Quest Journals
Journal of Architecture and Civil Engineering
Volume 10 ~ Issue 2 (2025) pp: 01-07
ISSN(Online) : 2321-8193
www.questjournals.org

Research Paper

Innovative use of Rice Husk Ash and Coconut shell in Self-Compacting Concrete: A step Towards Sustainable Construction

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ABSTRACT: *The construction industry's increasing demand for sustainable and eco-friendly materials has led to the exploration of innovative alternative, in the current construction business, concrete is a fundamental building material that accounts for a significant portion of costs. The quality of the concrete, which varies from normal to special specifications to satisfy design expectations in real practices, is the main source of concern. The construction industry may be able to overcome the drawbacks associated with using conventional concrete in densely reinforced structural elements by implementing Self-Compacting Concrete (SCC). The need for using sustainable building materials and reducing trash sent to landfills is growing in response to society's ongoing shift towards environmental consciousness. Thus, it has been determined that the actual use of Rice Husk Ash (RHA) as a Supplementary Cementitious Material (SCM) can help cut down on the amount of Portland cement used in the building sector. The study aims to ascertain the ideal ratio of Rice Husk Ash (RHA) for use as an additional cementitious material to partially substitute Portland cement in self-compacting concrete. This paper reports the performance evaluation of self-compacting coconut shell concrete (SCCSC) with Rice Husk Ash developed using discarded coconut shells as full replacement of coarse aggregate and partial replacement of ordinary Portland cement with RHA at 0 - 30%, while RHA was extracted through the uncontrolled burning of rice husk. Tests carried out on the fresh concrete include slump flow, V-funnel and L-box confirmed the flow ability, viscosity and passing ability of the developed mixes. Furthermore, on the hardened concrete, mechanical properties such as compressive strength and splitting tensile strength were conducted, the cubes were tested at 7, 14 and 28 days. Tests results showed that 5% replacement of RHA of SCCSC can be appreciably incorporated for light weight concrete showing an increase in compressive strength from 16.8N/mm at 7days to 19.6N/mm at 28 days and 1.33N/mm at 7 days to 1.41N/mm at 28days.*

KEYWORDS
Self-Compacting Concrete (SCC): *Self-Compacting concrete is a type of concrete that can flow and fill formwork without the need for vibration or compaction.*
It has a high fluidity and can maintain its stability without segregating, making it ideal for complex structures and reducing labor costs.
Rice Husk Ash (RHA): *This is a by-product of rice husk combustion, typically obtained from rice mills. It is rich in silica and has pozzolanic properties, making it a suitable partial replacement for cement in concrete production. RHA can improve the durability and strength of concrete*
Coconut Shell: *Coconut shell are waste product from coconut processing.*
They can be used as a sustainable and eco-friendly aggregate in concrete production, replacing traditional coarse aggregates like gravel or crushed stone.
Coconut shell have a low density, which can reduce the weight of concrete structure
Sustainable Construction: *this refers to the practice of building structures that minimize environmental impact, conserve natural resources, and promote social responsibility.*
It involves using eco-friendly materials, reducing waste, and optimizing energy efficiency throughout the building's lifecycle.
Eco-Friendly Materials: *Eco-friendly materials are products or substances used in construction that have a reduced environmental impact compared to traditional materials. They may be recycled, recyclable, sustainable sourced, or produced with minimal waste and emissions. E.g recycled aggregate, low-carbon cement and wood product*

R**eceived 03 Feb., 2025; **R**evised 11 Feb., 2025; **A**ccepted 13 Feb., 2025 © The author(s) 2025. **P**ublished with open access at **www.questjournas.org

I. INTRODUCTION

Concrete is a composite construction material made up of cement, aggregate (fine and coarse) and water (sometimes with admixtures) in required proportions. Gambhir (2004) considered the hardened concrete as an artificial stone in which the voids of large particle (coarse aggregate) are filled by the smaller particles (fine aggregate), and the voids of fine particles are filled with cement.

Conceivable application for using industrial waste products and agricultural wastes as cementitious materials was discovered during the hunt for other possibilities binding agent or substitute for cement sources. If these fillers possess pozzolanic qualities, they not only improve the final concrete but also make it possible to replace more cement in greater amounts.

