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Experimental Analysis on LECA as Fractional Substitution for Sand in Mortaring and Concreting

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Abstract: This research work deals with partial usage of LECA (Lightweight Expanded Clay Aggregate) as partial replacement for fine aggregate in mortaring, plastering and concreting. The experimental work had been gone through by replacing the fine aggregate by 25%, 50%, 75% and 100%. M20 grade of mortar and concrete is used in this project, the consistency of water-cement ratio initiated at 0.4 and increased up to 0.5. When the percentage of LECA increased the w/c ratio also get increased. Material study like specific gravity, water absorption and grading of LECA was initially done. strength characters of mortar cube and concrete had been done for 7,14 and 28 days. A comparison study of conventional specimens and LECA was done in this project. Comparatively replacing LECA in 100% obtaining the optimum strength in concreting and in mortar cube 25% replacement of LECA obtain the maximum result. The compressive strength of brick masonry structure had been studied for 9"x9" wall by replacing the fine aggregate by using LECA.
Keywords: sand, replacing, LECA, mortar, concrete, brick wall, compressive strength

I. INTRODUCTION

Sand is the main constituent of construction world. Without sand, the mortar or concrete will not function as intended. Sand is used for filling the voids it supports to pay uniform strength to concrete and in plastering it offering by cover the surface in peaceful manner. By taking fine aggregates from the riverbed will spoil the eco system of water, so the replacement of fine aggregate is an important issue in this era. Many of the government agencies and private sector were insisting to use M-Sand, some of the drawback were seen in M-Sand like water absorption, grading, angular and workability. So it is needed to find the alternative solution for fine aggregate. Here we planned to replace the fine aggregate by using LECA.(Light expanded clay aggregate). LECA is a material made of clay burnt in kiln under 1200^0C used as coarse aggregate in light weight concrete, which is easily available in the market and less expensive.

Whether doing large-scale or small-scale construction projects, in order to make the building process cost-efficient and run more smoothly, building materials need to be easy to handle, easy to transport and flexible to work. LECA satisfies the above requirements and also Durable, Recyclable, Environment friendly and Resistant to fire.

This project aims to use crushed LECA as fine aggregate by partial replacement for sand in various proportions like 0%, 25%, 50%, 75% and 100% for M20 grade of mortar and concrete.

II. LITERATURE REVIEW

M. Mahdy was concluded that concrete to be considered is light weight concrete (using leca as coarse aggregate) that is concrete with a density in the range 1.65-1.85 t/m^3 .in order to obtain high strength concrete, LECA was treated by solution of silica fume of different concentration (10% and 20 %) by weight of mixing water .three levels if silica fume (5, 10, 15%) and two ratios of course of total aggregate content (0.48, 0.65 by volume) were used. For this concrete, information on mechanical properties was provided. Silica flume content seems to lead to high early age strength in 7 days with relatively smaller increase in strength at 28 days .the economic silica fume content for LWC is 10 % .At 0.48 coarse aggregate ratio, the compressive strength and flexural strength were higher than for 0.65 coarse aggregate ratio.

A research by Gurpreet singh and Rafat Siddique on effect of waste foundry sand as partial replacement of sand states that, Waste foundry sand(wfs) is the major byproducts of metal casting industry and successfully used as a land filling materials as many years. This experimental investigation natural sand was partial replaced with (0%, 5%, 10%, 15%, and 20%) of wfs by weight.

A examine from malkit singh and Rafat Siddique on Effect of coal bottom ash as partial replacement of sand on properties of concrete conclude that Coal bottom ash is formed in coal furnaces, it also used for as structural fill. Effects of coal bottom ash on properties of fresh concrete, mechanical and durability properties.

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This paper focuses on some issues pertaining to brick mortar bond and masonry under compression strength by G. Saragapani, B.V. Venkatarama Reddy and K.S. Jagadish. In this investigation, the influence of bond strength has been examined through an experimental program using local bricks and mortars. The result clearly indicates that an increase in bond strength, while keeping the mortar strength constant, leads to an increase in the compressive strength of masonry.

