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Mechanical Properties of Light Weight Concrete using Lightweight Expanded Clay Aggregate

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Abstract: This research investigates the impact of partially substituting coarse aggregate with light weight coarse material (LECA). In numerous aspects, LECA mirrors the properties of coarse aggregate. Because self-weight accounts for a major amount of the total load applied to the structure, LECA is utilized in concrete to lower the need for coarse aggregate and in the design of concrete buildings. This is crucial in circumstances like poor soils and tall constructions. It also offers significant advantages in terms of lowering concrete density, which improves labour efficiency. Lightweight concrete has a lower density than standard concrete and provides better thermal insulation. The main purpose of this study is to examine the weight and strength characteristics of concrete, such as cube compressive strength, split tensile strength cylinders, and flexural strength of light weight concrete versus conventional concrete by substituting LECA for natural aggregates by 25%, 50%, 75%, and 100%, respectively. For far over two millennia, lightweight aggregate has been used successfully.
Keywords: Lightweight Expanded Clay Aggregate (LECA), Light-weight concrete, Flyash, Compressive Strength, Density.

I. INTRODUCTION

Concrete is the most widely utilised building material in the world's construction sector. The large self-weight of concrete is one of the downsides of traditional concrete [1]. The density of ordinary concrete ranges from 2200 to 2600 kg/m3. Because of its high self-weight, it requires greater load bearing parts and foundations, making it an non-economical material. Experiments have been made in the past to lower the self-weight of concrete in order to improve its structural adaptability [2]. As a result, light-weight concrete with densities ranging from 300 kg/m3 to 1850 kg/m3 emerged [3].

There are three basic methods for generating low weight Concrete. By substituting light weight aggregate for the traditional mineral aggregate. Adding gas or air bubbles to the mortar. This is referred to as "aerated concrete." By not including the sand fraction in the aggregate [4]. This type of concrete is known as 'no-fines' concrete. As a result, they are rarely employed in the production of light-weight concrete [5]. Pumice, diatomite, scoria, volcanic cinders, saw dust, and rice husk are some of the natural light weight aggregates, with pumice being the only one that is commonly employed [6].

The properties of expanded perlite aggregate (EPA) include extremely low bulk density, high brightness, high absorption, low thermal and acoustic conductivity, and non-flammability [7]. The test results for steel fibrous revealed a linear relationship between compressive strength and splitting-tensile strength [8]. The mechanical characteristics of light weight Geopolymer concrete generated by substituting regular coarse aggregate with light weight expanded clay aggregates are investigated in this research (LECA) [9]. However, structural application of LECA with a density of 1700kg/m3 was restricted to 60% replacement of coarse aggregate. Both split tensile strength and flexural strength reduced by roughly 35 percent when coarse aggregate was replaced with LECA by 40 percent, although they were still well within structural limitations [10].

Experimental inquiry on concrete mix M20 is done by replacing cement with fly ash, fine aggregate with bottom ash, and coarse aggregate with Light Expanded Clay Aggregate (LECA) at the rates of 5%, 10%, 15%, 20%, 25%, 30%, and 35 percent [11]. The results reveal that replacing 5% of the cement with fly ash, fine aggregate with bottom ash, and coarse aggregate with Light Expanded Clay Aggregate (LECA) yielded satisfactory compressive strength results [13]. To investigate the qualities of lightweight concrete, such as compressive and tensile strengths, EPS beads are utilised as a partial substitute for coarse aggregates in the amounts of 5, 10, 15, 20, 25, and 30% [13]. The compressive and tensile strength of concrete is reduced as the amount of EPS beads in the mix is increased. Non-structural uses include wall panels, partition walls, and the like [14].

Light Expanded Clay Aggregate (LECA) was employed as a fine aggregate for enhancing the mechanical characteristics of porous asphalt [15]. Three distinct combinations of stone material and LECA (0, 10 and 20% LECA) were employed to conduct the experiment in this study. The findings of moisture susceptibility tests showed that adding LECA to a porous asphalt mixture can improve the combination's resistance to moisture damage [16].

