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Behaviour Analysis of Light Weight Concrete with Coconut Shell as a Partial Replacement of Coarse Aggregate

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Abstract: Concrete is the most widely used material in the world for construction, more than any other commodity. It is also the second-most used material after water in the world. In concrete, aggregates are the most abundant component by volume and are naturally low in carbon, and the demand for natural coarse aggregate is increasing in construction activities. Using light aggregate materials as coarse aggregates can help reduce the environmental impact of construction projects. Lightweight aggregates in concrete have a low density, which gives it several other properties like low self-weight and good thermal and acoustic insulation. Coconut shells can also be used as a lightweight aggregate in concrete. Coconut shell, a natural by-product of the coconut industry and a renewable resource, is one potential lightweight aggregate. In this experimental investigation, coconut shells were used as a partial replacement for coarse aggregate in lightweight concrete at 0%, 10%, 20%, 30%, and 40% of the concrete mixes, whereas this paper presents practical work on mechanical properties such as compressive strength and split tensile strength in the concrete.
Keywords: Light Weight Concrete, Coconut Shells, Aggregate, Strength

I. INTRODUCTION

In the world's building industry, concrete is one of the most frequently utilised materials. It can be used to construct walls, bridges, roads, dams, and building foundations, among other things. Concrete is a preferred material for construction projects of all kinds because of its adaptability, toughness, and affordability. Nonetheless, there has been a shortage of concrete in several areas in recent years. Many issues, such as a scarcity of raw materials, an increase in demand, and problems with the supply chain, are blamed for the shortfall. There are a number of potential remedies to the concrete scarcity. Investing in the development of concrete-alternative building materials is one way to solve the problem. For instance, some researchers are investigating the use of coconut shells and other environmentally friendly materials as concrete substitutes. Coconut shells are a type of agricultural waste that is frequently thrown and not properly used. Yet, recent research has demonstrated that using coconut shells instead of coarse particles can produce concrete that is more environmentally friendly. Coconut shell concrete has been demonstrated to have strong compressive strength and durability qualities in addition to being environmentally friendly. Although there are some drawbacks to using coconut shells in the manufacture of concrete, their high lignin concentration makes them resistant to water and fungus growth, making them an appropriate material for usage in coastal areas and humid climates. For example, the shells must be properly cleaned and processed to remove any impurities before they can be used. Additionally, the use of coconut shells in concrete can affect the workability of the mixture, which must be carefully controlled. Despite these challenges, the use of coconut shells in concrete production is a promising development in sustainable construction. By utilizing this abundant agricultural waste product, we can reduce the environmental impact of concrete production and create more sustainable and eco-friendly buildings. The hard, outer covering of the coconut fruit is called a coconut shell, and due to its many special characteristics, it can be used for a wide range of purposes. These shells have a high degree of flexibility and resistance to bending because they are mainly made of fibres. However, because of their low tensile strength, they are unsuitable for use in applications requiring great force resistance. The uses for coconut shells are numerous despite their low compressive strength. Coconut shells are frequently used as a raw material for a range of goods, such as activated carbon, charcoal, and arts. Since coconut shell charcoal is a more sustainable option than conventional charcoal produced from wood, it is especially well-liked. Coconut shells have been successfully used in numerous construction endeavours throughout history, despite these difficulties. The traditional homes of the Bajau people, who reside in the Philippines and other regions of Southeast Asia, are one noteworthy example. Coconut palm leaves and bamboo are used to build these houses, with coconut shells filling in the spaces between the bamboo poles.

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Coconut shells are once again gaining popularity as a sustainable and environmentally friendly building resource. To make distinctive and long-lasting structures, some architects and builders have tried combining coconut shells with other materials like concrete or adobe. In the end, even though they are not frequently used in contemporary construction, coconut shells do have some special qualities that make them a good choice in some situations. Their natural aesthetic qualities can add a distinctive touch to any building project, and their insulation properties, lightweight nature, and resistance to pests and decay make them especially useful in tropical climates. Despite some difficulties, using coconut shells in construction can be a useful and beneficial addition to any building project with careful planning and creative design.

