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To Study the Effect of Addition of Lightweight Expanded Clay Aggregate on fresh and hardened properties of Concrete

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Abstract – an attempt is made in this study to evaluate the behavior of partially replaced coarse aggregate with light weight expanded clay aggregate (LECA) on various properties of the concrete. The performance of the concrete using LECA is not known much. The main goal of this study is to examine the compressive strength, split tensile strength and flexural strength of the concrete using LECA with replacing normal aggregate by 0- 100% in the increment of 25%. The result indicated that maximum reduction of weight is about 28% and strength reduced by 17% for 100% Replacement. The optimum dosage of replacement without affecting strength is 25%. This study shows that the performance of the developed LECA mixed concrete helps to reduce the weight of structure if a suitable mix design are provided.

Keywords: Lightweight Expanded Clay Aggregate Concrete, Lightweight Concrete, Compressive Strength, Spilt Tensile Strength, Flexural Strength

I. INTRODUCTION

Light Weight Expanded Clay Aggregate (LECA) is an impressive and versatile material for a variety of applications. For example, in the field of construction, it can be widely used in the production of lightweight blocks, concrete, prefabricated parts and infrastructure backfilling. In the field of horticulture or agriculture, LECA can be used in agricultural wastewater treatment, where LECA has a comprehensive high capacity to remove large amounts of pollutants present in agricultural wastewater, such as chemical oxygen demand and total suspended solids, polyphenols, nitrogen, pesticides and pharmaceuticals. In addition, LECA can discharge groundwater and surface water to regulate groundwater pressure. [4, 5, 9]

LECA is made up of special plastic clay with no or little lime. The clay is dried, heated and burned in a rotary kiln at a very high temperature of about 1150 °C. During the heating process, the gas is released inside the particles and captured during the cooling process, while the organic compound ceramic particles have a porous, lightweight and highly shatter resistant material. LECA particles can expand to 5-6 times the volume. Due to the circular motion of the kiln, the LECA has almost a potato shape or a circular shape. Inside the LECA particles, there are pores of different sizes, which are mostly interconnected. [2] The chemical composition of LECA consists mainly of SiO_2, Al_2O_3, Fe_2O_3, CaO and some alkalis such as Na_20 and k_2o. It can be noted that the content of Sio2 in the total composition fluctuated from 50% to 70%, Al_2O_3 fluctuated from 15% to 30%, Fe_2O_3 fluctuated from 1% to 15% and CaO fluctuated from 0.2% to 4%. LECA thermal conductivity in the range of 0.095 to 0.125 W/m K. [6] The Density of Concrete decreased as Lightweight Expanded Clay Aggregate content increased, when LECA is replaced by 10% to 100% in coarse aggregate, density of concrete decreases by 15% to 40%, in fine aggregate, density of concrete decreases by 25% to 35%, when replaced. Further reduction of 30% to 45% is observed when replaced by both fine and coarse aggregate. [12]

II. EXPERIMENTAL PROGRAM

In this study fresh properties of concrete is evaluated by slump test whereas the destructive tests are carried out to obtain the compressive strength by cube specimens, spilt tensile strength by cylinder specimens and flexure strength by beam specimens. Further the design mix is carried out for which all the ingredients are tested and narrated in the subsequent paragraphs.

A. MATERIAL

1. LIGHTWEIGHT EXPANDED CLAY AGGREGATE

Expanded clay aggregate is a lightweight aggregate made by heating clay to around 1200^0C having the density 600 kg/m^3 approximately, low thermal conductivity, high acoustic and fire resistant. The basic index and engineering properties are conducted and is listed in table 1.

Table 1 Physical Properties of LECA

No.	Physical properties	Value
1	Specific gravity	0.92
2	Water absorption	18 %
3	Impact Value	28.12 %
4	Crushing Value	24.43 %
5	Los Angeles Abrasion Value	21.34 %

Figure 1 LECA 2-8 mm size

Figure 2 LECA 8-15 mm Size

B. CONCRETE MIX DESIGN

In this study M25 concrete mix design is used, the concrete mix is done by using IS 10262:2009. And then the coarse aggregate is replaced with expanded clay aggregate by 0 – 100% in increments of 25%. Materials along with their content per metric cube volume are shown in Table – 2.

Table 2 Concrete Mix Design as Per IS 10262:2009

Mix Design	WC ratio	Water	Cement	Fly Ash	Fine Aggregate	Coarse Aggregate		Super plasticizer
						10 mm	20 mm	
M-25	0.40	132.06	297.14	33.02	730.49	505.84	758.77	3.3

C. RESULTS

1. SLUMP TEST

Slump test are carry out to check the fresh properties of concrete as per IS: 1199-1959 (Reaffirmed 2004).