Nigeria's building sector is essential to the country's development. But in regards to the depletion of natural resources and environmental sustainability it deals with formidable obstacles. Another of the primary components of traditional concrete cement manufacture, contributes significantly to emitting greenhouse gases. Also, natural resources are strained by the expanding need for natural aggregates and other essential component of concrete. The two main elements of natural coarse aggregates, which include granite and gravel, are getting harder to find in various regions of Nigeria. The main binder in traditional concrete, ordinary Portland cement (OPC), is a significant source of greenhouse gas emissions.

Concrete comprises of cement, standard water, and aggregates. Throughout the world, concrete is utilized more than any other artificial material. Furthermore, besides water, concrete is the second-most utilized material worldwide. 7.23 billion tons of concrete are thought to be produced annually. One ton of production is produced annually for each and every individual on the earth. The rapid expansion of the improvement of infrastructure and building activities worldwide is driving up concrete production. Concrete requires certain ingredients to be produced, including aggregates, cement, water, and admixtures. Conventional aggregate origins make up the majority of the concrete's composition. Large-scale concrete manufacturing in construction projects that uses traditional coarse aggregate, such granite, unnecessarily depletes natural stone reserves and has an adverse effect on the ecosystem, leading to an imbalance in ecology.

One of the unique type of concrete is self-compacting concrete (SCC), which in its initial state possesses qualities such as filling capacity, passage ability, and segregation tolerance. If SCC is created, it will maintain homogeneity without segregation, flow over extremely crowded reinforcement without vibrating, and stream under its own weight. It has been reported that in countries like Sweden and Japan, the use of SCC increased construction output by almost 60%. In addition to contributing to environmental damage, lightweight aggregates (LWA) can be produced intentionally from industrial leftovers or naturally occurring materials, but the sources of these materials are running out. The need for environmentally friendly and sustainable building materials has prompted some study on the utilization of agricultural waste products in concrete. Crushed CS can be utilized as LWA to make lightweight concrete (LWC) when it's appropriate in size. It provides the double benefit of lowering building material costs and improving the surroundings. Despite being a relatively new topic, the use of CS in the manufacturing of LWC has been highlighted in a few research publications as a novel approach with strength and durability attributes that fall within approved minimum specifications. According to reports from many research projects, it is conceivable to achieve normal concrete strength when CS is substituted for traditional coarse aggregate in regularly vibrated concrete.

This study investigates the viability of using easily accessible waste products from agriculture in Nigeria—more especially, rice husk ash (RHA) and coconut shells—as renewable substitutes for conventional concrete manufacturing methods. As a consequence of milling rice, rice husks produce a large volume of garbage that needs to be properly managed. RHA, a pozzolanic substance with cementitious qualities that can partially substitute cement, is created by blazing rice husk. Another common waste from agriculture product is the husks of coconuts, these shells which have excellent insulating qualities and a low density, which makes them perfect for use in lightweight concrete applications. As a result of burning rice husks, rice husk ash (RHA) presents a potential and environmentally friendly substitute for traditional concrete manufacturing. RHA has pozzolanic qualities. RHA, when smoothly crushed, forms extra calcium silicate hydrates (C-S-H), a significant phase in concrete that contributes to its toughness, when it combines with calcium hydroxide, a hydration product of cement, in the existence of moisture. The long-term rigidity and durability of concrete are preserved or even enhanced by RHA thanks to this pozzolanic reaction.

Pozzolanic waste a substance can be added to concrete to greatly improve its basic qualities in both the fresh and hardened phases. The durability of concrete is significantly increased by these components. Necessary technical, economic, and environmental advantages come from using byproducts that partially substitute cement. These advantages include less waste production, healthier surroundings, less energy use, long-lasting service performance over the course of the structure's life, and economical construction.

There are more advantages for the ecology and economy when waste materials are used to partially replace cement and concrete aggregates. This study hereby aims to determine the properties of rice husk ash as a pozzolanic and coconut shell as a coarse aggregate for light-weight concrete.

The compressive strength of concrete is the most important factor for buildings, as stated by . The concrete's compressive strength rises to 0.99% when 10% more additional minerals are introduced to the mixture than in the original combinations. One issue that many nations face is solid or industrial waste. Furthermore, inadequate solid waste management can negatively affect someone's well-being, the surroundings, and their economic situation, among other aspects of their standards of life. It is obvious that with no a decent disaggregate, the world cannot operate smoothly given the growing number of people and garbage output.

