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Research Article

An Experimental Investigation On Light Weight Concrete By Uisng Expanded Polystyrene Beads (Eps)

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ARTICLE INFO | **ABSTRACT**

Lightweight concrete constitutes a specialized form of concrete formulated with lightweight aggregates, including expanded clay, shale, slate, perlite, vermiculite, or polystyrene beads. The incorporation of these lightweight aggregates aims to decrease the overall density of the concrete, rendering it lighter in comparison to conventional concrete mixes. This variant finds applications across diverse sectors, including the construction of lightweight structures, flooring systems, and precast concrete items, where the minimization of weight proves essential. Lightweight concrete offers several benefits, including enhanced thermal insulation, heightened energy efficiency, simplified handling and transportation, and diminished dead load on supporting structures.However, it also has some limitations, such as lower fire resistance compared to traditional concrete. Lightweight concrete is a type of concrete that uses lightweight aggregates, such as polystyrene beads, in place of traditional aggregates, such as crushed stone, to produce a lighter weight product. The use of polystyrene beads as a replacement for traditional aggregates has been shown to improve the thermal insulation and energy efficiency of the concrete, while still maintaining its structural integrity. The experimental investigation of lightweight concrete using polystyrene beads would typically involve measuring the mechanical properties, such as compressive strength, tensile strength, and modulus of elasticity, and comparing them to those of traditional concrete. Additionally, the investigation may also assess the thermal insulation properties of the lightweight concrete, as well as any potential drawbacks, such as decreased fire resistance. The objective is to compare the mechanical properties like compressive strength, Tensile strength, Flexural strength and Modulus of elasticity of conventional concrete for 7, 14 & 28 days with light weight concrete comprising expanded polystyrene as per IS code 10262- 2009 consists of 0.2 & 0.3% EPS for Fine Aggregate and 10 % to 60% of Coarse Aggregate for M25 mix design. The effect of inclusion of expanded polystyrene on the mechanical properties of lightweight concrete will be studied

Keywords: Light weight concrete, Polystyrene beads, Thermal insulation, Energy efficiency, Structural integrity, Mechanical properties, Compressive strength, Tensile strength, Modulus of elasticity

I. INTRODUCTION

In contemporary construction practices, concrete stands out as the most suitable and extensively employed building material. Over time, this foundational material has undergone significant evolution and refinement. Concrete, by definition, comprises a blend of cement, water, and additives, occasionally supplemented with super-plasticizers. It is an engineered material, initially malleable, ductile, or fluid in nature, gradually transitioning to a solid state. Conceptually, concrete can be likened to an artificial stone, with cement being its pivotal component. However, the production of cement, a primary constituent, is associated with substantial CO_2 emissions, known to catalyze detrimental environmental alterations.Consequently, contemporary research endeavors strive to curtail industrial CO_2 emissions. The most efficient method for reducing CO_2 emissions in the cement industry involves replacing a portion of cement with alternative materials known as Supplementary Cementing Materials (SCMs). Fly ash is a commonly utilized SCM, often derived from industrial processes, thereby resulting in lower CO_2 emissions during cement manufacturing. In addition to mitigating environmental impact, SCMs offer various other benefits, contributing to their increasingly widespread adoption in concrete technology.

II. CONCRETE

Concrete, a composite construction material, primarily comprises aggregate, cement, and water, with diverse formulations yielding varied properties. The aggregate typically consists of coarse gravel or crushed rocks like limestone or granite, combined with a fine aggregate such as sand. Cement, often Portland cement, along with other cementitious materials like fly ash and slag cement, acts as a binder for the aggregate. Various chemical admixtures are incorporated to achieve specific properties. Water is added to this dry composite, facilitating shaping, typically through pouring, followed by solidification and hardening into a rock-like substance via hydration, a chemical process. During hydration, water reacts with the cement, binding the components together to form a durable material akin to stone.Concrete exhibits relatively high compressive strength but lower tensile strength, thus reinforcing materials, often steel, are commonly used to bolster its tensile properties. Despite its strength, concrete is susceptible to damage from various processes such as freezing. Concrete finds extensive application in construction, used for architectural structures, foundations, brick/block walls, pavements, bridges/overpasses, roads, runways, parking structures, dams, pools/reservoirs, pipes, footings for gates, fences, poles, and even boats.