Lightweight concrete has grown in popularity in recent years as the result of the many advantages it provides over traditional concrete [17]. Lightweight concrete has a number of advantages, including reducing dead load, increasing construction pace, and lowering handling costs [18]. The comparatively low heat conductivity and strong sound insulation are two more key characteristics of light weight concrete [19]. With these considerations, this study is aimed on using LECA, investigate the mechanical characteristics of light weight concrete

II. LITERATURE SURVEY

Thomas Tamu and colleagues [9], To investigate the qualities of lightweight concrete, such as compressive and tensile strengths. EPS beads are utilised as a partial substitute for coarse aggregates in the amounts of 5, 10, 15, 20, 25, and 30%. The compressive and tensile strength of concrete is reduced as the amount of EPS beads in the mix is increased. Non-structural uses include wall panels, partition walls, and the like.

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III. MATERIAL AND METHODOLOGY

A. Cement

"Ordinary Portland Cement" (OPC) (43 Grade) was employed, which had a 34 percent normal consistency and complied with IS: 8112-1989. Cement has a specific gravity (SG) of 3.14 and a fineness modulus of 4% respectively.

B. Coarse Aggregate

A coarse material used was 'crushed stone' that complied with IS 383 – 1987. Physical parameters were determined as well as the free and compacted bulk density values of coarse aggregates, which were 4.417kg and 4.905kg, respectively were also determined. The specific gravity is found to be 2.74

C. Fine Aggregate

Throughout the experiment, 'normal river sand was used as the fine aggregate', which conformed to grading 'zone III'. By conducting tests in accordance with IS 2386(part -1)-1963, the qualities of sand can be determined. The value of specific gravity is 2.65.

D. Lightweight Expanded Clay Aggregate (LECA)

'LECA' of size 10-20 mm were utilised. The bulk density of the light weight expanded clay aggregate utilised ranges from 300 to 750 kg/m3, with water absorption ranging from 18 to 20% of the size. The specific gravity of leca is 0.60.

E. Water

Because it actively participates in chemical reactions with cement, water is asignificant component of concrete. The concrete mixture was made using clean potable water that met IS 456 – 2000 standards.

F. Fly ash

Fly ash is a finely split residue produced by the burning of pulverised coal that is carried away by exhaust gases from the combustion chamber. Low-Calcium Fly Ash (ASTM Class F) was procured from a Thermal Power Plant for this investigation. Fly

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ash has a specific gravity of 2.36 and a fineness of 4 percent.

G. Design of Concrete Mix

'M25' grade with design mix as per 'IS 456-2000' was used in this study. For a 1m3 concrete mix, use a weight-based proportion and a 'water-to-cement' ratio of '0.45'. Mix proportion obtained for M25 Grade of conventional concrete and 100 percent, light weight concrete mix ratio was 1:1.37:2.6 and 1:1.37:0.49 respectively. The percentage 25%, 50%, 75 and 100%, The fly ash percentage of 20% was utilised as a partial substitute for cement concrete and was used as a partial replacement for natural coarse aggregate.

H. Casting and Testing

In this, LECA was replaced with natural aggregate in 25, 50 ,75 and 100 percent . To determine the hardened properties of concrete, cubes and cylinders were formed for each percent of LECA replacement as coarse aggregate. For each proportion of fresh concrete, a slump test is performed. The cube and cylinder's final strength is measured after, 7 and 28 days of cure. The average compressive and tensile strengths for each mix fraction are then calculated and explained in the final result. Furthermore, the to quantify the amount of strength increased over conventional concrete, the strength of light weight aggregate concrete is compared to that of conventional grade concrete.