III. METHODOLOGY

After completion of the literature study material study had done for the Fine aggregate, LECA, Coarse aggregate and bricks. From the literature study, it was concluded that replacing of fine aggregate by using LECA was done by 25%, 50% 75% & 100%. The bond strength of the brick and the mortar was needed to observed. Strengthen properties of mortar and concrete cube was done for 7, 14 and 28 days. In each combination three samples had tested. The brick pier of 9"x9" was casted to find the compressive strength three samples were casted in each combination and it awas tested after 15 days.

A. *Materials Used*

1) *Cement:* The Ordinary Portland Cement of 53 Grade conforming to IS 12269 – 1987 was used in this study. The specific gravity, initial and final setting of OPC 53 grade were 3.06, 32 and 290 minutes respectively.
2) *Fine Aggregate:* Locally available river sand conforming to grading zone II of IS 383 -1970 with the specific gravity of 2.62 was shown in Fig.1.
3) *Coarse Aggregate:* Blue metal was collected from the nearby crusher unit. Crushed granite stones of size passing through 20mm sieve and retained on 4.75 mm sieve as per IS: 383-1970 was used for experimental purpose was shown in Fig.2.
4) *LECA:* Most lightweight aggregate is produced from materials such as clay, shale, or slate. In this investigation clay based light weight aggregate of size 2 to 4 mm is used and it is shown in Fig.3. The specifications of aggregate were tabulate in Table 1.
5) *Bricks:* First class brick having compressive strength of 16 N/mm^2 is used in this work.


Fig.1 – Fine Aggregate


Fig.2 – Coarse Aggregate

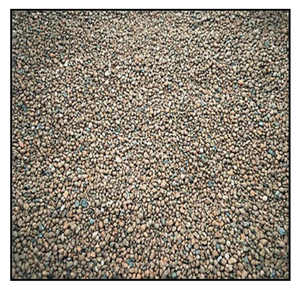
Fig.3 - LECA (2 – 4 mm)

Table 1 – Physical Properties of LECA

Water of plasticity	53.4
Dry MOR	15.6
Shrinkage %	2.67
Forming pressure (kg/cm ^{2})	200
Temperature °c	1116°c

B. *Mix Design*

Concrete mix design in the investigation was designed as per the guidelines specified in IS 10262 – 1982 "Indian standard concrete mix proportion guidelines" and it was shown in table 2.

Table 2 – Mix Design

Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)
1	1.45	3.15
1.44	2.09	4.55

C. Concrete Mix Proportion

The grade of concrete used for the study is M20. Four different proportion of concrete was used to make specimens for test. The proportions were listed in Table 3 for both the mortar cube and concrete.

Table 3 – Mix Proportion

Specimen	Cement (kg)	Partial Replacement (%)	Total fine aggregates	Sand	LECA	w/c ratio
Mortar Cube	0.2	25%	0.6	0.4	0.2	0.3
	0.2	50%	0.6	0.3	0.3	0.4
	0.2	75%	0.6	0.2	0.4	0.45
	0.2	100%	0.6	-	0.6	0.5
Concrete Cube	1.44	25%	2.09	1.57	0.52	0.3
	1.44	50%	2.09	1.45	1.45	0.4
	1.44	75%	2.09	0.52	1.57	0.45
	1.44	100%	2.09	-	2.09	0.5

D. Plastering Quantity

Dimension of Brick Wall: 1’5” x 2’5” x 4” = 425 x 725 x 10 mm = 0.0031 m^3
Plastering thickness = 12 mm
Volume of plastering = 0.425 x0.725 x 0.012 = 0.0037 m^3
Wet volume = 1.15 x 0.0037 = 0.0055 m^3
Mix ratio: (1: 5)
Cement required = 0.0055/6x1x1440 =1.32 kg
Fine aggregate required = 0.0055/6x5x1500 = 6.9 kg = 7 kg

IV. RESULT

Specific gravity of fine aggregate and LECA had formed 1.84 and 3.18 respectively; likewise the water absorption of LECA was quite less than fine aggregate as 1.47%. Fine aggregate belongs to zone – II and the coarse aggregate satisfy the limits of IS 383 – 1970 and water absorption of the coarse aggregate is 12%.

