USE OF COCONUT SHELL AND WASTE SLUDGE AS A BUILDING CONSTRUCTION MATERIAL

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Abstract: India, being a developing country, is experiencing constant depletion of natural resources due to rapid industrialization and construction activities. The current situation demands a search for alternative materials to make concrete, as natural resources are depleting rapidly due to industrialization and construction, particularly in developing countries like India. Coarse aggregate and cement are essential components, constituting around 65-80% of concrete used in various construction projects, including infrastructure development, low and high-rise buildings, and domestic developments. Unfortunately, waste materials such as coconut shells and water treatment plant sludge, generated from industrial processes, have become a significant environmental pollution concern, leading to disposal and management challenges. This study aims to explore the potential of utilizing these waste materials, coconut shells, and sludge, as building construction materials. To assess their suitability, the research examines the compressive strength of M - 35 grade concrete cubes by replacing 10% of natural coarse aggregates with coconut shell, and 5% and 8% of cement by weight with sludge. The compressive strength of the coconut shell-sludge concrete cubes is evaluated after 7 and 28 days, offering valuable insights for eco-friendly waste management solutions.

Keywords: cement; ground granular blast furnace; cubes

1. Introduction

In today's era of rapid technological advancement and a growing global population, the overconsumption of natural resources poses significant challenges to the environment. To combat these issues and work towards sustainability, it is crucial to adopt practices that prioritize recycling, reuse, and the substitution of waste materials. Sewage sludge, a byproduct of wastewater treatment, has traditionally been disposed of through land filling, raising environmental concerns. However, with limited land availability, alternative methods for managing and disposing of sludge must be explored. The construction industry, facing increasing demand for materials, has seen innovative approaches to incorporate novel materials in concrete, with a focus on natural materials' advantages. In tropical countries like India, improper agricultural waste disposal leads to societal and ecological hurdles, hindering affordable housing. Research on alternative construction materials, such as coconut shells, has gained momentum due to their biodegradable properties and potential carbon neutrality.

Our research focuses on the beneficial use of sewage sludge and coconut shells in cement bricks, aiming to assess their impact on physical, mechanical, and durability properties. By promoting sustainable construction practices, our findings can contribute to waste management solutions, resource conservation, and the delivery of cost-effective housing, paving the way for a more sustainable future.

1.1 Objectives

The main objective is to use coconut shell and sludge waste as building construction material.

Specific objectives include:

- To analyze the coconut shell and water treatment plant (WTP) sludge waste for physicochemical characteristics.
- To check the feasibility of sludge as an ingredient in brick making.
- To know the compressive strength for different ratios of waste and cement.
- To determine the optimum percentage of coconut shell and dry sludge replacement in concrete.

2. Materials and Methods

2.1 Materials

2.2.1 Sludge

Sludge is a semi-solid slurry generated from wastewater treatment processes or industrial processes. In this study, sludge from a water treatment plant near Hebbal Lake in Mysuru was used. The sludge contributes to environmental contamination when not managed properly.

2.2.2 Ground Granulated Blast Slag (GGBS)

GGBS is a byproduct of the iron-making process in blast furnaces. It is rapidly cooled, enhancing its cementitious properties. Benefits of using GGBS in concrete include lower temperature rise, high chloride resistance, better workability, and reduced carbon dioxide emissions.

2.2.3 Coconut Shells

Coconut shells have unique characteristics due to their higher lignin content and lower cellulose content. They were processed into chips (sizes above 12 mm and below 20 mm) and used as a partial replacement for conventional coarse aggregates.

2.2.4 Cement

Cement serves as a binding agent in concrete construction. Ordinary Portland cement of grade 53 was used in this study.

2.2.5 Manufactured Sand

Manufactured sand, or M-Sand, is an alternative to river sand in concrete construction. It is produced by crushing hard granite stone. Double washed M-Sand was used in this study.

2.2.6 Coarse Aggregate

Coarse aggregates with sizes above 12 mm and below 20 mm were used in the study.

2.2.7 Water

Potable water was used for concreting and curing as per the specified requirements.

2.2 Mix Design

Two concrete mixes, Mix-1 and Mix-2 were designed as per IS:10262 -2019. The percentage replacement of sludge, coconut shell and GGBS in Mix-1 is 5 %: 10 %: 10 % and Mix- 2 is 8 %: 10 %: 10 %: 10 %: 10 %: 10 %. The following table depicts the quantities of materials of each mix.