Table 3 Slump Test Result

s.no.	type of concrete	Slump Value
A	conventional concrete	66
B	concrete with 25% LECA	64
C	concrete with 50% LECA	70
D	concrete with 75% LECA	72
E	concrete with 100% LECA	68

2. COMPRESSIVE STRENGTH TEST

Compressive Strength Test is conducted following the guidelines of IS:516 – 1959 (Reaffirmed 2004) using Compression Strength Testing Machine possessing the capacity of 2000 KN on Cubes of size 150 mm x 150 mm x 150 mm casted using appropriate mould size. The average of three specimen is considered to get appropriate results.

Table 4 Compressive Strength Test Result

s.no.	type of concrete	compressive strength N/mm2 (7 days)	weight of cube(at 7 days)	compressive strength N/mm2 (28days)	weight of cube(at 28 days)
A	conventional concrete	25.08	8.66	33.6	8.67
B	concrete with 25% LECA	24.19	7.96	32.25	7.95
C	concrete with 50% LECA	22.91	7.27	30.69	7.27
D	concrete with 75% LECA	21.7	6.92	29.07	6.93
E	concrete with 100% LECA	20.84	6.23	27.93	6.23

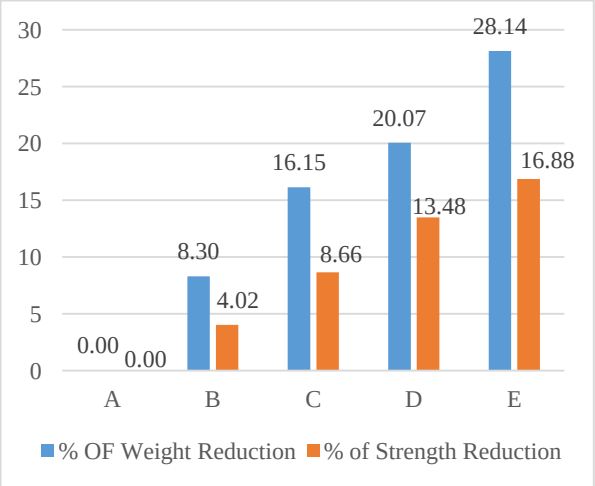

Figure 3 compressive test result at 7 days

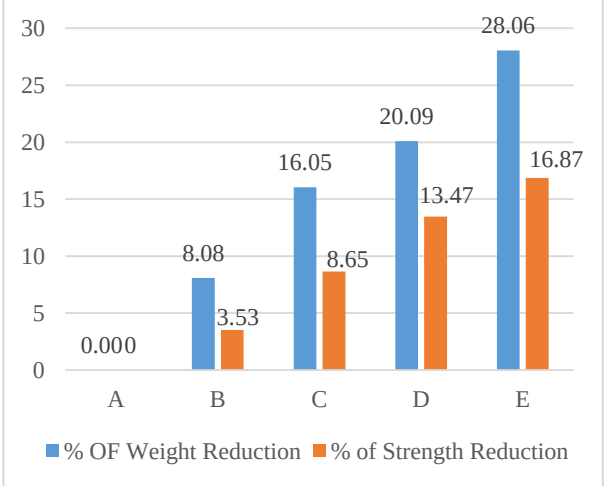

Figure 4 Compressive test result for 28 days

3. SPILT TENSILE STRENGTH TEST

Split Tensile Strength Test is conducted following the guidelines of IS:5816 – 1999 (Reaffirmed 2004) using Compression Strength Testing Machine possessing the capacity of 2000 KN on Cylinder of dia. 150 mm x Height 300 mm casted using appropriate mould size. The average of three specimen is considered to get appropriate results.

Table 5 Spilt Tensile Strength Test Result

s.no.	type of concrete	Spilt tensile strength N/mm2(7 days)	weight of cube(at 7 days)	Spilt tensile strength N/mm2(28days)	weight of cube(at 28 days)
A	conventional concrete	13.61	2.63	3.70	13.64
B	concrete with 25% LECA	12.38	2.48	3.49	12.39
C	concrete with 50% LECA	11.46	2.36	3.33	11.48
D	concrete with 75% LECA	10.8	2.19	3.08	10.82
E	concrete with 100% LECA	9.8	2.16	3.06	9.81