II. LITERATURE SURVEY

In India, enterprises that produce coconut products and temples produce a lot of trash coconut shell that has to be disposed of It has been suggested by researchers that it be used as a concrete additive. Results revealed that with 40% replacement of conventional coarse aggregate by coconut shell, 7 days compressive strength of concrete decreased by 62.6%; whereas decrease in 28 days compressive strength was only 21.5%. 40% replacement makes the concrete lighter by 7.47%. Further, it was revealed that for mix design of concrete of 20 N/mm2 characteristic strength, no additional cement is required for 5% replacement and only 3.6% additional cement was required for 10% replacement. The results confirm that although there is an increase in cost due to additional cement requirement, the advantages being many, including efficient utilization of waste coconut shell, reduction in natural source depletion etc [1]. Lightweight concrete is composed up of lightweight aggregates such as shale, clay, or slate, which give its distinctive low density. LWC is becoming more popular for building the slim-line foundations, and it's proving to be a viable alternative to the ordinary concrete. Lightweight concrete can be classified by its unit weight or density, which normally ranges from 320 to 1920 kg/m^3. Glazed Iso Ball claims to be one of the lightest aggregates, which has a density ranging from 100 to 250 kg/m^3 . This whitish or light grey substance weighs about a tenth of the weight of sand or gravel. The specially processed Glazed Iso Ball is made up of larger particles that can be used instead of (or) in addition to sand or gravel in lightweight concrete, fire retardant plaster, or insulating concrete. Coconut shell is a by-product obtained from the agricultural and industrial processes. These coconut shell wastes face issues with disposal and management which have resulted in major pollution concerns. The coconut shells can be used in place of natural coarse aggregate [2]. Due to a number of factors, including aggregate shape, a weak interfacial transition zone around the CSA, and the orientation of many CSA particles along the direction of load acting parallel to the specimen height, the compressive strength of CSBAC at all ages declined as the CSA content increased. Although WC55CS15 (a CSBAC with a 0.55 w/c ratio and 15% CSA) was the only CSBAC that did not meet the minimum criterion of compressive strength (17 MPa) for structural LWC, all other CSBACs did. At later ages, the compressive strength of CSBAC significantly improved. Due to the increased compactness of concrete brought on by its higher workability, which helped to contribute to its higher compressive strength at ages 56 and 90 days, the rate of gain in CSBAC's compressive strength was notably high for the w/c ratio of 0.50 [3]. The workability decreases as more Cs is added. When compared to conventional concrete, the proportion of Cs increases as deceased compressive strength, split tensile strength, and flexural strength. The use of CS in lieu of conventional concrete can increase compressive strength by up to 20%. In concrete, the different sizes of 10% Cs (8 mm, 10 mm, and 12.5 mm) substitute Cs.The split tensile strength, flexural strength, and compressive strength all decrease as the sizes of Cs rise. 10% of the CS is replaced, and fibre is introduced. after replacing 10% of the CS and adding fibre to concrete at various high temperatures [4].

By the literature we can say that the properties of coconut shell which may make it suitable coarse aggregate for concrete should be had high strength its high lignin content that makes the composites more weather resistant (Lignin is an important organic polymer), Absorbs less moisture (low cellulose content). Sugar in the coconut shell is not in a free sugar form, and therefore does not affect the setting and strength concrete. No additional cement is required for 5% replacement and only 3.6% additional cement is required for 10% replacement. Replacement of conventional aggregate by waste coconut shell makes the concrete lighter. Reduction in concrete density is about 7.5% for 40% replacement.

III. EXPERIMENTAL WORK AND RESULTS DISCUSSION

A. Introduction

Concrete mixing is the process of properly mixing the materials required to form concrete, such as cement, sand, aggregate, and, in the case of coconut shell replacement, water. The primary goal of concrete mixing is to produce a homogeneous and uniformly coloured concrete mass while maintaining the required consistency. The outer layer of coconut shells is removed, and then the shells are prepared for use as aggregate by being sliced into little pieces of the proper size.

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In the appropriate ratios, cement, sand, water, and coconut shell aggregate are combined to create the concrete mix. Casting takes place in the cube specimens of size 150x150x150 mm and cylinder specimen of size 150 mm diameter and 300 mm height and curing done to determine various mechanical properties such as compressive strength and spilt tensile strength respectively.

B. Materials Used

1) Cement - Ordinary Portland cement of 53 grade was used.
2) Fine aggregate - Natural sand conforming to Zone I was used as fine aggregate in this work.
3) Coarse aggregate - Crushed coarse aggregate with size of 20 mm was used.
4) Sustainable aggregates - Waste coconut shells were replaced with partial percentages 10%, 20%, 30% and 40%
5) Water - Portable water was used.

C. Compressive Strength

The compressive strength experiment is performed on UTM after it has been cured in water for 28 days. Table I lists the compressive strength values for LWC with CS, and Fig. 1 illustrates the variations in compressive strength. According to the results, up to 30% of CS replacement in LWC results in improved compressive strength, whereas 40% results in poor compressive strength for water curing after 28 days and this because of the compacted aggregate particles, closed morphology of the aggregates and the pozzolans with the medium inter-particle relationship, reduced porosity, and the evolution of strengths over time are typically responsible for the strength achieved in conventional concrete. However, CS concrete has a unique nature than regular concrete. Because the concrete has a smooth texture, the inter-particle bond plays a smaller function in the development of mechanical strengths in CS concrete. The key characteristics for the light weight concrete are therefore reduced rigidity and reduced strength.

