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Experimental Investigation on Mechanical Properties of Light Weight Concrete Using Leca

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Abstract: ***This study examined the structural behaviour of Lightweight concrete (LWAC) using lightweight aggregates (Light expanded clay aggregates LECA) and normal weight aggregates, aims to investigate on concrete mix M_{25} by the effect of partially and fully replacement of the coarse aggregate by Leca with various percentage such as 20%, 40%, 60%, 80% and 100% and fly ash percentage such as 15%, 20%, 25% used as partial replacement for cement in concrete. Analysis of this concrete was done in fresh state as well in hardened state to evaluate physical and mechanical properties of concrete. This paper concentrated on performance parameters such as compressive strength, splitting tensile strength of the light weight concrete using LECA. The Lightweight concrete density varies from 40% - 100% replacement of LECA such as 1996kg/m^3-1597kg/m^3. It reduces the weight of concrete and cost of concrete by reducing the aggregate cost and produces economical system. In strength performance of 15% replacement of fly ash content with 40% replacement of coarse aggregates concrete for better results to ensure its optimal proportions.***

Key words: Light Expanded Clay Aggregate (LECA), Fly ash, Light-weight concrete, Strength, Density

1. Introduction

Light-weight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities like lessened the dead weight. It's lighter than the conventional concrete [1]. The required properties of the light-weight concrete will have a bearing on the best type of light Expanded Clay Aggregate to use. The Structural light weight concrete as we call is a concrete whose density varies from 1400 to 2000 kg/m^3[2].The literatures have thrown a light on influence of palm oil clinker, coconut shell, ceramic waste, Light expanded clay aggregate concrete to reduce the density of structural concrete member[3]. It reduces the weight of concrete and cost of concrete by reducing the aggregate cost and produces economic infrastructure system [4]. Light-weight concrete cubes, cylinders are casted and tested for determining compressive strength, split tensile strength, and obtain the results are compared with the control specimens.

2. Objective

To study the mechanical properties of light weight concrete using LECA.

3. Literature Survey

Mahyar Arabani ,et-al [10]Light Expanded Clay Aggregate (LECA) was used as a part of fine aggregate for improving mechanical properties of porous asphalt. To conduct the experiment in this research, three different mixtures of stone material and LECA (0, 10 and 20 percent LECA) were used. The results of moisture susceptibility tests demonstrated that adding LECA to porous asphalt mixture can increase resistance against moisture damage in this mixture.

Serkan Suba[1][3]The effect of using fly ash in high strength lightweight aggregate concrete produced with expanded clay aggregate on physical and mechanical properties of the concrete was investigated and in order to determine the effect of use of fly ash in expanded clay aggregated concretes on bond strength, lightweight concrete mixtures of 350, 400, 450kg/m^3 cement content and of 0, 10, 20 and 30% fly ash replacement were prepared**.**

V.Khonsari, E.Eslami & Ah.Anvari,[4] The expanded perlite aggregate (EPA) has a wide range of uses, generally due to its properties of extremely low bulk density, high brightness, high absorption, low thermal and acoustical conductivity, and non-flammability and the test results indicated a linear relationship between the compressive strength and splitting-tensile strength for steel fibrous**. Sivakumar[1] and B.Kameshwari[2] [8],** Experimental investigation on concrete mix M20 is done by replacement of cement with fly ash, fine aggregate with bottom ash and coarse aggregate with Light Expanded Clay Aggregate (LECA) at the rate of 5%, 10%, 15%, 20%, 25%, 30% and 35% and The results shows that 5% replacement of cement with fly ash, fine aggregate with bottom ash and coarse aggregate with Light Expanded Clay Aggregate (LECA) was found to be good performance in compressive strength**. Sachin Paul[1] Ganesh Babu[2] [7],** This paper investigates the mechanical properties of light weight Geopolymer concrete produced by replacing normal coarse aggregate by Light weight expanded clay aggregates (LECA). Structural use was although limited to 60% replacement of coarse aggregate by LECA with a density of 1700kg/m3. On replacement of coarse aggregate by LECA by 40%, both split tensile strength and flexural strength decreased by about 35%, but still very much within structural limits**.**

Thomas Tamu et al [9], To study the properties such as compressive strength and tensile strengths of lightweight concrete. Expanded Polystyrene (EPS) beads are used as partial replacement to coarse aggregates with 5,10,15,20,25,30% Increase in the EPS beads content in concrete mixes reduces the compressive and tensile strength of concrete. It is used for non-structural applications, like wall panels, partition walls, etc**.**

4. Experimental Study

4.1 Materials

4.1.1 General

Concrete is an artificial stone like material having an excellent resistance to compression. It resembles the principal asset of natural stone and is usually cast in place in a plastic condition. The composition of concrete is determined by the properties of the constituent materials, which are binding material (e.g. cement), fine aggregate (e.g. sand), coarse aggregate (e.g. gravel), fly ash, water and super plasticizer to harden in forms of the shape and dimensions of the desired structure.

