Partial Replacement of Coarse Aggregate with EPS Beads

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Abstract - The rising for natural aggregates in construction has caused resource exhaustion and environmental issues, prompting the search for sustainable options. This research explores the substitution of coarse aggregates with Expanded Polystyrene (EPS) beads in concrete, with the goal of tackling issues related to aggregate shortages and the management of EPS waste. EPS beads, recognized for their light weight, thermal insulation capabilities, and moisture resistance, provide possible advantages for the creation of lightweight and environmentally friendly concrete. The study assesses how different volumes of EPS beads as a replacement impact the physical and mechanical characteristics of concrete, such as density, workability, compressive strength, and durability. Experimental findings indicate that raising the EPS bead content decreases the self-weight of concrete and improves thermal insulation, although it negatively affects compressive strength. An optimal replacement ratio achieves a balance between structural performance and sustainability, rendering EPS-concrete appropriate for non-load-bearing structures, lightweight construction, and thermal insulation uses. The Compressive strength of 5%, 10% EPS based concretes compared to control concrete.This research shows the viability of utilizing EPS beads as a partial substitute for coarse aggregates, promoting sustainable construction methods and lessening environmental effects. The results offer important perspectives on the mix design and real-world uses of EPS-concrete, promoting its use as an eco-friendly option in the construction sector.

KEYWORDS: Exhaustion, workability, expanded polystyrene, durability, thermal insulation.

1. INTRODUCTION

The swift urban growth and rising need for infrastructure projects have greatly heightened the use of natural resources, such as coarse aggregates, which are essential in concrete. This has resulted in the exhaustion of natural aggregate sources and related environmental issues like habitat loss and higher carbon emissions from extraction activities. In reaction, the construction sector has been diligently investigating alternative materials and sustainable methods to address these issues. A promising approach is to partially substitute coarse aggregates with lightweight and eco-friendly materials like Expanded Polystyrene (EPS) beads. EPS, a by-product from the packaging and insulation sectors, is non-biodegradable and presents considerable waste management difficulties because of its high volume and resistance to breaking down. Integrating EPS beads into concrete tackles waste management challenges while promoting sustainable construction methods by decreasing dependence on natural aggregates.

EPS beads provide various benefits, including decreased concrete self-weight, enhanced thermal insulation, and superior shock absorption characteristics. Nonetheless, issues like reduced compressive strength and possible durability problems need to be tackled via appropriate mix design and treatment methods. EPS beads provide multiple advantageous characteristics, such as being lightweight, having excellent thermal insulation capability, and resisting moisture uptake. These traits render EPS-based concrete a suitable choice for uses where diminished density and thermal efficiency are essential, such as in lightweight constructions, thermal insulation boards, and non-load-supporting elements. Nonetheless, substituting conventional coarse aggregates with EPS beads may negatively impact the mechanical characteristics of concrete, including compressive strength and modulus of elasticity, requiring a well-balanced mix design to maintain structural integrity.

While EPS beads have their benefits in concrete, they also pose difficulties, especially regarding mechanical strength and durability. EPS beads are significantly less dense and weaker compared to traditional aggregates, potentially compromising the compressive strength of concrete. Nevertheless, by refining the mix design and ratio of EPS, one can attain a balance between efficiency and sustainability. Studies in this field focus on determining the best replacement levels, assessing the effects on essential attributes like strength, workability, thermal conductivity, and durability, and investigating the practical viability of EPS-concrete in actual construction projects.

This research aims to assess the viability of EPS beads as a partial substitute for coarse aggregates in concrete. Its objective is to evaluate the impact of different EPS bead ratios on essential characteristics like compressive strength, density, workability, and durability. The results are anticipated to aid in the creation of sustainable building materials while tackling the dual issues of aggregate shortages and EPS waste disposal. Additionally, the study aims to offer understanding of the practical uses of EPS-concrete and how it performs in different environmental situations, facilitating its broader implementation in the construction sector.

This research emphasizes a method for minimizing environmental effects and promoting sustainable construction techniques by incorporating waste materials such as EPS beads into concrete manufacturing.

2. OBJECTIVE

1. To examine how EPS bead substitution affects the physical and mechanical characteristics of concrete, such as density, compressive strength, and workability.

2. To determine the ideal replacement ratio of EPS beads that results in notable weight loss while ensuring sufficient strength for practical uses.

3. To investigate the possible environmental advantages of integrating EPS waste into concrete, including decreased aggregate requirements and enhanced waste management strategies.

4. To create guidelines for the mix design of EPS-concrete aimed at lightweight construction and non-load-bearing uses.

3. EPS BEADS

Expanded Polystyrene (EPS) beads are lightweight, closed-cell thermoplastic substances made from polystyrene. EPS is created by expanding granules of polystyrene through the use of a blowing agent, usually pentane gas, and heat to generate tiny spherical beads. These beads are frequently employed as insulation materials, packaging, lightweight fillers, and in construction because of their distinctive characteristics. EPS beads are not environmentally degradable and possess chemical stability, which makes them impervious to moisture, chemicals, and biological decay. Although not inherently recyclable, these materials can be repurposed or reused for uses like lightweight concrete, soil stabilization, and geotechnical engineering fillers

Fig. 1: Eps beads

4. METHODOLOGY

The methodology outlines the systematic steps undertaken to evaluate the effects of partial replacement of coarse aggregates with EPS beads on the properties of concrete. The study includes mix design, specimen preparation, curing, and testing of fresh and hardened concrete properties.

