19	18	19	18.7

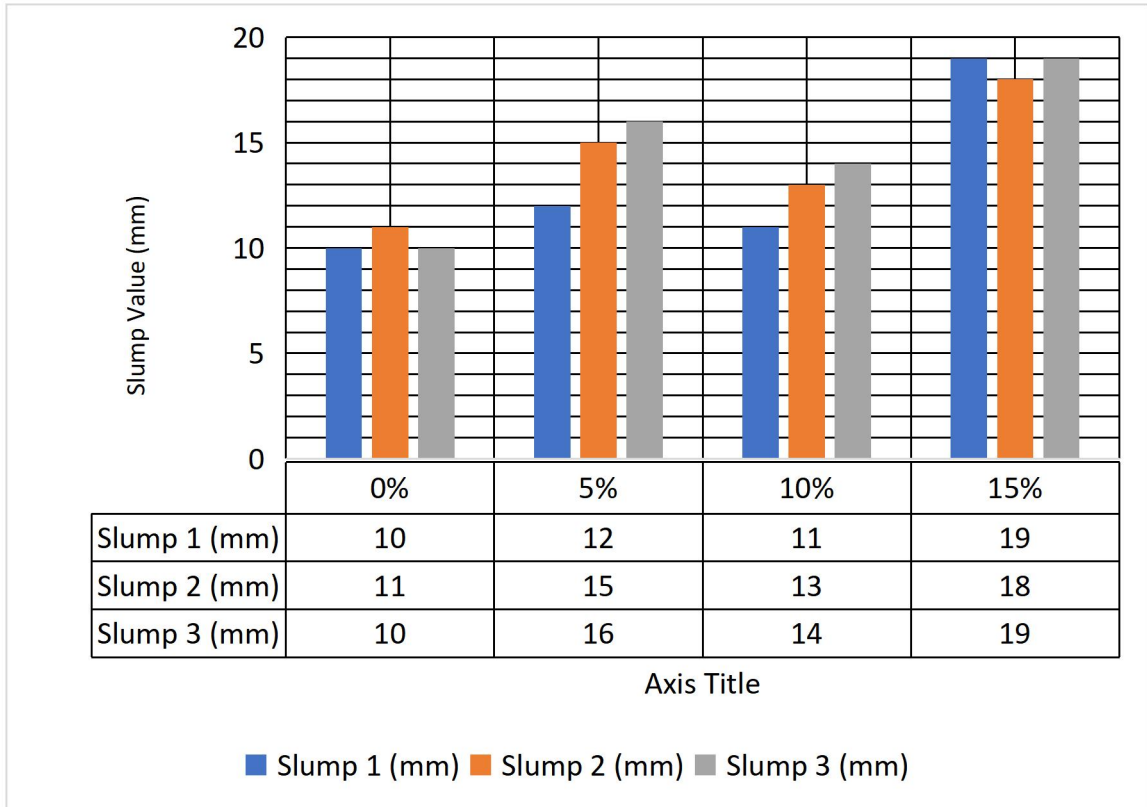


Fig 4.6: Graph of Slump test on coconut shell concrete

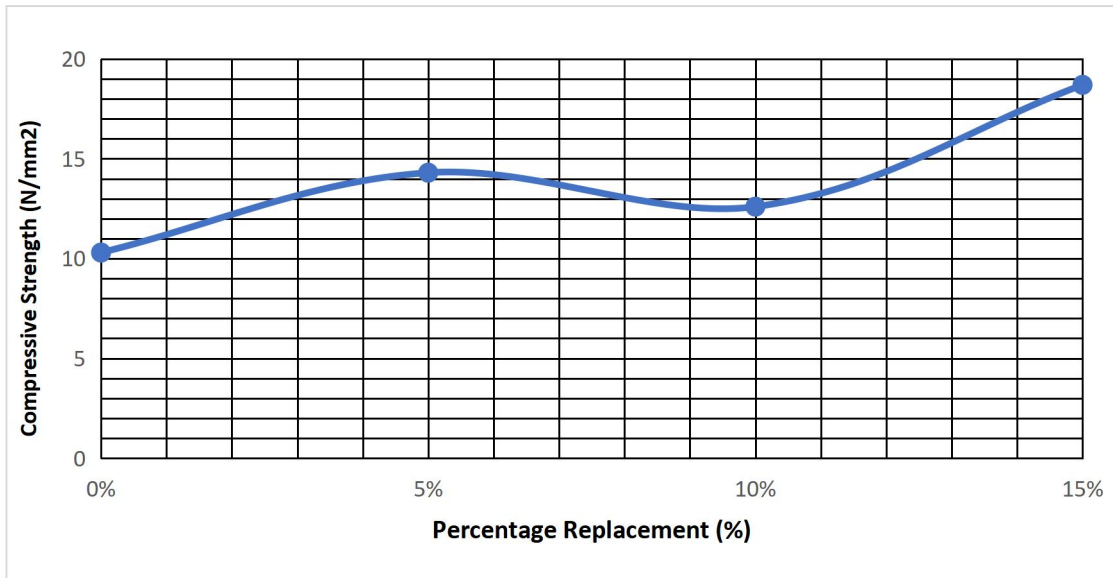


Fig 4.7: Graph of Average Slump value of coconut shell concrete at various % replacement

4.3 DISCUSSION OF SLUMP TEST

The results from the slump test shows that the slump of the fresh concrete decreased with increase in the replacement of the coarse aggregate. This implies that the presence of coconut shell in the concrete decreased its workability. However, the average slump values shows that all the replacement percentages passed the slump test which is expected to range between 10mm to 30mm for the designed concrete grade (C25).