A. Fly ash

Fly ash is predominantly sourced from coal-fired power plants that generate electricity. These plants pulverize coal into fine powder before combustion. During the burning process, fly ash, a mineral residue, is captured from the exhaust gases of the power plant and collected for various applications.

Under microscopic examination, the disparity between fly ash and Portland cement becomes evident. Fly ash particles exhibit nearly spherical shapes, facilitating their flow and homogeneous blending within mixtures. This characteristic makes fly ash a sought-after admixture in concrete formulations. Below Fly ash is shown in Fig1.1.

Fig. 1.1: Fly ash

B. Thermocol

Expanded polystyrene (EPS), commonly known as Thermocol, is a rigid and resilient closed-cell foam material. It is typically white and manufactured from pre-expanded polystyrene beads. EPS boasts nonhydroscopic, odorless, rigid, and closed-cell properties, making it suitable for various applications. Its lightweight nature, water resistance, dimensional stability, and inert characteristics enable diverse uses. EPS is widely utilized as a building insulation material, particularly in structures like insulating concrete forms and structural insulated panel building systems. Additionally, grey polystyrene foam, incorporating graphite, offers enhanced insulation properties. Beyond insulation, EPS finds applications in non-load- bearing architectural structures, such as ornamental pillars. However, it's important to note that discarded polystyrene does not biodegrade for extended periods, remaining resistant to photolysis. Due to its specific gravity, polystyrene foam can be carried by wind and float on water surfaces, posing potential hazards to birds and marine life.

Fig. 1.2: Thermocol

III. EXPERIMENTAL INVESTIGATIONS

A. Objective of Study

In the current study, the performance of M25 grade cement concrete is examined by partially substituting cement with fly ash and coarse aggregate with Expanded Polystyrene (EPS), juxtaposed with conventional concrete.

B. Materials

The raw materials necessary for the concreting operations in this project include cement, fly ash, fine aggregate, coarse aggregate, Expanded Polystyrene (EPS), and water.

C. Cement

Cement of 43 Grade Ordinary Portland Cement was used.

PROPERTIES OF CEMENT

Table – 1 Physical properties of ordinary Portland cement

S.NO.	Property	Test Results
1	Normal Consistency	32%
2	Specific Gravity	3.13
3	Initial and final setting time	60 & 380 Minutes
4	Soundness value	1.5mm
5	Fineness of cement(Dry sieving method)	4%
6	Specific gravity	3.13

A. Specific Gravity

S.NO	NAME OF THE INGRIDIENT	SPECIFIC GRAVITY
1	FINE AGGREGATES	2.614
2	COARSE AGGREGATES	2.88
3	FLYASH	2.3

IV. EXPERIMENTAL RESULTS

V.

Table - 5.1 Shows the various mixes used in this investigation.

Constituents of Concrete	Binding Material		Fine Aggregate		Coarse Aggregate
Mix Types	Cemen t	Fly ash	Sand	Thermocol	20mm

OPC	100%	0%	100%	0%	100%
OPC+35%Fly ash+0.2% Thermocol	65%	35%	99.8%	0.2%	100%
OPC+40%Fly ash+0.3% Thermocol	60%	40%	99.7%	0.3%	100%

Table - 5.2 Compressive strength values for replacement of cement with fly ash and fine aggregate with thermocol

