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Development of Agriculture Waste-based Accelerator for Enhanced Concrete Hardening

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ABSTRACT: Due to the growing population and increasing demand for more construction, much attention has been paid to environmental issues and the devastating effects of overgrowth in nature. Many challenges, including the 2030 challenge, have united developed countries to come together for a better and cleaner future. Furthermore, higher awareness on climate change is forcing companies to rethink their strategies in developing more sustainable construction materials. Diverse types of agro-waste ranging from rice husk ash (RHA), sugarcane bagasse ash (SCBA), and bamboo leaves ash (BLA) among others have been identified as potent solutions in the development of sustainable construction materials. This thesis will work on different applications of industrial and agro waste which can be practiced to make sustainable construction to optimize and stability coconut shell (CS) as replacement of aggregate and coconut shell Ash (CSA) as replacement of cement in concrete of OPC M30 in this work and also suggests various approach to ameliorate the processing of waste materials.

KEYWORDS: Coconut Shell, Coconut Shell Ash, OPC M30.

I. INTRODUCTION

Since the beginning of human life, humans have always built shelters to protect themselves from external factors. The construction materials for these shelters has changed over time, from wood and stone to new modern residential buildings of concrete and metal. The existence of concrete with its standard ingredients, cement, water, and stone dates back to several centuries.

As the construction industry grew, there was more need to manage the concrete sector better. Among several ideas, the production of a new generation of sustainable green concrete while maintaining the same strength and durability of the previous generation attracted more attention. "Green concrete is defined as concrete which uses waste material as at least one of its components, or its production process does not lead to environmental destruction, or it has high performance and life cycle sustainability". One of the most important reasons for introducing a new generation of concrete to replace ordinary concrete is to curb environmental and social disruptions. According to earlier studies, concrete production has a significant impact on the environment due to its high carbon footprints, such as warming the earth and climate change.

1.1 Coconut Shell (CS)

Coconut shells have good durability characteristics, high toughness and abrasion resistant properties; it is suitable for long standing use. Coconut shells are mostly used as an ornament, making fancy items, house hold utensils, and as a source of activated carbon from its charcoal. The powdered shell is also used in the industries of plastics, glues, and abrasive materials and it is widely used for the manufacture of insect repellent in the form of mosquito coils and in agarbathis. The purpose of this research work is to develop a concrete with coconut shells as coarse aggregate. The whole entity could be called coconut shell aggregate concrete (CSAC). After the coconut is scraped out, the shell is usually discarded as waste as shown in Figure 1.1. The vast amount of this discarded coconut shells resource is as yet unutilized commercially; its use as a building material, especially in concrete, on the lines of other LWA is an interesting topic for study. The study of coconut shells will not only provide a new material for construction but will also help in the preservation of the environment in addition to improving the economy by providing new use for the coconut shells.



Fig 1 Coconut Shell

Table 1 Materials Density(kg/m3)

Properties	Aggregate	Coconut Shell
Density(kg/m3)	1200–1600 kg/m3	550–800 kg/m3

1.2 Coconut Shell Ash (CSA)

Coconut is a non-fossilized, biodegradable organic material that may replace fossil fuels and supplement other renewable energy sources burning either fossil fuels or biomass releases CO₂. However, according to a study conducted by, coconut shell-derived energy can save 18.3% of GHGs emission that causes global warming, 64.1% of the same emission that results in ozone depletion, and 71.5% of non-renewable energy consumption.



Fig 2 Materials Density(kg/m3)

Table 2 Materials Density(kg/m3)

Properties	Cement	Coconut Shell Ash
Density(kg/m3)	1440 kg/m3	800 /m3

II. PROBLEM STATEMENT

Early-age concrete hardening is essential for timely construction; however, commonly used chemical accelerators are costly and environmentally unfriendly. Large quantities of agricultural waste such as coconut shells and coconut shell ash are generated and remain underutilized, creating disposal issues. Although these materials show potential to enhance cement hydration, their effectiveness as natural concrete accelerators has not been adequately studied. There is a lack of experimental data on the influence of varying proportions (0%, 5%, 7.5%, 10%, 12.5%, and 15%) of coconut

shell and coconut shell ash on concrete hardening. Hence, this study addresses the need to develop a sustainable agriculture waste-based accelerator to improve concrete hardening performance.

Table 3 Mix proportions of Coconut Shell

Mix %	Cement	Sand	Aggregates	Coconut Shell
0	350	812	1284	0
5%	350	771.4	1284	40.6
7.50%	350	751.1	1284	60.9
10%	350	730.8	1284	81.2
12.50%	350	710.5	1284	101.5
15%	350	690.2	1284	121.8

Table 4 Mix proportions of Coconut Shell Ash

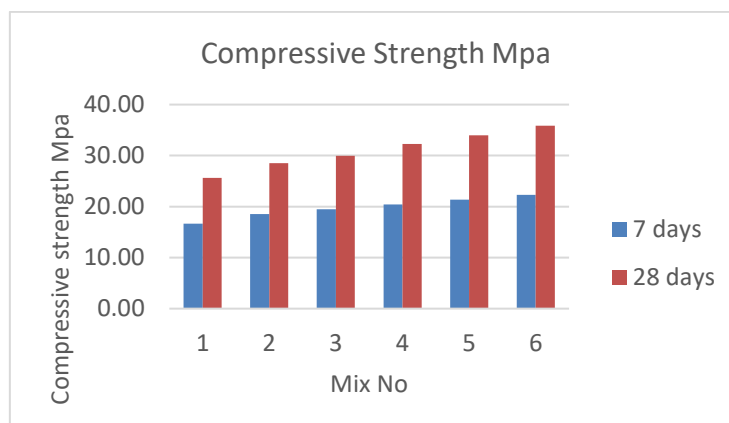
Mix %	Cement (Kg)	Coconut Shell Ash (Kg)	Sand (Kg)	Aggregates (Kg)	Coconut Shell (Kg)
0	350	0	812	1284	0
5%	332.5	17.5	771.4	1284	40.6
7.50%	323.75	26.25	751.1	1284	60.9
10%	315	35	730.8	1284	81.2
12.50%	306.25	43.75	710.5	1284	101.5
15%	297.5	52.5	690.2	1284	121.8