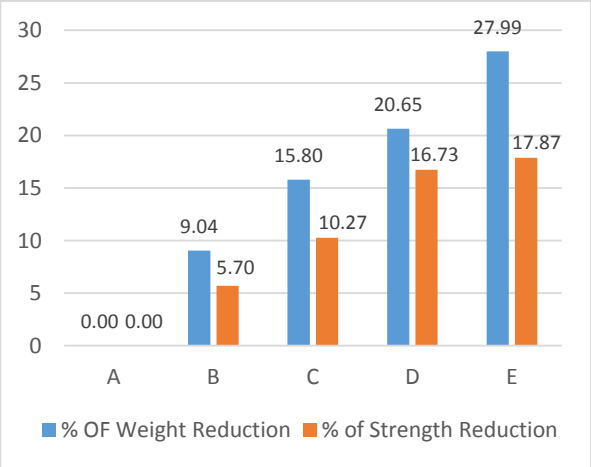

Figure 5 spilt tensile strength test result at 7 days

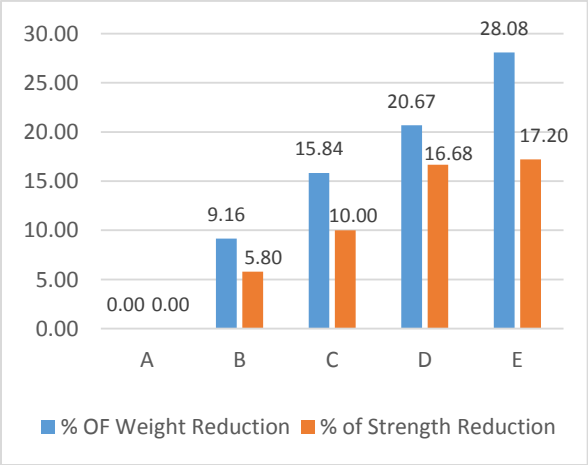

Figure 6 spilt tensile strength result at 28 days

4. FLEXURAL STRENGTH TEST

Flexural Strength Test is conducted following the guidelines of IS:516 – 1959 (Reaffirmed 2004) using universal testing machine possessing the capacity of 2000 KN on Beam of size 750 mm x 150 mm x 150 mm casted using appropriate mould size. The average of three specimen is considered to get appropriate results.

Table 6 Flexural Strength Test Result

s.no.	type of concrete	Flexural strength N/mm2(28days)	weight of beam(at 28 days)
A	conventional concrete	4.59	40.48
B	concrete with 25% LECA	4.48	37.17
C	concrete with 50% LECA	4.37	33.95
D	concrete with 75% LECA	4.23	32.31
E	concrete with 100% LECA	3.98	29.09

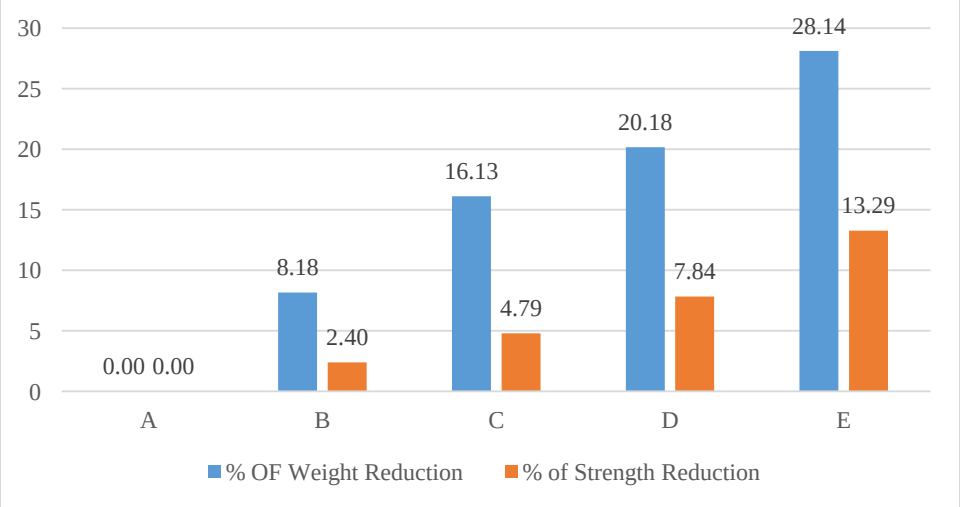

Figure 7 Flexural strength test result at 28 day

III. CONCLUSION

Following conclusions can be derived from the Experimental study.

- The compressive strength decrease as LECA content increased. Reduction of 16.87% in Compressive Strength, 17.20% in Split Tensile Strength and 13.29% in Flexural Strength is observed after 28 days of curing along with the reduction in weight of around 28% with 100% LECA replacement of coarse aggregate. However, with 25% LECA replacement, negligible loss of strength is observed (Refer Fig. 3 to 7)
- To modify mechanical properties of concrete containing LECA, materials like silica fume, fly ash, slag, steel fibre's, polypropylene fibres can be used to increase its strength.

IV. References

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