Experimental Investigation on Partial Replacement of Coarse Aggregate with Lightweight Expanded Clay Aggregate (LECA)

R.Ayswarya[1], P.Iswarya[2], M.Priyanka[3], K. SathyaPriya[4]
[1]*UG student Department of Civil Engineering, Sri Venkateswara College of Engineering,*
[2]*UG student Department of Civil Engineering, Sri Venkateswara College of Engineering,*
[3]*UG student Department of Civil Engineering, Sri Venkateswara College of Engineering,*
[4]*Assistant Professor, Department of Civil Engineering, Sri Venkateswara College of Engineering*

Abstract - Invention of smart material and promising technologies were the need of construction industry since the overall economic development of the country relies in the developing infrastructure. With the increased exploitation and quarrying the availability of blue metal will face its shortcoming soon. The objective of this paper is to find out replacement such that its purpose serves efficient. Lightweight Expanded Clay Aggregate (LECA) is aceramic material produced by expanding and vitrifying clay in a rotary kiln at 1200°C. LECA is lightweight, porous material which aids in reduced density, internal curing, acoustic and thermal insulation. The performance of LECA in concrete is evaluated by analyzing the compressive strength, mechanical property of concrete. M40 grade concrete was considered as a reference mix and comprehensive experimental study was carried out on a series of concrete mixes in which ratios of 20%, 40%, 60% and 80% of conventional coarse aggregate were replaced with LECA. The 3rd and 7th day compressive strength test results have found that 20% is the optimum replacement which showed 80% achievement of target strength of reference mix.

Keywords: Lightweight aggregates, LECA, compressive strength

I. INTRODUCTION

Concrete is the most widely and oldest construction material in the world. It is obtained by mixing cementing materials, water and aggregates, and sometimes admixtures, in required proportions. The mixture when allowed to cure hardens and forms concrete.The strength, durability and other characteristics of concrete depends upon the properties of ingredients, mix ratio, compaction methods and other factors such as placing, compaction and curing. It has high compressive strength, minimal corrosive and weathering effects resulting in excessive use in construction industry. However its high density makes the weight of construction greater than the live load carried and poor insulation characteristics. Intense research in the area of materials for structural application has found various aggregate that are suitable for concrete production. This includes pumice, diatomite, scoria, volcanic, rice husk and saw dust which are natural while Artificial aggregates include artificial cinders, lightweight expanded clay aggregate, foamed slag and thermocol beads. Lightweight Expanded Clay Aggregate (LECA) is a ceramic material produced by expanding and vitrifying clay in a rotary kiln at 1200°C. With this addition, the concrete becomes lightweight, self-curable, acoustic and thermal resistant. Depending on the source and the method of production, lightweight aggregates exhibit considerable differences in particle shape and texture. Shapes vary from cubical to angular, while the textures may range from fine pore to large exposed pores. The porosity of the aggregate is responsible for retention of water which will aid internal curing. This aggregate renders increased workability. Lightweight aggregate concretes are naturally utilized in structures in which major part of the total load is caused by the dead weight of concrete thereby reducing the dimensions of footing beneath subsoil and eliminates the need for expensive foundations.

II. LITERATURE REVIEW

Cvk chaitanya, Priya Prasad, D. Neeraja, A. Ravitheja (2019) in this study comparison of self-curing concrete properties are carried out with LECA as self-curing agent. LECA 0%, 10%, 15%, 20% by volume for M30 grade concrete was considered and strength property was determined. The mechanical properties are determined periodically up to 28 days of curing.Concrete with LECA gives the best results under all curing regimes, significant water retention and good mechanical properties.

Alaa M.Rashad (2018) an overview on lightweight expanded clay aggregate as a building material. In this article, LECA as a part ofbuilding material in traditional cementitious materials and various materials which added to

modify some properties of LECA have been reported. The main findings are increased workability, decreased density, decreased chloride penetration but increased water absorption, fire resistance and thermal insulation.