The researchers are attempting to determine how they might significantly diminish this societal issue because one of the burdens connected with resolving these issues is being lowered. Although they are not frequently used in the building sector, coconut shell (CS) and sugarcane bagasse ash (SCBA) are frequently disposed of as waste from agriculture.

Due to its advantageous properties, coconut shell is a sought-after ingredient in concrete, and its use in the material may alleviate disposal issues. Due to the significant amount of carbon and hardness, coconut shells are used to manufacture activated carbon, or AC. These have numerous advantages over conventional coarse aggregates like sand and gravel, and they are an ecologically sound substitute for these. Because of their strength, low weight, and inherent resistance to weathering of the materials, they are the perfect aggregate for a range of construction uses .

It was discovered that crushed coconut had with an average moisture content as well as water absorption of 4.20 percent and 24 percent, respectively. As a result of the greater porosity that exists in the shell structure, coconut shell aggregates have a higher specific gravity when tested under SSD conditions of 1.05. Compared to crushed stone aggregate, coconut shell aggregates have much lower aggregate effect and crushing values, indicating that they have excellent shock absorbance. The densities of the fresh concrete and hardened concrete using coconut shell after a period of 28 days (under SSD conditions) were found to be between 1975 and 2110 kg/m3. The 28-day compressive strength of coconut shell concrete, after full curing in water, was achieved to be 22.81 and 21.81 for 25 percent and 50 percent substitution by coconut shell aggregate, respectively. This value meets the structural requirements of lightweight concrete criteria.

In the process of making concrete, RHA shows promise as a pozzolanic ingredient to partially replace OPC. The theoretical underpinnings and possible advantages of RHA inclusion are explored in this paper. One by-product produced while burning rice husks for energy production or agriculture is rice husk ash (RHA). Because RHA has pozzolanic qualities, it combines with the calcium hydroxide ($Ca(OH)2$) that is created during cement hydration to create more calcium silicate hydrate (C-SH) gel, which is an essential component that gives concrete its strength. Research has demonstrated that adding RHA to concrete can enhance its workability, durability, and mechanical qualities while lessening the environmental effect of cement manufacture.

RHA was the word used to define an agricultural by-product obtained from burning husk at temperatures below 800 °C under regulated conditions. The procedure yields approximately 25% ash which is hydrophilic, consisting of eighty-five percent to ninety percent amorphous silica and roughly 5% alumina. Following a research by Mehta, the cellular RHA particles in concrete with RHA have an absorptive quality, which means that more water was needed for the same consistency. In a study, RHA from Indian paddy was burnt again at 650 °C for one hour, and after that, it became an active pozzolanic measurable with a high proportion of amorphous silica (87%) and a comparatively low ignition value loss (2.1%).

II. METHODOLOGY

This section provides a detailed explanation of the materials and tests that were performed on the samples that were going to be used in the study through a variety of laboratory studies. Coarse aggregate (granite for control mixes and coconut shell as a complete replacement), fine aggregate (sand), cement, water, rice husk ash, and super-plasticizer are the materials utilized in the experiment.

III. MATERIALS

- **Cement**

Ordinary Portland Cement of 45 Grade from the Dangote brand, which is widely available in the local market was used throughout the study. The type of cement used was selected according to British Standards Specification for Portland Cement (BS 4550: Part 3)

- **Fine Aggregate**

River sand locally available was used for this project ensuring it does not contain harmful chemicals that could weaken the strength of concrete. The river sand used conformed to British Standards Aggregates for Concrete (BS EN 12620:2013).

- **Coarse Aggregate**

Coarse aggregate obtained from a local market of ¾ size was also used passing through the sieve of 12.5mm. The coarse aggregate conformed to British Standards Aggregates for Concrete (BS EN 13055:2016).

- **Rice Husk Ash (RHA)**

The RHA was a primary by product of the incineration of Rice Husks that were collected as a waste product at Ketu, Lagos and transported to the institution.

- **Superplasticizer**

Superplasticizer named SP4000 was purchased from a chemical store at Mushin.