For mortar cube test of 70.6mmx70.6mmx70.6mm mould are used .these specimen are tested by compression testing machine after 7, 14 and 28 days curing the result was shown in table 4 & Fig.4.

Table 4 – Compressive Strength of Mortar Cube

Days	Specimen	25 %	50 %	75 %	100 %
7 days	Trial 1	13.04	11.04	11.04	9.03
	Trial 2	15.04	13.04	11.04	10.04
	Trial 3	14.04	12.04	10.04	8.03
14 days	Trial 1	21.06	17.04	12.04	10.04
	Trial 2	19.05	19.05	14.04	12.04
	Trial 3	19.05	18.04	14.04	11.04
28 days	Trial 1	22.06	19.05	16.04	13.04
	Trial 2	21.07	18.04	19.05	14.04
	Trial 3	24.07	21.06	18.04	16.04

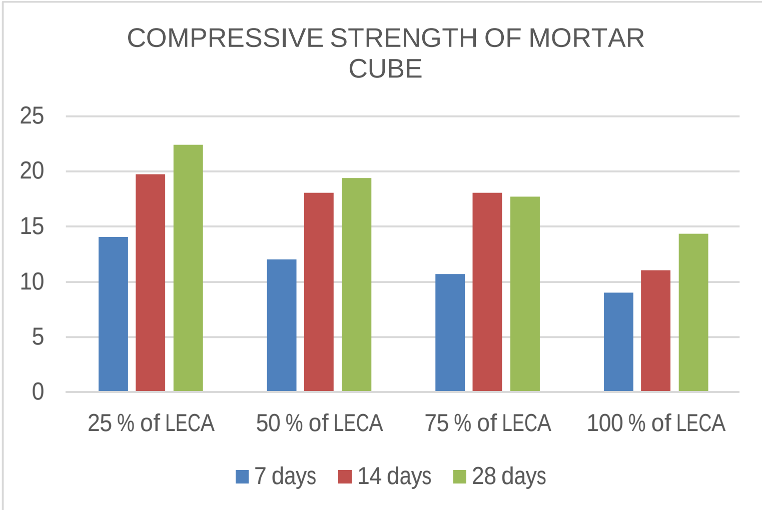

Fig. 4 – Compressive Strength of mortar cube

For mortar cube test of 150mmx150mmx150mm mould are used .these specimen are tested by compression testing machine after 7, 14 and 28 days curing the result was shown in table 5 & Fig. 5.

Table – 5 Compressive strength of Concrete Cube

Days	Specimen	25 %	50 %	75 %	100 %
7 days	Trial 1	14.66	16.00	17.44	19.11
	Trial 2	13.77	16.22	17.55	18.88
	Trial 3	14.22	17.55	18.88	18.22
14 days	Trial 1	22.40	23.77	26.88	28.88
	Trial 2	22.00	24.88	28.00	27.77
	Trial 3	21.77	24.00	27.33	28.44
28 days	Trial 1	24.44	25.78	31.10	32.00
	Trial 2	24.88	28.00	31.10	31.55
	Trial 3	24.22	26.66	30.22	32.00