Table 2.2 Quantity of Materials for M35 mixes

Raw Materials	Mass of Mix-1 (Kg)	Mass of Mix-2 (Kg)
Sludge	0.168	0.269
GGBS	0.337	0.337
Cement	2.86	2.76
Coarse Aggregate	9.889	9.78
Fine Aggregate	6.410	6.39
Coconut shell	0.518	0.511

2.3 Weighing and Batching of Materials

The materials were weighed on an electronic scale and batched as per the mix design for Mix-1 and Mix-2.

2.4 Mixing Procedure

The materials were mixed dry in a pan mixer and water was added cautiously to achieve the desired workability.

2.5 Moulding and Compaction

The concrete mixtures were poured into standardized cube Moulds of size 100 x 100 x 100mm and compacted using a vibrating table to ensure even distribution and eliminate air voids.

2.6 Drying and Demoulding

The concrete specimens were allowed to dry for 24 hours before being demoulded to avoid deformation.

Fig. 2.6 Drying and Demoulding of cubes.

2.7 Curing

After demoulding, the concrete cubes were submerged in water to provide controlled curing conditions for optimal hydration and increased strength and durability.

3. Results

3.1 Compression test

Compressive strength is defined as the ability of a material to withstand surface loads without cracking or deflecting. Under compression, the material tends to reduce in size, while tension causes elongation.

Compressive Strength = Load / Cross-sectional Area

The compressive test was conducted following the guidelines outlined in IS 516-1959. For concrete with a grade of M35, the minimum required compression strength in N/mm^2 at 7 days, 14 days, and 28 days is specified as 23.5, 31.85, and 35, respectively.

3.2 Compressive strength for 7 days

Table 3.1 shows that compressive strength of mix – 1 cement cube of sample 1 and sample 2 for 7 days , 5% sludge, 10% GGBS and 10% coconut shell chips, is found to be 10.09 and 9.75 N/mm^2 respectively and that of mix – 2 cement cube of sample 1 and sample 2 for 7 days , 8% sludge, 10% GGBS and 10% coconut shell chips, is found to be 12.53 and 12.78 N/mm^2 respectively.

Table 3.1 compressive strength for 7 days

grade of concrete	proportions	samples	Compressive strength (N/mm²)	avg strength (N/mm²)
M35	MIX 1	sample 1	10.09	9.92
		sample 2	9.75	
	MIX 2	sample 1	12.53	12.65
		sample 2	12.78	

Figure 3.1 reveals that the average compressive strength of mix-2 is approximately 27.56% higher than that of mix-1 after 7 days

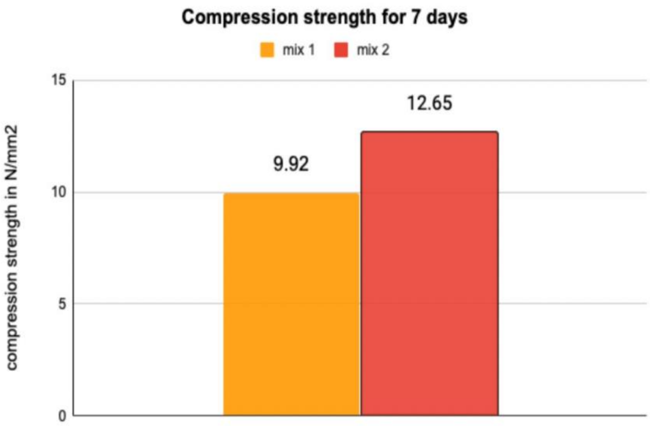

Fig 3.1 average compression strength of mix1 and mix 2 for 7 days

3.2 Compressive strength for 14 days

Table 3.2 shows that compressive strength of mix – 1 cement cube of sample 1 and sample 2 for 7 days , 5% sludge, 10% GGBS and 10% coconut shell chips, is found to be 17.97 and 20.33 N/mm² respectively and that of mix – 2 cement cube of sample 1 and sample 2 for 7 days , 8% sludge, 10% GGBS and 10% coconut shell chips, is found to be 16.07 and 15.36 N/mm² respectively.

Table 3.2 compressive strength for 14 days

grade of concrete	proportions	samples	Compressive strength (N/mm²)	avg strength (N/mm²)
M35	MIX 1	sample 1	17.97	19.15
		sample 2	20.33	
	MIX 2	sample 1	16.07	15.71
		sample 2	15.36	

Figure 3.2 shows that the average compressive strength of mix-1 is approximately 21.90 % higher than that of mix-2 after 14 days.