IV. RESULTS AND DISCUSSION

4.1. Physical Properties of Cement

The table below shows the result obtained from the test carried out on the physical properties of cement. These test were carried out according on Dangote ordinary Portland cement and they conformed with BS 4550: Part 3

Table 1: Physical properties of cement

1.Specific Gravity	2.80
2. Initial Setting Time	39minutes
3. Final Setting Time	242 minutes
4. Standard Consistency	33%
REMARKS: The cement satisfies the condition for BS 4550: Part 3	

Table 2: Chemical Composition of Cement and RHA

S/N	Cement		Rice Husk Ash	
	Composition	**Quantity (%)**	**Composition**	**Quantity (%)**
1.	Calcite	45	Quartz	71
2.	Calcite	39	Graphite	12
3.	Lime	5.7	Sodalite	2.4
4.	Quartz	10.8	Orthoclase	14

Table 3: Properties of Fine & Coarse Aggregate used

Test Description	Fine Aggregate	Coarse Aggregate	Coconut Shell
Specific Gravity	2.50	2.61	1.31
Crushing Value	-	22%	2.47%
Impact Value	-	16%	3.22%

4.2. Mix Proportioning

In this research work a designed mix of 1:1:1 was employed to achieve the objective of this research. The table below shows the measurement of each concrete component. RHA was used to partially replace cement at 5-30% percentage and their respective weight was measured and added into the concrete mix. Water cement ratio of 0.35 was utilized because of the nature of the concrete which is a S.C.C, super plasticizer was mixed with small quantity of water from the already measured water to make increase the concrete workability and allow for self-compaction without vibration or tamping.

Table 4: Mix Proportioning of SCC

MATERIALS	CONTROL	0%	5%	10%	15%	20%	25%	30%
CEMENT (kg)	22.86	22.86	22.86	22.86	22.86	22.86	22.86	22.86
RICE HUSK ASH (kg)	0	0	1.14	2.28	3.42	4.56	5.70	6.84
SAND (kg)	23.05	23.05	23.05	23.05	23.05	23.05	23.05	23.05
COARSE AGGREGATE (kg)	23.67	11.16	11.16	11.16	11.16	11.16	11.16	11.16
WATER/CEMENT (kg)	0.38	0.35	0.35	0.35	0.35	0.35	0.35	0.35
SUPER PLASTICIZER (ML)	0	400	400	400	400	400	400	400

4.3 Compressive Strength Test

Self-compacting concrete cubes were casted with granite as coarse aggregate in order to track and monitor the fresh & mechanical properties that were to be achieved in the percentage replacement mixes. The concrete cubes were cured for a duration of 7, 14, 21 and 28 days.

Table 5 presents the results for the compressive strength of Rice Husk Ash / OPC concrete at 7, 14, and 28 days.

Table 5: Compressive Strength Result

Mix Proportions	Compressive Strength 7-Days (N/mm²)	Compressive Strength 14-Days (N/mm²)	Compressive Strength 28-Days (N/mm²)
Control (Granite)	24.2	31.7	33.6
0%	21.6	23.5	24.0
5%	16.8	17.7	19.6
10%	13.0	15.6	18.6
15%	12.8	13.3	19.3
20%	12.2	12.6	13.6
25%	11.5	11.0	13.2
30%	9.55	9.65	11.0