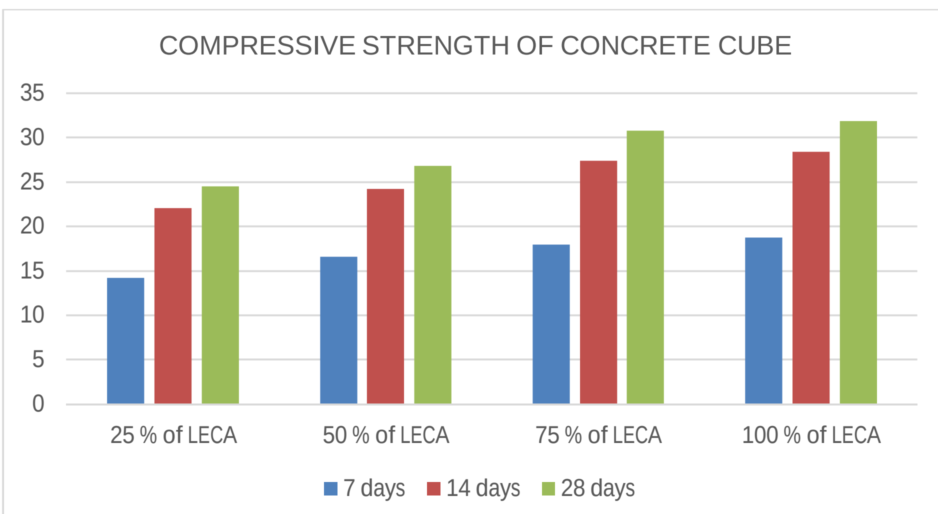

Fig. 5 – Compressive Strength of concrete cube

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A. Compressive Strength of Brick Masonry Wall

For the Wall dimension 1'2" x 9" x 9" As per IS 1905 – 1987 Code of practice for structural use of unreinforced masonry was induce to compressive strength table in 6 & Fig. 6 & 7 and permissible strength also examined.

$$F_c = f_b \times K_s \times K_a \times K_p \times K_l$$

Where,

f_b= Basic comp.stress (IS 1905-1987, Pg No 15, table 8, table1)

k_s = Stress reduction factor (IS 1905-1987, Pg No 16 ,table 9)

k_a = Area reduction factor (IS 1905-1987, Pg No 16 , clause 5.4.1.2)

k_p = Shape modification factor (IS 1905-1987, Pg No 16, clause 5.4.1.3 ,table10)

k_l = Load factor (IS 1905-1987, Pg No 16 ,clause 5.4.1.4)

$$F_c = 1.03 \times 1 \times 0.78 \times 1 \times 1 = 0.803 \text{ N/mm}^2$$

Table 6 - Compressive Strength for brick masonry wall

Brick wall	LECA percentage	Wall dimension	Compressive strength (N/mm^2)	Permissible Compressive strength (N/mm^2)
1.	25 %	1'2" x 9" x9"	1.22	0.80 (N/mm^2)
2.	50 %		1.55	
3.	75 %		1.89	
4.	100%		3.21	

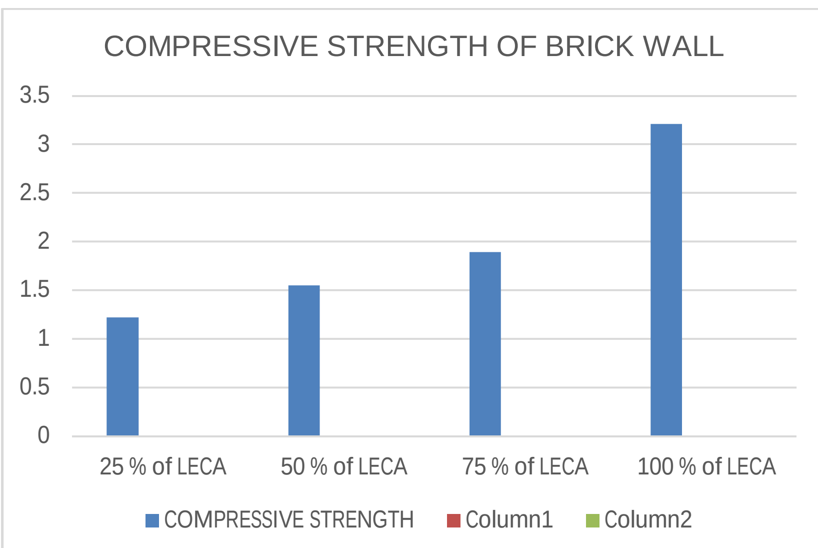

Fig. 6 & 7 – Compressive strength of Brick pier

V. CONCLUSION

A. The specific gravity of LECA was comparatively lesser than the sand; the water absorption by LECA was lower in percentage.

B. When replacement of LECA get improves water absorption in mortar is also get improves, so the w/c ratio gets varied from 0.4 to 0.5.

C. The mortar cubes are kept in oven drying at 60 0 C for 24 hours and kept for ambient curing to 7, 14 & 28 days.

D. The compressive strength of LECA added mortar cube of is comparatively lower than conventional mix in all proportions.

E. The compressive strength of LECA added concrete cube gives optimum results comparing with the conventional mix.

F. The mortar brick pier, 75% replacement of LECA attained permissible compressive strength comparing with the grade of mortar used.