Mix	3 days compressive Strength (N/mm^2)	7 days compressive Strength (N/mm^2)	28 days compressive Strength (N/mm^2)
Normal mix	10.7	21.2	33.25
35% Fly ash + 0.2% of Thermocol	11.2	24.3	35.5
40% Fly ash + 0.3% of Thermocol	12.3	25.1	36.8

Trial 1:

Table 8:

	Quantity (gm)	**Replacement (%)**
Cement	391	NIL
FA	42.8	NIL
CA	327.2	NIL
Aluminium powder	107	10% of FA
POP	428	40% of FA
Fly ash	492.2	46
Thermocol Beads	90.8	60% of CA

The concrete doesn't float for the above replacements.Trial 2:

Table 9:

	Quantity (gm)	**Replacement (%)**
Cement	391	NIL
FA	42.8	NIL
CA	306.75	NIL
Aluminium powder	107	10% of FA
POP	428	40% of FA
Fly ash	492.2	46
Thermocol Beads	101.25	62.5% of CA

The concrete doesn't float for the above replacementsTrial 3:

Table 10:

	Quantity (gm)	**Replacement (%)**
Cement	391	NIL
FA	42.8	NIL
CA	286.3	NIL
Aluminium powder	107	10% of FA
POP	428	40% of FA
Fly ash	492.2	46
Thermocol Beads	131.7	65% of CA

The concrete doesn't float for the above replacementsTrial 4:

Table 11:

	Quantity (gm)	Replacement (%)
Cement	391	NIL
FA	42.8	NIL
CA	572.6	NIL
Aluminium powder	107	10% of FA
POP	428	40% of FA
Fly ash	492.2	46
Thermocol Beads	145.4	30% of CA

The concrete doesn't float for the above replacementsTrial 5:

Table 12:

	Quantity (gm)	Replacement (%)
Cement	391	NIL
FA	42.8	NIL
CA	490.8	NIL
Aluminium powder	107	10% of FA
POP	449.4	42% of FA
Fly ash	470.8	44
Thermocol Beads	186.3	35% of CA

The concrete doesn't float for the above replacementsTrial 6:

Table 13:

	Quantity (gm)	Replacement (%)
Cement	350	NIL
FA	34.58	NIL
CA	276.5	NIL
Aluminium powder	86.44	10% of FA
POP	397.62	46% of FA
Fly ash	345.76	40%
Thermocol Beads	198.6	65% of CA
Limestone	110.6	10% of CA

The concrete doesn't float for the above replacements.Trial 7:

Table 14:

	Quantity (gm)	Replacement (%)
Cement	350	NIL
FA	34.58	NIL
CA	221.2	NIL
Aluminium powder	86.44	10% of FA
POP	363.05	42% of FA
Flyash	380.34	44%
Thermocol Beads	204.2	70% of CA
Limestone	110.6	10% of CA

The concrete doesn't float for the above replacementsTrial 8:

Table 15:

	Quantity (gm)	Replacement (%)
Cement	350	NIL
FA	34.58	NIL
CA	387.1	NIL
Aluminium powder	86.44	10% of FA
POP	397.62	46% of FA
Flyash	345.76	40%
Thermocol Beads	-	-
Limestone	718.9	65% of CA

The concrete doesn't float for the above replacements 150 x 150 x150 mould
Trial 9:

Table 16:

	Quantity (gm)	Replacement (%)
Cement	1.18 kg	NIL
FA	120	NIL
CA	1.12 kg	NIL
Aluminium powder	292	10% of FA

POP	1.34	46% of FA
Flyash	1.168	40%
Thermocol Beads	2.61 kg	70% of CA
Limestone	-	-

The concrete doesn't float for the above replacements 150 x 150 x150 mould
Trial 10:

Table 17:

	Quantity (gm)	Replacement (%)
Cement	350	NIL
FA	34.58	NIL
CA	221	NIL
Aluminium powder	86.44	10% of FA
POP	397.62	46% of FA
Flyash	345.76	40%
Thermocol Beads	111	10% of CA
Limestone	774	70% of CA

