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EXPERIMENTAL STUDY ON CONCRETE WITH GROUNDNUT SHELL ASH, COCONUT SHELL, AND CRIMPED STEEL FIBRES AS PARTIAL REPLACEMENTS AND ADDITIONS

[1]J.SREE NAGA CHAITANYA, [2]DR.K.CHANDRAMOULI, [3]SK.SAHERA,[4]PATAN HUSSEN

[1,3] Assistant Professor,[2]Professor & HOD,[4]B. Tech Student

[1,2,3,4] Department of Civil Engineering, NRI Institute of Technology, Visadala (V), Medikonduru (M), Guntur, Andhra Pradesh, INDIA .

Email:jarugumillichaitanya1989@gmail.com, koduru_mouli@yahoo.com

ABSTRACT

This study investigates the mechanical performance of concrete incorporating sustainable agricultural and industrial by-products. Fine aggregate was partially replaced with groundnut shell ash (GNSA), an agro-waste material with pozzolanic properties, to enhance concrete strength and durability. Coarse aggregate was partially replaced with coconut shell (CS) to utilize renewable waste while reducing the density of concrete. Additionally, crimped steelfibres were added to improve tensile strength, crack resistance, and overall toughness. Standard concrete cubes and cylinders were cast and cured, and compressive strength and split tensile strength tests were performed at 7 and 28 days. Results showed that optimum replacement levels of GNSA and CS, combined with steel fibres, improved both compressive and split tensile strengths compared to normal concrete. At 7 days, compressive strength showed significant early gain, while at 28 days, the concrete achieved higher ultimate strength. Split tensile strength also increased, demonstrating enhanced crack resistance and load-carrying capacity. The study highlights that the synergy between agricultural waste replacements and steel fibres produces a durable, eco-friendly concrete mix suitable for structural applications. This approach reduces reliance on natural aggregates and cement, promotes waste utilization, and supports sustainable construction practices.

KEYWORDS: Groundnut shell ash, Coconut shell, Steel fibres, Sustainable concrete, Compressive strength, Split tensile strength.

1. INTRODUCTION

Concretes the most widely used construction material due to its versatility, durability, and high compressive strength. It is composed of cement, fine aggregate, coarse aggregate, and water, which together form a composite material capable of bearing structural loads. With increasing demand for construction materials, there is a growing need to explore sustainable alternatives to reduce environmental impact, optimize resource use, and improve mechanical performance.

Groundnut Shell Ash (GNSA) is an agricultural by-product obtained from the controlled burning of groundnut shells. Rich in silica and other pozzolanic compounds, GNSA can partially replace fine aggregate in concrete. Its incorporation improves particle packing, contributes to long-term strength development, and promotes the utilization of agro-waste, thereby reducing environmental pollution.

Coconut Shell (CS) is a renewable, lightweight agricultural waste obtained after coconut processing. When used as a partial replacement for coarse aggregate, coconut shell reduces the density of concrete, enhances toughness, and provides sustainable construction solutions. Its use also helps manage agricultural waste and reduces dependency on natural coarse aggregates.

Crimped Steel Fibres are short, deformed steel strands added to concrete to enhance tensile strength, ductility, and crack resistance. By bridging cracks and improving energy absorption, steel fibres improve the load-bearing capacity of concrete, especially under tension and bending stresses. Their addition is particularly useful in combination with lightweight or waste-based aggregates to maintain or enhance structural performance.

2. OBJECTIVES

1. To study the effect of Groundnut Shell Ash (GNSA) as partial replacement of fine aggregate on concrete properties.
2. To investigate the effect of coconut shell (CS) as partial replacement of coarse aggregate.
3. To investigate the effect of steel fibres on crack control.

3. MATERIALS

3.1 Cement:- A fine powder made from limestone and clay that acts as a binder in concrete. It reacts with water to form a hard, stone-like mass, providing strength to the concrete.

3.2 Fine Aggregate:- Naturally occurring sand or crushed stone particles smaller than 4.75 mm. It fills the voids between coarse aggregates and improves workability of concrete.

3.3 Coarse Aggregate:- Gravel or crushed stone particles larger than 4.75 mm. It provides bulk, strength, and stability to the concrete mix.

3.4 Water:- A key ingredient that hydrates cement and gives workability to fresh concrete. It also helps in achieving proper curing for strength development.

3.5 Ground Nut Shell Ash:- A pozzolanic material obtained by burning groundnut shells. It can partially replace fine aggregate, improving strength and utilizing agricultural waste.

3.6 Coconut Shell:- A pozzolanic material obtained by burning groundnut shells. It can partially replace fine aggregate, improving strength and utilizing agricultural waste.

3.7 Crimped Steel Fibres:- Short, deformed steel strands added to concrete to enhance tensile strength, toughness, and crack resistance. They improve load-bearing capacity and ductility of concrete.

4. EXPERIMENTAL RESULTS

4.1 Compressive strength:-In this test, standard concrete cubes measuring 150 mm × 150 mm × 150 mm are cast and properly cured. After 7 or 28 days of curing, the cubes are placed in a compression testing machine, and a gradually increasing load is applied until failure occurs. The maximum load at failure is then used to calculate the compressive strength of the concrete.