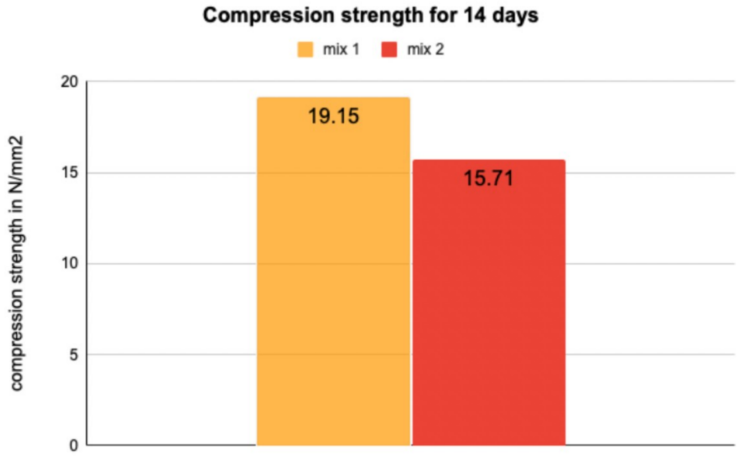

Fig 3.2 average compression strength of mix1 and mix 2 for 14 days

3.3 Compressive strength for 28 days

According to Table 5.3, the compressive strength of mix-1 cements cubes for sample 1 and sample 2, containing 5% sludge, 10% GGBS, and 10% coconut shell chips, after 7 days, is recorded as 19.75 N/mm² and 22.35 N/mm², respectively. On the other hand, the compressive strength of mix-2 cements cubes for sample 1 and sample 2, incorporating 8% sludge, 10% GGBS, and 10% coconut shell chips, after 28 days, is measured as 17.67 N/mm² and 16.89 N/mm², respectively.

Table 3.3 compressive strength for 28 days

grade of concrete	proportions	samples	Compressive strength (N/mm²)	avg strength (N/mm²)
M35	MIX 1	sample 1	19.75	21.05
		sample 2	22.35	
	MIX 2	sample 1	17.67	17.28
		sample 2	16.89	

Based on the data presented in Figure 5.3, it can be noted that the average compressive strength of mix-1 is roughly 21.8 % greater than that of mix-2 after a period of 28 days.

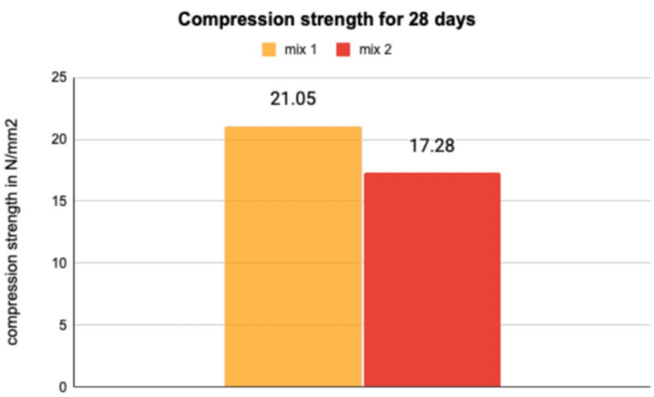

Fig 3.3 average compression strength of mix1 and mix 2 for 28 days

The compressive strength of conventional concrete, determined by testing small cubes measuring 100mm x 100mm, was observed to be 52.5 N/mm2 at the age of 28 days.

4. Conclusions

- Average compression strength of mix-1 is found to be 21.05 N/mm^{2}and mix-2 is
- 17.28 N/mm^2 for 28 days. It can be said that cubes of mixed proportion having 5% sludge, 10% coconut shell and 10% GGBS have more compression strength than mix proportion having 8% sludge, 10% coconut shell and 10% GGBS.
- The strength of the cube decreases as the percentage of sludge increases.
- Hence the optimum percentage of coconut shell ash and dry sludge replacement in concrete is 5% and 10%.
- Utilizing sludge and coconut shells as replacements in cement cubes proves cost- effective, as it optimizes the use of waste materials alongside cement and coarse aggregate, enhancing sustainability and reducing expenses although it is cost effective, results appeared to be unsatisfactory and failed to meet the requirements.
- Therefore, it is not advisable to utilize it in construction projects.

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