4.1 Material Selection

1. Cement:

Ordinary Portland Cement (OPC) 43/53 grade conforming to IS 8112

2. Fine Aggregates:

Manufactured sand passing through a 4.75 mm sieve, conforming to IS 383.

3. Coarse Aggregates:

Natural aggregates with a nominal size of 20 mm.

4. EPS Beads:

Expanded Polystyrene (EPS) beads of uniform size, used as a partial replacement for coarse aggregates.

5. Water:

Potable water, free from impurities, conforming to IS 456.

Fig. 2: Cement

Fig. 3: Fine aggregate

Fig. 4: Coarse aggregate

Fig. 5: EPS beads

4.2 Physical properties of EPS beads

Specific Gravity	Bulk density	Particle size
0.011	6.86 kg/m^3	Spherical (8-9 dia)

4.3 MIX RATIO

With w/c = 0.46, the proportion of concrete mix is,

W	C	FA	CA
200	**434**	**660.67**	**999.5**
0.461	**1.000**	**1.522**	**2.303**

5. TESTING

5.1 COMPRESSIVE TEST

A set of three cubes were tested for each of the mix for their compressive strengths at 7 and 28 days of curing. As expected, the normal weight concrete has more compressive strength at all ages compared to lightweight concrete. At 28 days, it was found that compressive strength of 5%, 10% EPS based concretes compared to normal concrete.

USING THIS FORMULA

Compressive Strength = P/A

P= Maximum load applied (N)

A= Cross-sectional area of the specimen (mm^2)

6. TEST RESULT

MIXTURE	DURATION			
	7 DAYS		28 DAYS	
	LOAD (kN)	STRENGTH	LOAD (kN)	STRENGTH
Normal concrete with 0% EPS	303.75	13.5	468	20.8
Concrete with 5% EPS	274.5	12.2	425	18.9
Concrete with 10% EPS	231.75	10.3	360.225	16.01

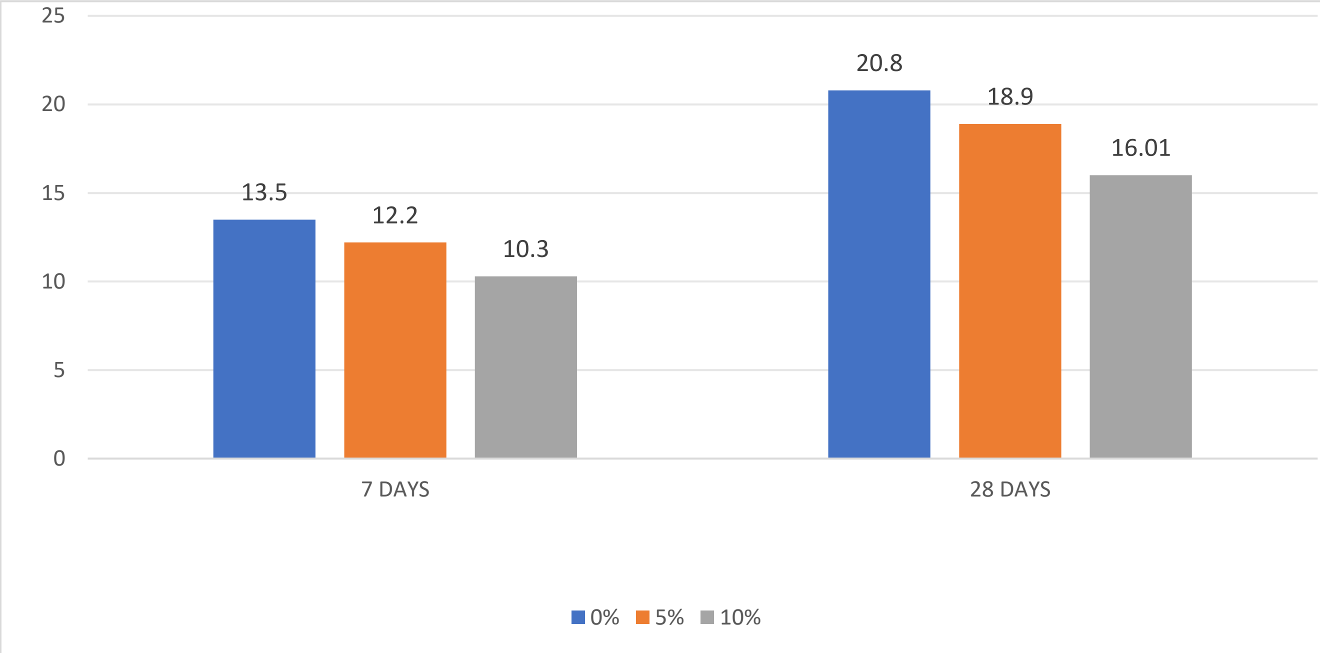

Fig. 7: compressive strength

7. CONCLUSION

The use of Expanded Polystyrene (EPS) beads as a partial substitute for coarse aggregates in concrete provides numerous advantages, rendering it an effective choice for lightweight and eco-friendly construction. Main discoveries from the study indicate that although there is a decrease in compressive strength as EPS content rises, the material is still appropriate for non-load-bearing structures, lightweight building, and uses that demand thermal insulation. Using EPS beads enhances recycling efforts and decreases dependence on natural aggregates, aiding sustainable construction methods. EPS concrete improves thermal and acoustic insulation, making it perfect for energy-efficient and soundproof buildings. Despite the material's diminished strength, its lightness and insulating qualities can help offset expenses by lowering structural dead weights and enhancing energy efficiency.

Results: At 28 days, it was found that compressive strength of 5%, 10% EPS based concretes compared to control concrete were 92%, 78%

8. REFERENCE

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