IV. RESULTS

A. Compressive Strength

The bar graph depicts the compressive strength of conventional concrete and light weight aggregate concrete using LECA for various grades . Compressive strength results of 24.64N/mm2 , 22.04N/mm2 and strength reduction of 14.44% and 23.47% where for LECA25 & LECA50 respectively these percentages of replacement are attributable to light weight concrete with densities ranging from 1100- 2100kg/m3. This mixture may also be used to build structures. It is observed that the concrete made with LECA aggregates is marginal to that of conventional concrete.

B. Split Tensile Strength

Split tensile strength results of 2.20 N/mm2 , 1.90 N/mm2 . The split tensile strength was reduced by 22.26 percent and 32.86 percent when 25% and 50% of LECA were replaced, respectively.

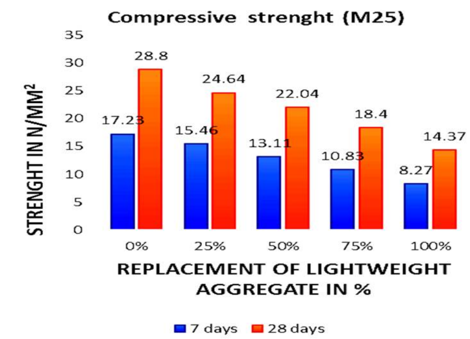
C. Density

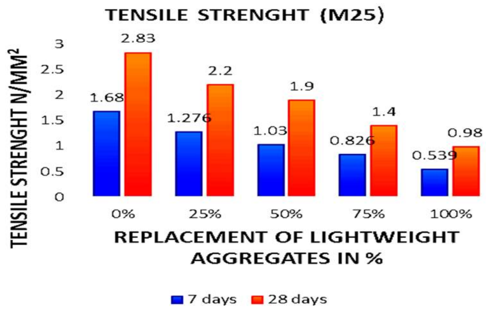
Table 1 shows the densities of normal concrete and light weight aggregate concrete using LECA. The difference in density was estimated to be roughly 1250 kg/m3.

D. Workability

The workability of Light weight aggregate concrete with LECA was measured using conventional slump cone test apparatus. The details of the results are presented in Table 2.

Fig. Compression testing





CONCRETE	WEIGHT (Kg)	DENSITY
NORMAL	8.21	2432.5
25%	7.22	2139.2
50%	5.87	1739.2
75%	4.98	1475.5
100%	4.03	1194.07

Table 1: Weight and density

S.no.	Percentage of leca	Slump value (mm)
1	0	76
2	25	73.5
3	50	74
4	75	72
5	100	71

Table 2 : Slump value

V. CONCLUSION

LECAs (lightweight expanded clay aggregates) are a type of fabricated lightweight aggregate that has a wide range of applications and has become a well-known material in civil engineering projects. LECA has unique properties that make it an excellent structural and geotechnical material. LECA has been used to construct lightweight concrete buildings, lightweight fill, drainage, and insulating materials in embankments for roads, railroads, and other traffic zones, and lightweight backfill for retaining walls and as foundation for structures and agricultures. According to the findings, incrementing the percentage of lightweight aggregate reduces the weight of the cubes from 8.21 to 4.03 kilograms.

1) The results of the investigation show that as the amount of leca increases, the compressive strength of the cube decreases.
2) With an increase in the amount of leca, the split tensile strength gradually decreases.
3) With a above percentage of regular aggregate replaced with leca, the density of concrete is shown to decrease.

4) When 50% of the leca is replaced with regular aggregate, the compressive strength, tensile strength and density are improved, as compared with other mix proportions.
5) As a result, we infer that concrete manufactured with these aggregates can be used in the construction sector to reduce the concrete's dead weight in multi-story buildings.
6) From the above result we can also conclude that It can be used as :
a) Screeds and thickening for general use, particularly when such screeds or thickening are used to support the weight of floors, roofs, and other structural parts.
b) Screeds and walls where wood must be nailed in place.
c) Using structural steel as a covering for architectural purposes or to protect it from fire and corrosion.
d) Roof and wall insulation for heat .
e) Insulating water pipes .
f) In frame structures, build partition walls and panel walls.
g) Surface rendered for small house outside walls,