4.1.2 Cement

Cement is the binding material. In this study 43 grade of OPC confirming to the requirements of IS 8112-1989 has been used. The physical properties of cement: Specific gravity is 3.14, Specific surface area is 310 kg/m^2 and the Fineness modulus is 4%. Normal consistency of cement is 34%, initial and final setting time is 30 min and 60 min respectively.

4.1.3 Fly ash

Fly ash, also known as flue-ash, is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. In this study Low-Calcium Fly ash (ASTM Class F), obtained from Thermal Power Plant at Thoothukudi. The specific gravity of fly ash is 2.36 and fineness of fly ash is 4%.

4.1.4 Aggregates

Aggregates are the fine aggregate and coarse aggregate. The River sand as the fine aggregate and coarse aggregates from crushed rock, conforming to the requirements of IS 383-1970.

4.1.5 LECA Aggregates

LECA means **L**ight **E**xpanded **C**lay **A**ggregate. LECA consists of small, lightweight, bloated particles of burnt clay. The thousands of small, air-filled cavities give LECA its strength and thermal insulation properties. The base material is plastic clay which is extensively pretreated and then heated and expanded in a rotary kiln. Finally, the product is burned at about 1100°C to form the finished LECA product. In this study 4mm – 10mm sizes and 480 kg/m^{3}is used.

Figure 1: LECA

Table1: Properties of Fine Aggregate, Coarse Aggregate and Leca.

Property	*Fine Aggregate*	*Coarse Aggregate*	*Leca*
Specific gravity	2.65	2.68	0.44
Fineness modulus	2.83	7.04	5.99
Water absorption	1.5%	0.85%	10%
Bulk density(kg/m^3)	1481	1659	357
Impact value	-	29.41%	16.5%

4.1.6 Potable Water

Water is an important ingredient because it actively participates in the reaction with cement. It ensures workability. However, good quality concrete can be made with water that would pass normal standards for drinking water.

4.1.7 Super plasticizer

Super plasticizer based on conplast SP430(G) produced by fosroc with specific gravity 1.22 and dosage of super plasticizer 0.5% of cement weight used in leca concrete.

5. Mix Proportion

The mix design has been made for M_{25} grade conventional concrete and light weight concrete use of code IS 10262-1982, IS 456-2000 recommended. The water cement ratio (W/C) was kept constant at approximately 0.48 for all mixes, The percentage like 20%, 40%, 60%, 80 and 100% incorporation was used as partial and full replacement of natural coarse aggregate and the fly ash percentage like 15%, 20%, 25% used as partial replacement for cement concrete. Mix proportion obtained for M25 Grade of conventional concrete and light weight concrete mix ratio was 1:1.4:2.4 and 1:1.86:0.52.

5.1 Detailing of specimen

Table 2: Details of casting the cubes and cylinders

Mixtures		No.of cubes	No.of cylinders
Conventional Concrete		3	3
CC with % of Fly ash (FC)	15%	3	3
	20%	3	3
	25%	3	3
Leca (L1)	20%	3	3
	40%	3	3
	60%	3	3
	80%	3	3
	100%	3	3
Optimum proportion(L2)	40% Leca+15% fly ash	3	3
	60% Leca+15% fly ash	3	3

5.2 Casting of specimen

Fresh prepared mixes were casted for each group in three standard cube moulds, cylinder moulds Four groups of mixtures were produced**.** For each mixture, specimens were prepared in the cubical 150×150×150mm, cylindrical 150×300mm shapes. The mixing process was as follows: firstly, coarse, fine and lightweight aggregate (Leca) and 1/3 of the water were loaded into the mixer for 1 minute. Then the cement, remaining water, and super plasticizer were added. Finally, the constituents were mixed for 3 minutes.

The mixture was rested for 3 minutes then mixed again for a further 2 minutes. After that moulds were filled by concrete in the suitable mix. The top surface of the concrete was leveled with the help of trowel and was lefted for 24 hours allowed the concrete to set. The specimen were remolded after 24 hours.

Figure 2: Cube and cylinder specimens

5.3 Curing of Specimen

All the casted moulds were cured by putting in to the water for 28 days until the test. The specimens were brought out from water approximately 24 hours before testing and rest at room temperature till testing.

5.4 Testing of Specimen

After curing, the cube, cylinder specimens are tested under Compression Testing Machine.