TABLE I
COMPRESSIVE STRENGTH OF CUBES AFTER 28 DAYS

MIX	Percentage of replacement with coconut shells in LWC (%)	Compressive Strength after 28 days (MPa)
MIX1	0	38.01
MIX2	10	30.41
MIX3	20	24.74
MIX4	30	20.44
MIX5	40	10.2

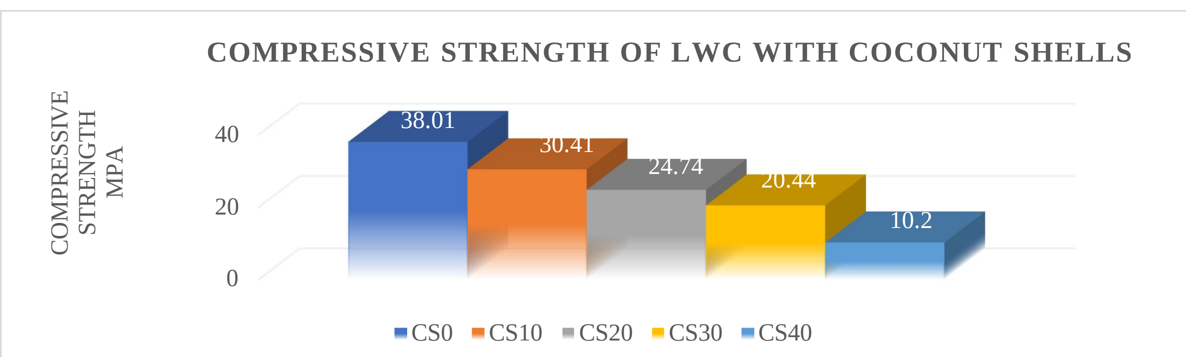

Fig.1 A graph shows compressive strength after 28 days

D. Split Tensile Strength

The split tensile strength experiment is performed on UTM after it has been cured in water for 28 days. Table 9 lists the split tensile strength values for LWC with CS, and Fig. 2 illustrates the variations in split tensile strength. The results of this study obtained indicate the control mix's tensile strength is low. Concrete is known to be strong in compression and weak in tension. Concrete cracks that are hazardous are caused by this property of concrete. Due to this nature, bending stresses also form in the concrete.

According to the results, up to 10% of CS replacement in LWC results in improved Split tensile strength, whereas after 20% results were poor split tensile strength for water curing after 28 days and this because of fibres that make up the majority of a coconut skin give it a high degree of flexibility and resistance to bending. However, because these fibres have a low tensile strength, they cannot resist forces that draw or stretch them apart. Because of how the fibres are arranged inside the shell, coconut shells have a low compressive strength. The fibres' random and erratic arrangement prevents them from forming solid connections with one another. As a result, when subjected to tensile pressures, they are more likely to be pulled apart.

TABLE II
SPLIT TENSILE STRENGTH OF CONCRETE CUBES 28 DAYS

MIX	Percentage of replacement with coconut shells in LWC (%)	Split Tensile Strength after 28 days (MPa)
MIX1	0	4.29
MIX2	10	3.12
MIX3	20	2.12
MIX4	30	1.33
MIX5	40	0.49