The concrete doesn't float for the above replacements

Trial 11:

Table 18:

	Quantity (gm)	Replacement (%)
Cement	350	NIL
FA	44.26	NIL
CA	259.32	NIL
Aluminium powder	154.84	14% of FA
POP	464.52	42% of FA
Flyash	442.4	40%
Thermocol Beads	-	-
Limestone	605.08	70% of CA

The concrete doesn't float for the above replacementsTrial 12:

Table 19:

	Quantity (gm)	Replacement (%)
Cement	350	NIL
FA	44.26	NIL
CA	216.1	NIL
Aluminium powder	154.84	14% of FA
POP	464.52	42% of FA
Flyash	442.4	40%
Thermocol Beads	-	-
Limestone	648.3	75% of CA

The concrete doesn't float for the above replacementsTrial 13:

Table 20:

	Quantity (gm)	Replacement (%)
Cement	391	NIL
FA	42.8	NIL
CA	245.4	NIL
Aluminium powder	149.8	14% of FA
POP	449.4	42% of FA
Flyash	42.8	40%
Lime stone	572.6	70% of CA
Thermocol Beads	-	-

The concrete floats for the above replacements

Trial 14:

Table 21:

	Quantity (gm)	Replacement (%)
Cement	1.32kg	NIL
FA	144.4	NIL
CA	828	NIL
Aluminium powder	505.4	14% of FA
POP	1516.2	42% of FA
Flyash	144.4	40%
Lime stone	193.2	70% of CA
Thermocol Beads	-	-

The concrete floats for the above replacements.

Table 22: Results on Light Weight Concrete (Cube and slab)

TRAILNO	DENSITY OF CUBE (kg/m3)	FLOAT	LIGHT WEIGHT CONCRETE TIME
1	**825**	YES	Does not sink at all
2	**545**	YES	Does not sink at all

SUMMARY AND CONCLUSIONS

Based on the literature reviewed and referenced sources, a novel type of Lightweight Concrete has been proposed. This concrete incorporates aluminium powder as an air-entraining agent to increase its volume, resulting in a lightweight composition capable of floating. Mixing aluminium powder into the cement-sand slurry demonstrates observable volume expansion, generating numerous pores that contribute to its lightweight nature. However, it's noted that this type of concrete may lack structural strength due to its porous structure. Additionally, lightweight aggregates are integrated into the concrete mix to further decrease its density, while partial replacement of sand with fly ash serves to reduce the weight of fine aggregate. The study indicates that by utilizing fly ash and aluminium powder as partial replacements for fine aggregate, it's feasible to produce Lightweight Concrete with satisfactory strength properties. Furthermore, the research suggests that incorporating lightweight ingredients into the concrete mixture can decrease dead load while potentially compromising concrete strength. Nonetheless, certain trial proportions, such as the 14th trial for cube proportions, yield compressive strength comparable to that of second-class brick, indicating promise for lightweight concrete with a density of 525 kg/m^3. Looking ahead, the focus shifts towards enhancing concrete strength to withstand imposed loads, facilitating the construction of large Lightweight Concrete structures. This may involve reinforcement with steel and other fibers to bolster structural integrity and durability. So based on the discussions what are all the benefits of this Light Weight Concrete are mentioned below:

- With the help of the Light Weight Concrete having the Light Weight Concrete property it can be used in Harbours, Docks and Dams
- They can be used as a platform to cover the surface of the water areas to stop the evaporation of water which can give a huge amount of water to the agricultural fields.
- The Light Weight Concreteslabs can cover the water surface with some proper gaps. The gaps are must because water i.e., the universal solvent also need some amount of oxygen to keep the water as a fresh one.
- The Light Weight Concrete slabs can also be tied to each other by some insulating materials to avoid rusting also to reduce the pollution caused due to rusting.

These are the discussions we made and with all these results and discussions we have made the conclusion

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