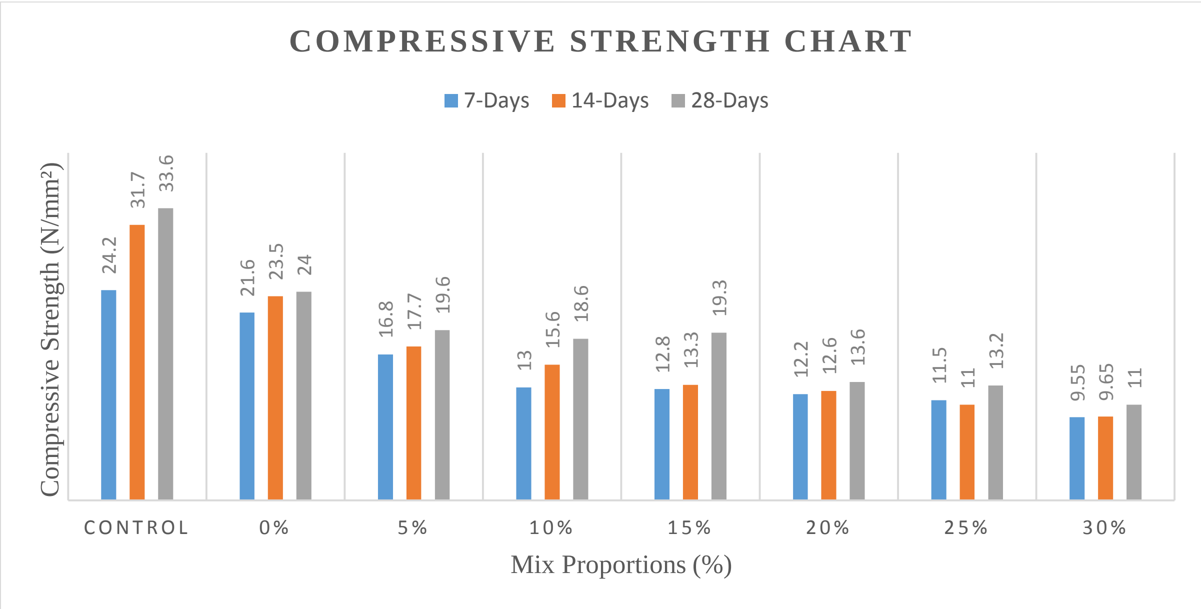

Fig. 1: Compressive Strength Chart

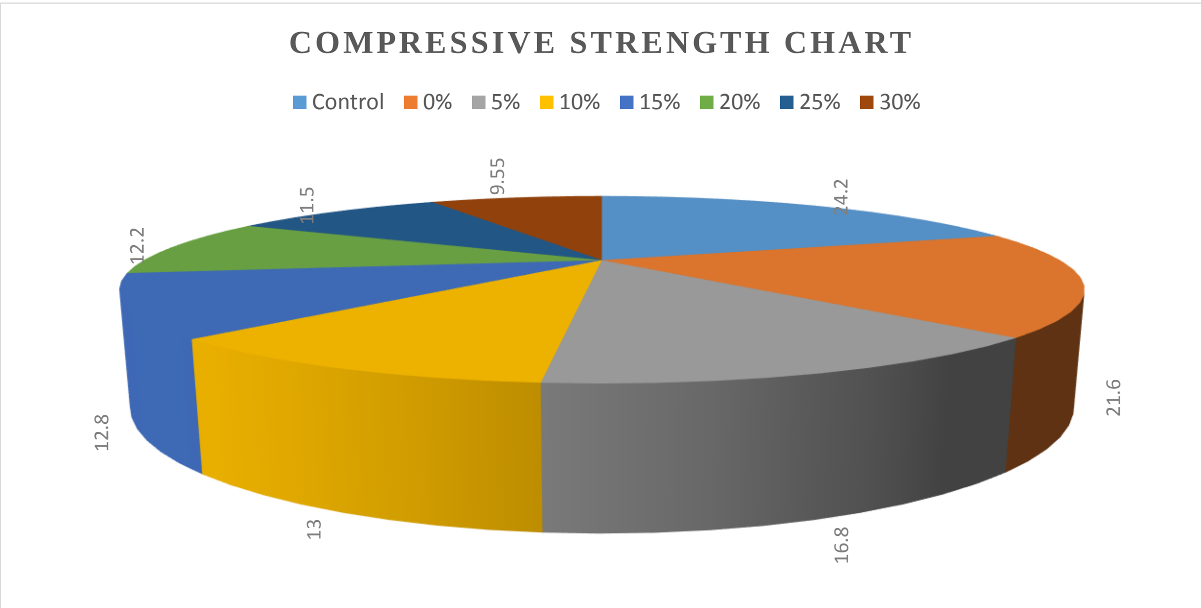

Fig. 1: Compressive Strength Chart

The chart above shows that the cubes produced with full replacement of CS increased in compressive strength with respect to the curing days, and 5% replacement recorded the highest compressive strength in reference to the 0% replacement mix used as the control with varying curing days. The cubes with 0% rice husk ash had the highest compressive strength, according to the results. This is because this mix has the largest cement concentration per cubic meter. The findings also demonstrate that, for a given age, the compressive strength falls off as the percentage of R.H.A./cement content increases but strength is increased with respect to increasing number of curing days as seen in figure 1 and Table 5 above.

4.5. Split Tensile Strength

In this study, RHA was used to partially replace cement in the preparation of the replacement cubes. The specimens were prepared as described in chapter three. the results for the tensile strength of Rice Husk Ash / OPC concrete were compiled at 7, 14, and 28 curing days.