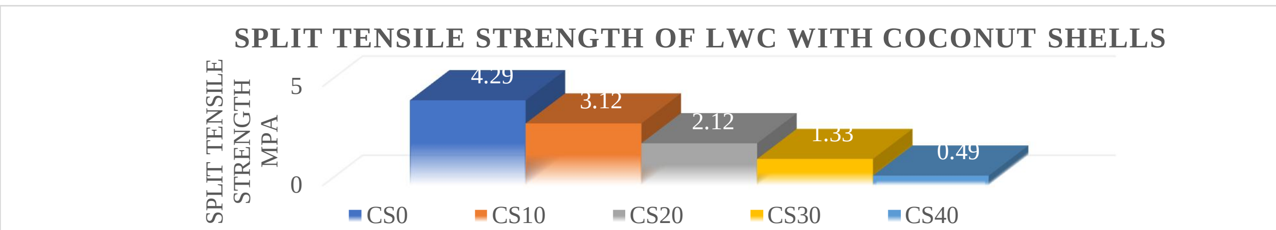

Fig.2 A graph shows split tensile strength after 28 days

IV. CONCLUSIONS

Every year, coconut shells, a typical agricultural waste, are harvested for a variety of uses all over the world. A promising approach that can be used in lightweight construction methods is the outer shell cover of the coconut. The adaptability of such waste serves as filler for concrete building materials as well as reducing the effects of soil pollution. This experimental research primarily examines the potential for substituting coconut shell (CS) for coarse aggregate (CA) in order to address disposal issues and reduce waste. CS can be used as an alternative material to CA to make concrete lightweight and ecologically friendly, according to the experimental results of this research. The results of tests for compressive and split tensile strength were determined to be satisfactory. Therefore, it is logically inferable from the overall strength findings that the replacement of CS can only be accepted up to 10%.

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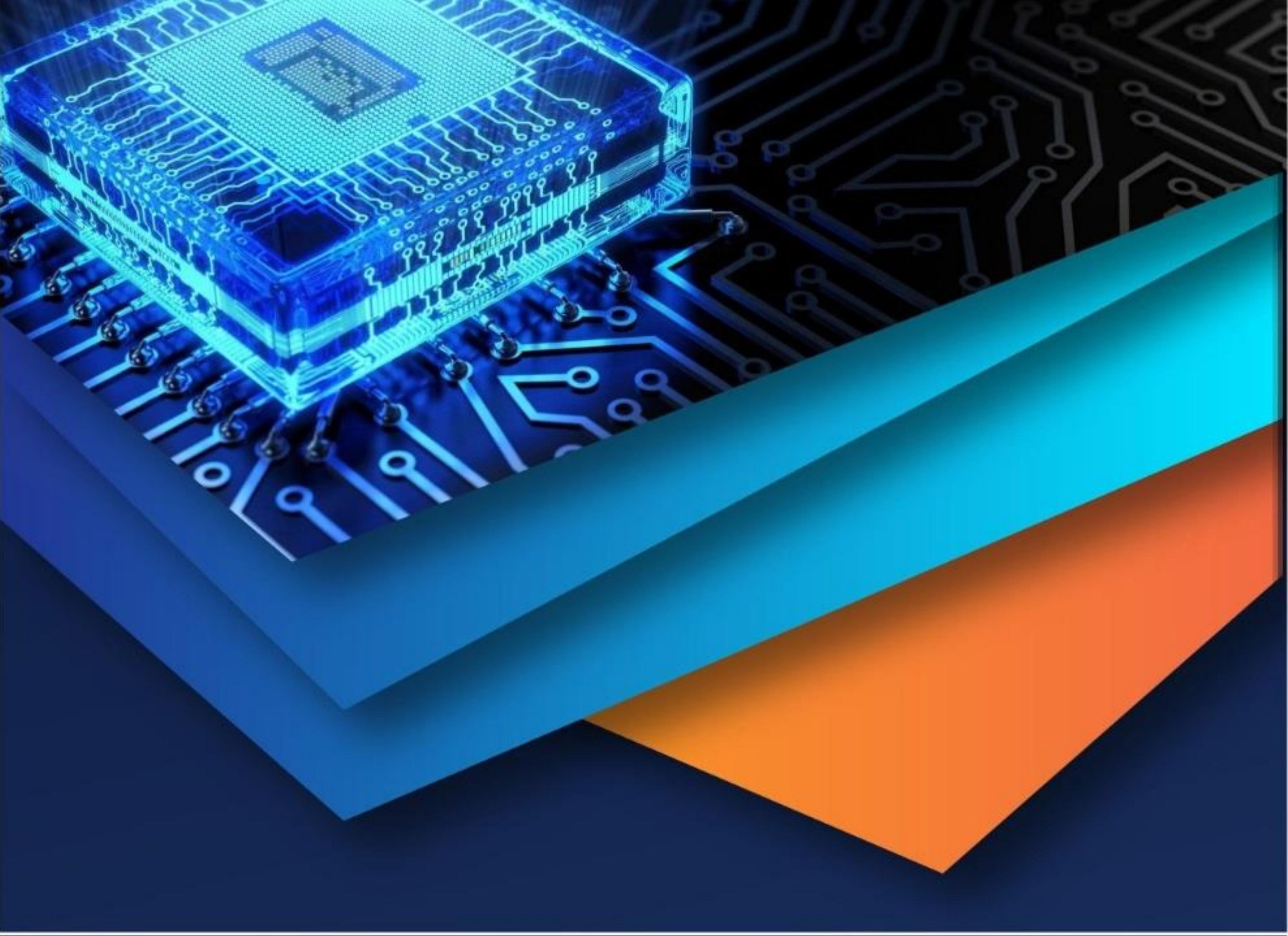

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