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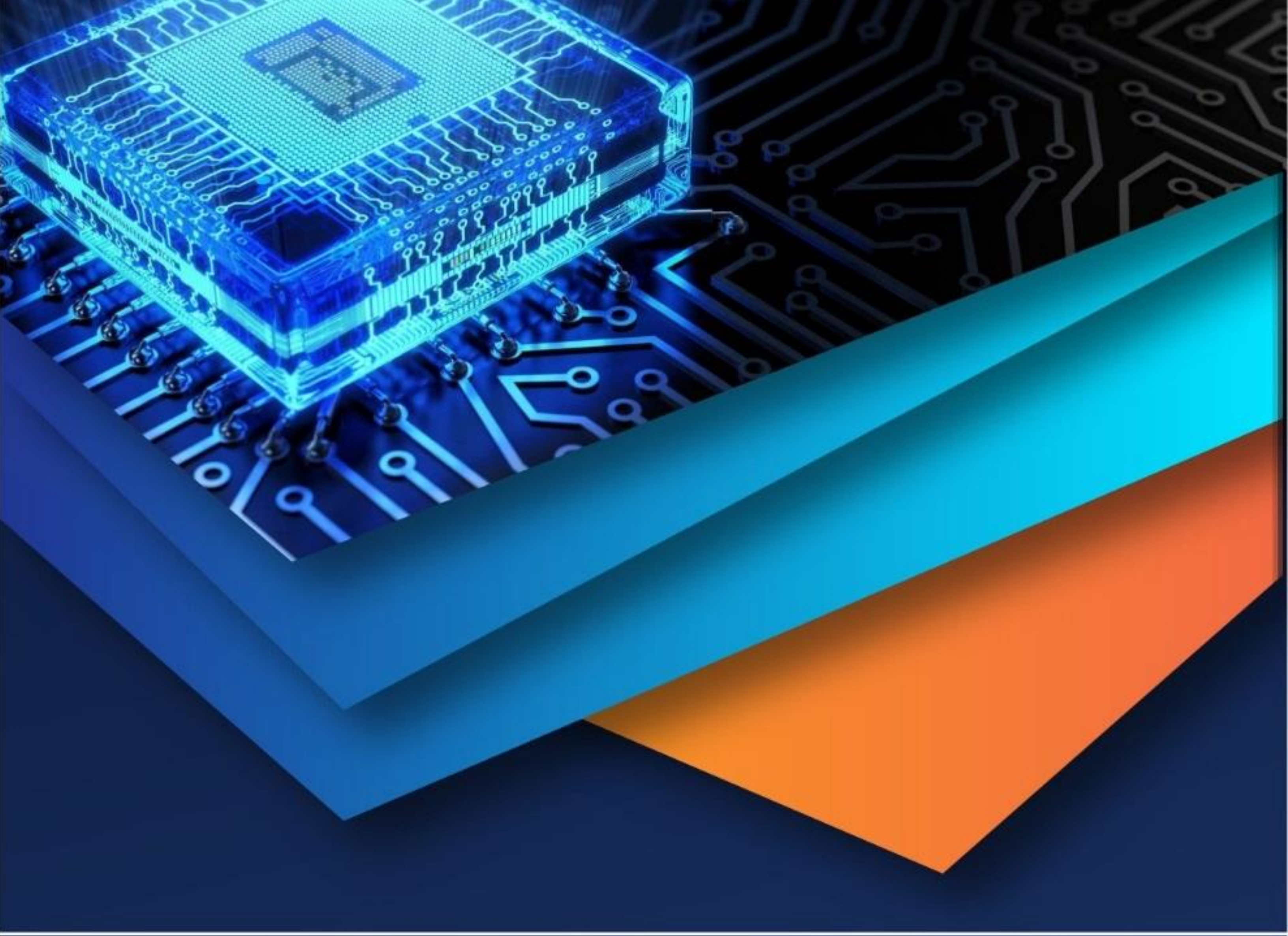

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