Table 6: Split Tensile Strength Result

Mix Proportions	Split Tensile Strength 7-Days (N/mm²)	Split Tensile Strength 14-Days (N/mm²)	Split Tensile Strength 28-Days (N/mm²)
0%	1.35	1.37	1.46
5%	1.33	1.34	1.41
10%	1.30	1.33	1.40
15%	1.20	1.33	1.38
20%	1.11	1.31	1.32
25%	1.07	1.15	1.30
30%	1.02	1.12	1.20

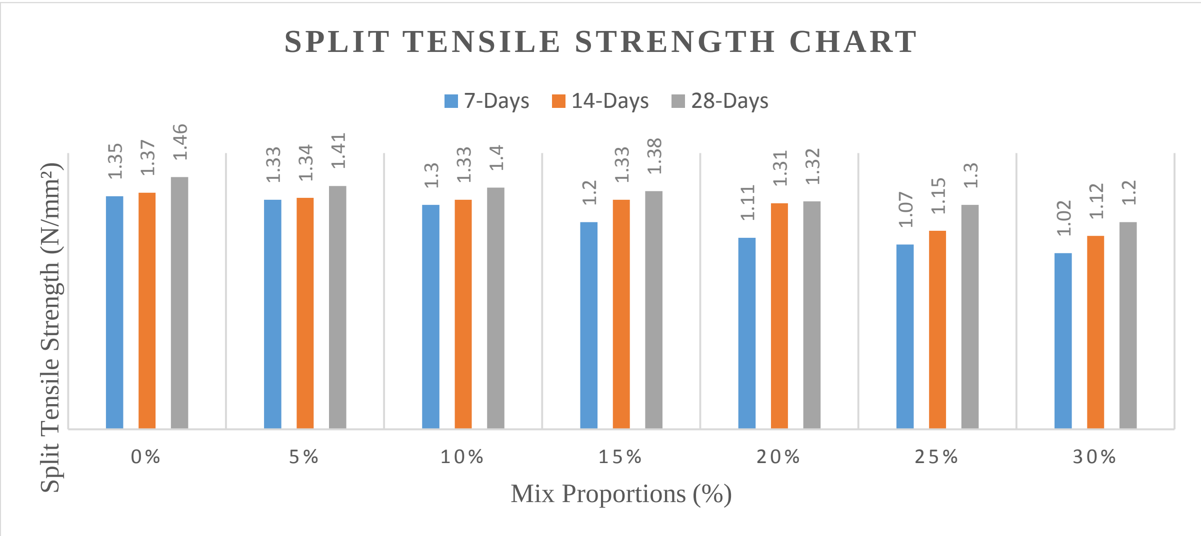

Fig. 2: Split Tensile Strength Chart

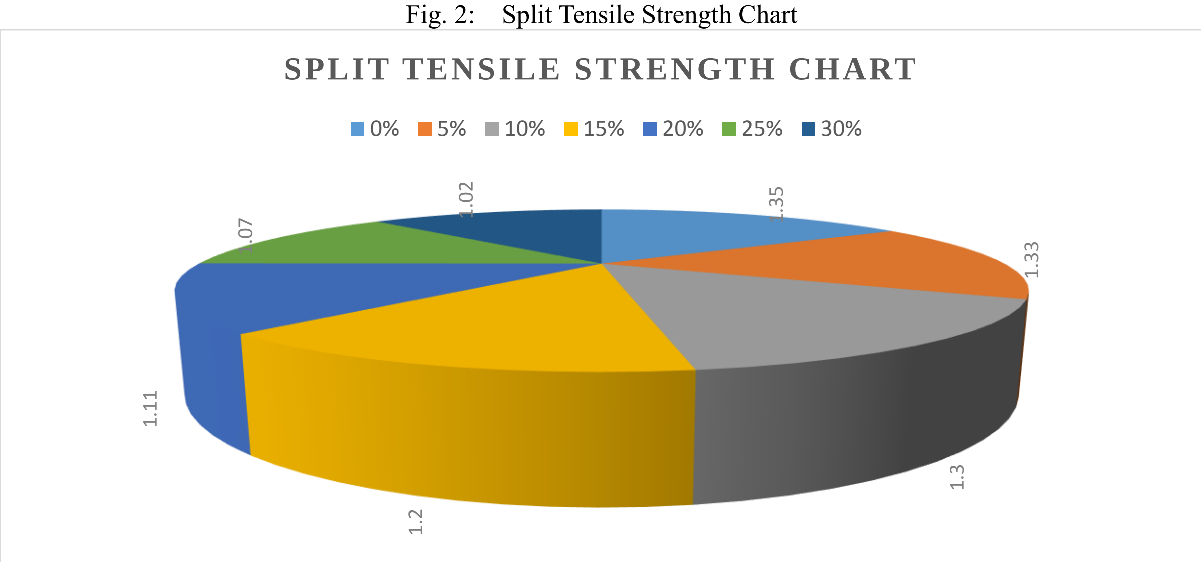

Fig. 2: Split Tensile Strength Chart

In this research similar trend was shown as in the compressive strength. The split tensile strength reduced with increasing proportion of RHA. However, the strength increased with increase in curing days. The result obtained from Fig 2 indicates that's RHA can be used up to 15% for full replacement of coarse aggregate with coconut shell aggregate.