G. Using LECA seems to be difficult for plastering, because of moisture it was converted as clay substance, but in observing there is no shrinks were formed in external surface and optimum strength was observed in LECA activated mortar.

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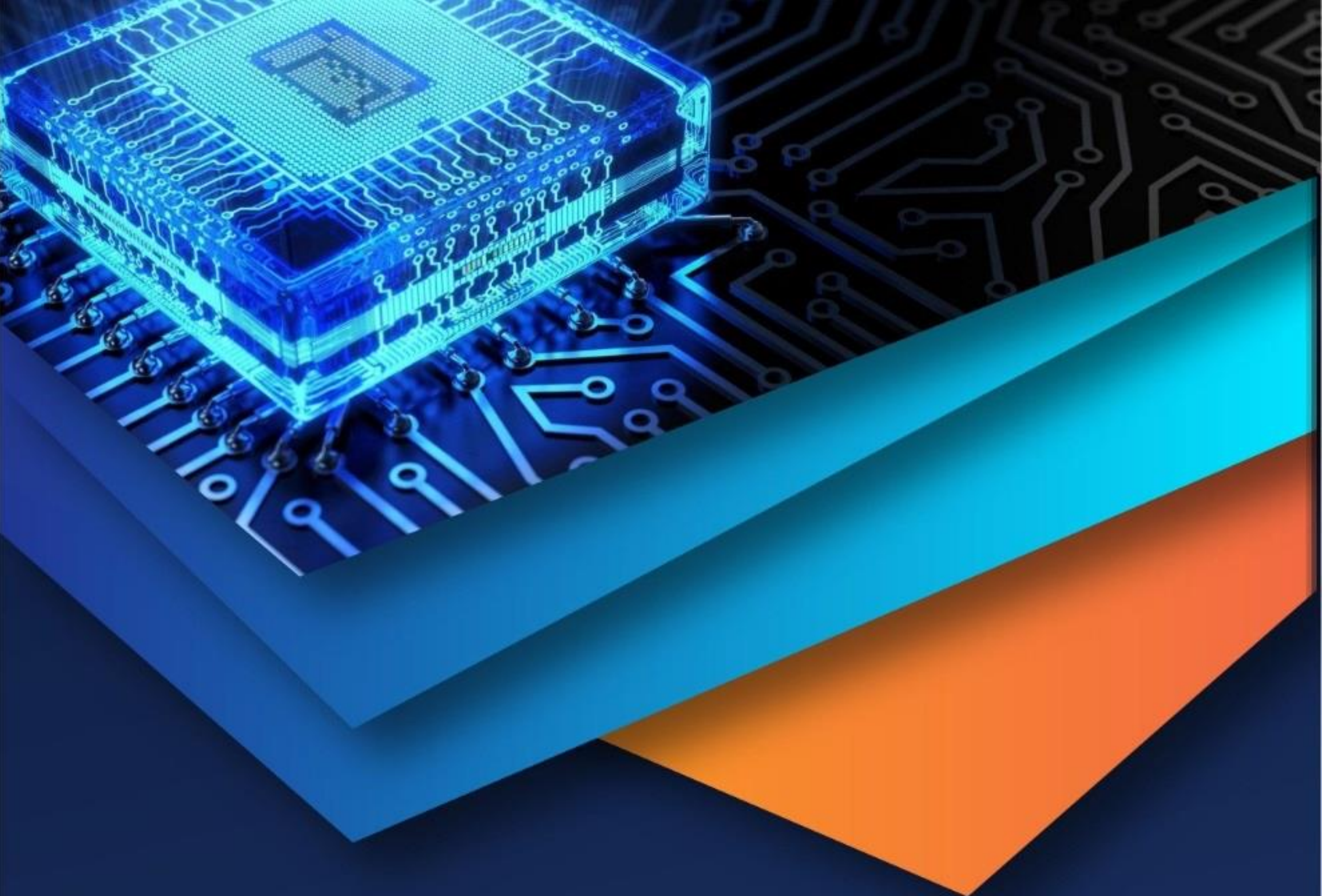

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