Table: 4.7: Result of water absorption Percentage Obtained After 24hrs of Immersion of Concrete Cubes with Coconut Shell Replacement of 0%, 5%, 10% and 15% cured for 28 days

S/N	PERCENTAGE REPLACEMENT	DRY WIEGHT	SATURATED WEIGHT AFTER 24HRS	PERCENTAGE OF WATER ABSORBED	AVERAGE OF WATER ABSORBED
1	0%	2.730	2.750	0.732	0.459
2		2.695	2.700	0.187	
3	5%	2.705	2.719	0.517	1.1367
4		2.619	2.665	1.756	
5	10%	2.598	2.600	0.077	0.446
6		2.577	2.598	0.814	
7	15%	2.511	2.536	0.995	0.996
8		2.485	2.500	0.998	

$$W_A = \frac{W_T - W_D}{W_{D1}} \times 100 = \text{WATER ABSORPTION}$$

4.4 DISCUSSION OF THE WATER ABSORPTION

From the results presented in Table 4.6, the water absorption generally increased with higher percentages of coconut shell replacement. While the 5% replacement level exhibited the highest average water absorption, it's important to note that this level also corresponded with the highest average strength, as indicated in Fig 4.3. Conversely, all other replacement levels (0%, 5%, and 10%) exhibited water absorption values that, while higher than the control mix (0%), still conformed to the expected design characteristic strength of the concrete (25 N/mm²).

Abstract

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The study investigated the mechanical properties of coconut shell concrete by partially replacing coarse aggregate with crushed coconut shells at various levels (0%, 5%, 10%, and 15%). Compressive strength tests performed on cube specimens revealed that the control mix (0% replacement) achieved strengths of 21.09 N/mm² at 7 days, 23.90 N/mm² at 14 days, and 30.51 N/mm² at 28 days. Among the replacement levels tested, the mix with 5% coconut shell replacement recorded compressive strength values that were closest to the control mix, indicating that low-level replacement maintains the necessary structural integrity while introducing sustainable practices.

In terms of durability, water absorption tests indicated that coconut shell replacement generally increases water uptake due to the porous nature of the shells. However, the 5% replacement mix exhibited only a modest increase in water absorption compared to the control, suggesting that durability is not significantly compromised at this level. Density measurements further confirmed that incorporating coconut shells reduces the overall weight of the concrete, contributing to the production of lightweight concrete suitable for concrete production construction. Slump tests also demonstrated that while workability decreases with higher replacement levels, the 5% mix maintains an acceptable slump within the target range for the designed concrete grade.

Overall, the research confirms that the optimal coconut shell replacement level for concrete production concrete is 5%, as it achieves a desirable balance between

compressive strength, durability (water absorption and density), and workability. This optimized mix design not only meets the design requirements for structural integrity and safety but also enhances sustainability by utilizing an abundant agricultural waste material. The findings provide valuable insights for adopting more environmentally friendly construction practices, ultimately contributing to the development of lightweight, durable, and cost-effective concrete for infrastructure projects in regions with similar environmental challenges.

5.2 RECOMMENDATIONS

Based on the findings of this project work, several recommendations can be made on the impact of partially substituting coconut shell for coarse aggregate on concrete's compressive strength:

1. **Optimal Coconut Shell Content:** For practical applications, consider using a 10% (percentage) of coconut shell as a partial replacement for coarse aggregates based on the study's findings. However, further research is advised to determine the optimal content for specific construction projects.
2. **Adjusting Curing Practices:** Construction professionals should consider modifying curing practices to accommodate the use of coconut shell in concrete, particularly concerning curing duration and humidity control.
3. **Structural Performance:** Future research should delve deeper into the structural performance of concrete with coconut shell as an aggregate. This includes exploring its behavior under different load conditions, such as flexural and tensile strengths.
4. **Durability and Longevity:** Investigate the long-term durability and service life of concrete with coconut shell. Assess its resistance to environmental factors like freeze-thaw cycles, corrosion, and chemical exposure.

5. Sustainability Assessment: Conduct a comprehensive life cycle assessment (LCA) to evaluate the overall sustainability of using coconut shell in concrete production, considering environmental, economic, and social aspects.
6. Awareness and Training: Promote awareness and provide training for construction professionals on the use of sustainable materials like coconut shell in concrete.
7. Regulatory Support: Advocate for regulatory support and standards that encourage the use of sustainable construction materials and practices.

APPENDIX



Plate 1: Vibrating of concrete on the vibrating table



Plate 2: Measuring of coconut shell replacement for coarse aggregate



Plate 3: Slump Test on concrete



Plate 4: Removal of concrete from concrete mould

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