V. Conclusion

This project encompassed every step of the process, starting with the design phases of the concrete mix and ending with the data analysis. From this investigation, the following findings was be made:
The Rice Husk Ash (RHA) and coconut shell cannot be efficiently used as 100% replacement
As the percentage of RHA in the concrete rises, the compressive strength of RHA concrete falls. The compressive strength of concrete generated without RHA (0% RHA) was greater than that of concrete produced with RHA.
The compressive strength of concrete diminishes as the proportion of RHA component rises.
The water cement ratio tends to alter as the replacement percentage rises.
The compressive strength of each percentage replacement decreases as the percentage replacement of RHA increases but increase with increasing curing days.
Based on a variety of tests done with reference to the 0% replacement mix, it is noticed that the 5% replacement has the maximum compressive strength.
The use of RHA in concrete can be prove to be economical as it is no-use full waste and with free cost
The use of RHA from Husk and coconut shell from coconut fruit in construction industry will eliminate the dumping and land filling problem of waste and will prove to be environmentally friendly thus makes road map and planning way for greener concrete
In conclusion to our research work, it can be said that this research work is similar to the work carried out by Kumar. D., & Suresh. S. chat (2018) on the study on the partial substitution of coconut shell for coarse aggregate and rice husk ash as cement in the production of light-weight concrete, with the result that the compressive and tensile strength for each percentage replacement rises as the number of curing days increases but falls as the percentage of rice husk ash increases.

Reference

[1]. Akhtar, A., Sondossi, M., & Magalhães, A. (2017). A review on the development of lightweight concrete using coconut shell as aggregate. Renewable and Sustainable Energy Reviews, 74, 1307-1321.

[2]. Ajala, E. O., Ighalo, J. O., Ajala, M. A., Adeniyi, A. G., & Ayanshola, A. M. (2021). Sugarcane bagasse: a biomass sufficiently applied for improving global energy, environment and economic sustainability. Bioresources and Bioprocessing, 8, 1-25.

[3]. Ganesan, K., Rajagopal, K., & Thangavel, K. (2008). Rice husk ash blended cement: Assessment of optimal level of replacement for strength and permeability properties of concrete. Construction and building materials, 22(8), 1675-1683.

[4]. Kanojia, A., & Jain, S. K. (2017). Performance of coconut shell as coarse aggregate in concrete. Construction and Building Materials, 140, 150-156.

[5]. Mehta, P.K., & Monteiro, P.J.M. (2014). Concrete: Microstructure, Properties, and Materials (Fifth Edition). McGraw-Hill Education.

[6]. Mo, Y.-L., Abdullahi, M.A.P., Abdullahi, M.R., Al-Attas, A.T., Voo, C.G., & Universiti Teknologi Malaysia. (2016). Use of Rice Husk Ash as Partial Replacement with Cement In Concrete A Review. Research Gate.

[7]. Nagrockienė, D., Girskas, G., & Skripkiūnas, G. (2017). Properties of concrete modified with mineral additives. Construction and Building Materials, 135, 37-42.

[8]. Prakash, R., Thenmozhi, R., Raman, S. N., & Subramanian, C. (2020). Characterization of eco-friendly steel fiber-reinforced concrete containing waste coconut shell as coarse aggregates and fly ash as partial cement replacement. Structural Concrete, 21(1), 437-447.

[9]. Yurttagül, İ.Ö., & Hindi, R. (2018). Influence of recycled coarse aggregate replacement level on the mechanical and transport properties of concrete. Construction and Building Materials,171, 1138-1149.

[10]. Shaikh, A. S., Thorat, S. B., Unde, R. V., & Shirse, P. S. (2015). Advance concrete-Aggregate replaced by coconut shell. International Research Journal of Engineering and Technology, 2(05), 698-702.