Table 1: Compressive strength results of concrete ground nut shell ash as partial replacement offine aggregate.

Sl.no	% of ground nut shell ash	Compressive Strength Results, N/mm^2	
		7 days	28 days
1	0%	33.71	49.07
2	5%	35.02	50.54
3	10%	36.32	51.96
4	15%	35.17	51.05

Table 2: Compressive strength results of concrete coconut shell as partial replacement of coarse aggregate.

Sl.no	% of coconut shell	Compressive Strength Results, N/mm^2	
		7 days	28 days
1	0%	33.71	49.07
2	2.5%	44.99	64.84
3	5%	48.17	68.72
4	7.5%	43.52	63.17

Table 3: Compressive strength results of concrete by addition of crimped steel fibres .

Sl.no	% of crimped steel fibres	Compressive Strength Results, N/mm^2	
		7 days	28 days
1	0%	33.71	49.07
2	1%	33.88	49.69
3	2%	35.31	50.38
4	3%	35.64	51.52
5	4%	35.47	50.91

Table 4: Compressive strength results of combined replacement of 10%GSA+5%CS+3%CSFin concrete.

Sl.no	10%GSA+5%CS+3%CSF	Compressive Strength Results, N/mm^2	
		7 days	28 days
1	0%	33.71	49.07
2	10%GSA+5%CS+3%CSF	49.92	71.42

4.2 Split tensile strength: - Split tensile strength is an indirect method used to assess the tensile capacity of concrete, as concrete is naturally weak in direct tension. In this test, a cylindrical specimen is placed horizontally, and a compressive load is applied along its diameter. The applied load generates tensile stresses within the cylinder, causing it to split along the line of loading. Tests are conducted at 7 and 28 days of curing to evaluate the development of tensile strength and observe cracking behavior in the concrete.

Table 5: Split tensile strength results of concrete ground nut shell ash as partial replacement offine aggregate.

Sl.no	% of ground nut shell ash	Split tensile Strength Results, N/mm^2	
		7 days	28 days
1	0%	3.33	4.85
2	5%	3.47	5.04
3	10%	3.72	5.29
4	15%	3.51	4.98

Table 6: Split tensile strength results of concrete coconut shell as partial replacement of coarse aggregate.

Sl.no	% of coconut shell	Split tensile Strength Results, N/mm^2	
		7 days	28 days
1	0%	3.33	4.85
2	2.5%	4.42	6.36
3	5%	4.85	6.94
4	7.5%	4.21	6.18

Table 7: Split tensile strength results of concrete by addition of crimped steel fibres .

Sl.no	% of crimped steel fibres	Split tensile Strength Results, N/mm^2	
		7 days	28 days
1	0%	3.33	4.85
2	1%	3.38	4.91
3	2%	3.56	5.13

4	3%	3.61	5.25
5	4%	3.58	5.03

Table 8: Split tensile strength results of combined replacement of 10%GSA+5%CS+3%CSF in concrete.

Sl.no	10%GSA+5%CS+3%CSF	Compressive Strength Results, N/mm^2	
		7 days	28 days
1	0%	3.33	4.85
2	10%GSA+5%CS+3%CSF	5.18	7.38

5. CONCLUSION

1. The **Normal concrete** without any replacement achieved a compressive strength of **33.71 N/mm² at 7 days** and **49.07 N/mm² at 28 days**.
2. The use of **groundnut shell ash (GNSA)** as a partial replacement of fine aggregate showed optimum compressive strength at **10% replacement**, reaching **36.32 N/mm² at 7 days** and **51.96 N/mm² at 28 days**.
3. The use of **coconut shell (CS)** as a partial replacement of coarse aggregate yielded the best compressive strength at **5% replacement**, achieving **48.17 N/mm² at 7 days** and **68.72 N/mm² at 28 days**.
4. The addition of **crimped steel fibres (CSF)** improved compressive strength maximally at **3% addition**, with values of **35.64 N/mm² at 7 days** and **51.52 N/mm² at 28 days**.
5. The **combined replacement** of **10% GNSA + 5% CS + 3% CSF** resulted in the highest compressive strength, reaching **49.92 N/mm² at 7 days** and **71.42 N/mm² at 28 days**, significantly higher than normal concrete.
6. The Normal concrete without any replacement achieved a **split tensile strength of 3.33 N/mm² at 7 days** and **4.85 N/mm² at 28 days**.
7. **Groundnut shell ash (GNSA)** as partial replacement of fine aggregate showed optimum split tensile strength at **10% replacement**, reaching **3.72 N/mm² at 7 days** and **5.29 N/mm² at 28 days**.
8. **Coconut shell (CS)** as partial replacement of coarse aggregate yielded the best split tensile strength at **5% replacement**, with values of **4.85 N/mm² at 7 days** and **6.94 N/mm² at 28 days**.
9. **Crimped steel fibres (CSF)** addition improved split tensile strength maximally at **3%**, achieving **3.61 N/mm² at 7 days** and **5.25 N/mm² at 28 days**.
10. The **combined replacement** of **10% GNSA + 5% CS + 3% CSF** gave the highest split tensile strength, reaching **5.18 N/mm² at 7 days** and **7.38 N/mm² at 28 days**, which is significantly higher than normal concrete.

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