Figure 3: Testing of cube and cylinder specimens

Table 3: Mix proportions by weight for various mixes

Mixes	CC	CC with % of Fly ash (FC)			LECA (L1)					Optimum proportion (L2)	
		15%	20%	25%	20%	40%	60%	80%	100%	F.A15% + Leca 40%	F.A15% +Leca 60%
Cement	440	374	352	330	440	440	440	440	440	374	374
Fly ash	0	66	88	110	0	0	0	0	0	66	66
Water	211	211	211	211	211	211	211	211	211	211	211
Fine Aggregates	614	614	614	614	614	614	614	614	614	614	614
Coarse Aggregates	1067	1067	1067	1067	853.6	646.2	426.8	213.4	0	646.2	426.8
Leca	0	0	0	0	42.6	85.2	127.8	170.4	213	85.2	127.8
Super plasticizer	4.4	4.4	4.4	4.4	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Unit weight	2336	2336	2336	2336	2163	1998	1821	1651	1480	1998	1821

Note: CC-Conventional Concrete, F.A- Fly Ash, LECA-Light Expanded Clay Aggregate, FC-Fly ash Concret

6. Result and Discussion

6.1 Workability

Workability means easy to work. The workability of the concrete was measured using the slump test.

6.2 Compressive strength

Compressive strength results of 28.56N/mm^2, 26.40N/mm^2 and strength reduction of 17.36% and 23.69% where for LECA40 & LECA60 respectively these replacement percentage due to made up light weight concrete with densities varying from 1400- 2000kg/m3. This mix can also be used for structural purposes.

6.3 split tensile strength

Split tensile strength results of 2.53N/mm^2, 2.28N/mm^2. A replacement of 40% and 60% of LECA resulted in a decrease of split tensile strength by 20.93% and 28.75%.

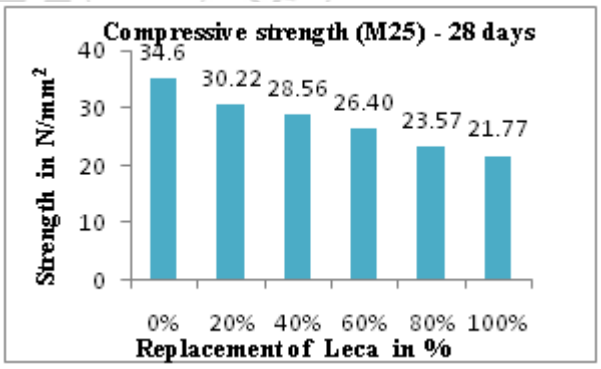

Figure 4: Compressive strength comparison of L1 & L3

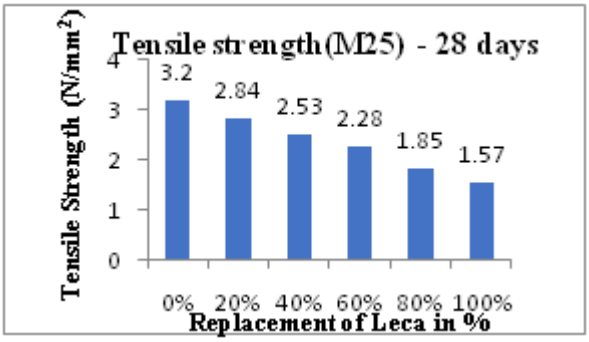

Figure 5: Split tensile strength comparison of L1 & L3

7. Conclusion

Based on the experimental results of this study the following conclusion can be drawn.

- The density of concrete is found to decrease with the increase in percentage replacement of normal aggregate by Light Expanded Clay Aggregate.
- Compressive Strength and split tensile strength of concrete is found to decrease from 34.60 to 21.77 MPa and 3.20 to 1.5 MPa respectively with increase
- in Leca content from 0% to 100%
- The Leca concretes when replaced with 40% and 60% of coarse aggregates shown better results, when compared to conventional concrete.
- The experimental work carried out to optimize the fly ash content in cement and from the results obtained, I recommended the replacement of cement by 15% fly ash gives better results.
- The usage of fly ash and Leca,15%and 40% shows better compressive strength, tensile strength, results with other mix proportion and hence it can be proposed for structural purposes.

Table 4: Compressive strengths, Tensile strengths of M25 Grade of various Mixture of Concrete.

Mixtures		Cube weight (kg)	Density (kg/m^3)	Compressive strength (N/mm^2)	Split tensile strength (N/mm^2)
Leca 0% (L1)		8.36	2477	34.6	3.20
Leca0%+Fly ash (L2)	15%	8.54	2530	33.18	2.95
	20%	8.42	2494	30.83	2.57
	25%	8.37	2480	28.15	2.26
Leca (L3)	20%	7.40	2194	30.22	2.84
	40%	6.73	1996	28.56	2.53
	60%	6.30	1868	26.40	2.28
	80%	5.87	1739	23.57	1.85
	100%	5.39	1597	21.77	1.57
Optimum proportion of Leca and F.A 15% (L4)	40%	6.84	2026	29.33	2.62
	60%	6.43	1906	27.55	2.40

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