III. RESULTS AND ANALYSIS

3.1 Results For Coconut Shell

Table 4 Compressive strength (Coconut Shell)

Mix No	Mix %	7 days	28 days
1	0	16.67	25.65
2	5%	18.54	28.52
3	7.50%	19.47	29.95
4	10%	20.44	32.26
5	12.50%	21.38	33.98
6	15%	22.33	35.85



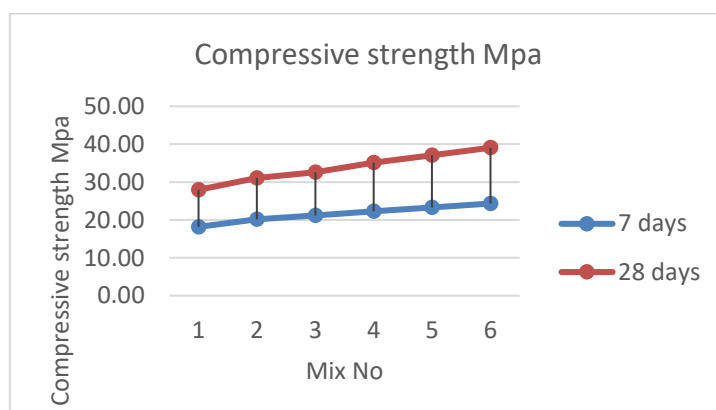
Graph 1 Compressive strength (Coconut Shell)

Above graph shows the results of Compressive strength (Coconut Shell) for 7 and 28 days, from the results it is observe that specimen with having Coconut Shell gives better results.

3.2 Results For Coconut Shell Ash

Table 5 Compressive strength (Coconut Shell Ash)

Mix No	Mix %	7 days	28 days
1	0	18.17	27.96
2	5%	20.21	31.09
3	7.50%	21.22	32.64
4	10%	22.28	35.16
5	12.50%	23.30	37.04
6	15%	24.34	39.08



Graph 2 Compressive strength (Coconut Shell Ash)

Above graph shows the results of Compressive strength (Coconut Shell Ash) for 7 and 28 days, from the results it is observe that specimen with having Coconut Shell Ash gives better results.

3.3 Non-Destructive Test (NDT) Results – Rebound Hammer & UPV

Table 6 Coconut Shell Concrete

Mix No	Mix %	Rebound Number (7 Days)	Rebound Number (28 Days)	Estimated Comp. Strength (MPa)	UPV (km/s)	Concrete Quality
1	0%	21	28	25	3.52	Good
2	5%	22	30	27.5	3.6	Good
3	7.50%	23	31	28.8	3.68	Good
4	10%	24	33	31.2	3.79	Very Good
5	12.50%	25	34	32.5	3.85	Very Good
6	15%	26	36	34.8	3.92	Excellent

This table shows that as the percentage of Coconut Shell increases, both the rebound number and estimated compressive strength gradually improve. UPV values also increase, indicating good internal density and overall sound concrete quality. Even though CS is lightweight, the mixes remain in the good to excellent quality range.

Table 7 Coconut Shell Ash Concrete

Mix No	Mix %	Rebound Number (7 Days)	Rebound Number (28 Days)	Estimated Comp. Strength (MPa)	UPV (km/s)	Concrete Quality
1	0%	23	30	27	3.58	Good
2	5%	25	33	30.2	3.74	Very Good
3	7.50%	26	35	32.1	3.82	Very Good
4	10%	27	37	34.9	3.95	Excellent
5	12.50%	28	39	36.8	4.08	Excellent
6	15%	29	41	38.9	4.21	Excellent

The table indicates that adding Coconut Shell Ash significantly enhances surface hardness and internal compactness. Both rebound numbers and UPV values rise consistently with higher CSA replacement, showing better pozzolanic action and improved concrete quality. CSA mixes fall in the very good to excellent range, proving CSA is an effective cement replacement.

IV. CONCLUSION

- The experimental study was conducted to evaluate the effect of agricultural waste materials—Coconut Shell Ash (CSA) as a partial replacement for cement and Crushed Coconut Shell (CCS) as a partial replacement for fine aggregate—on the performance of concrete. The replacement levels were varied at 5%, 7.5%, 10%, 12.5%, and 15%, and the concrete samples were tested for compressive and split tensile strength at 7 and 28 days of curing.
- The results indicate that the inclusion of both CSA and CCS led to improved strength properties compared to the control mix. Notably, specimens containing Coconut Shell Ash exhibited the highest improvements in both compressive and split tensile strength, demonstrating its effectiveness as a pozzolanic material. Crushed Coconut Shell also contributed positively to compressive strength, while the use of plastic granules showed a marked increase in split tensile strength.
- Coconut Shell Ash proved to be the most effective among the tested materials for enhancing the overall strength performance of concrete. The findings support the use of agricultural and plastic waste as sustainable alternatives in concrete production, promoting environmental conservation while maintaining structural performance.
- The combined use of Coconut Shell Ash and Crushed Coconut Shell offers a more effective and sustainable alternative to conventional materials, improving concrete strength while promoting the reuse of agricultural waste

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IS Code

- IS Code 383 2016 for coarse and fine aggregate
- IS 456 : Plain and Reinforced Concrete



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