Miguel C.S. Nepomuceno, L.A. Pereira-de-Oliveira, Sandrine F.Pereira (2018) This paper reports an experimental study on parameters for mix design of structural lightweight self-compacting concrete (LWSCC) incorporating coarse lightweight expanded clay aggregates. The 28-days compressive strength depends on the water cement ratio and volume of lightweight coarse aggregates.

T.Sonia , R.Subashini (2016) This study examined the structural behaviour of lightweight concrete on mix M_{25} by replacement of coarse aggregate by LECA with various percentage such as 20%,40%,60%,80% and 100% and fly ash such as 15% , 20% , 25% for cement in concrete. Analysis was done in fresh state as well as hardened state. This paper concentrated on compressive strength and splitting tensile strength. In strength performance of 15% replacement of fly ash and 40% of LECA for better results.

M.Mahdy (2016) In order to obtain high strength concrete, LECA was treated by solution of silica fume of different concentration. Three levels of silica fume and two ratios of course to total aggregate content were used.The results indicated that silica fume content lead to high early age strength in 7days with relatively smaller increase in strength at 28 days. The economic silica fume content is 10%. At 0.48 coarse aggregate ratio, the compressive strength and flexural strength were higher than for 0.65 ratio.

III. MATERIALS

3.1 General

Concrete is a composite material composed of cement, coarse and fine aggregates mixed with water which hardens with time.The character of concrete is determined by water cement ratio.

3.2 Cement

In this work, CHETTINADU cement of OPC 53 grade was used for all concrete mixes. The cement was of uniform colour i.e., grey with a light greenish shade and was free from any hard lumps. The consistency of cement paste initial and final setting time, specific gravity was found. Testing of cement was done as per IS: 4031 (Part 4) – 1988, IS: 4031 (Part 5) – 1988, IS: 4031 (Part 11) – 1988 and the results were verified with specification mentioned in IS 12269: 2013. The tests results conducted on the cement are reported in Table 1.

S.No.	Properties	Values
1	Specific gravity	3.15
2	Normal consistency	30.5%
3	Initial setting time	130mins
4	Final setting time	240mins

Table 1: Physical properties of cement

3.3 Coarse aggregate

Locally available coarse aggregates having the maximum size of 12.5 mm were used in the present work. The gradation, specific gravity, water absorption, density were found. Testing on coarse aggregates was done as per IS : 2386 (Part I) – 1963, IS : 2386 (Part III) - 1963 IS : 2386 (Part III) - 1963 and the results obtained were referred with IS 383 : 2016.The test results conducted on coarse aggregate are reported in Tables 2.

S.No.	Properties	Values
1	Specific gravity	2.76
2	Water absorption	0.67%
3	Bulk density	1642.67kg/m^3

Table 2: Physical properties of coarse aggregate

3.4 Fine aggregate

The sand used for the experimental program was MSAND that is locally procured. The gradation, specific gravity, water absorption, density was found. Testing on fine aggregates was done as per IS: 2386 (Part I) – 1963, IS: 2386

(Part III) - 1963 IS : 2386 (Part III) - 1963 and the results obtained were referred with IS 383 : 2016.The test results conducted on fine aggregate are reported in Tables 3.

S.No.	Properties	Values
1	Specific gravity	2.53
2	Water absorption	3.5%
3	Bulk density	1830kg/m^3

Table 3: Physical properties of fine aggregate

3.5 LECA

LECA obtained from Chennai is used in the present work. The specific gravity, water absorption, density of LECA was found in similar procedure carried for conventional coarse aggregate and the results were reported in Table3. Image of the LECA is shown in Figure. 1.

Figure 1. LECA

S.No.	Properties	Values
1	Specific gravity	2.10
2	Water absorption	10.5%
3	Bulk density	318kg/m^3

Table 4: Physical properties of LECA

3.6 Admixture

MasterGlenium SKY 8233, an admixture based on modified polycarboxylic ether is used. The dosage of admixture 0.2-0.4% of cement weight is used in concrete. The main purpose of the addition of admixture is to eliminate the segregation of fresh concrete. The specific gravity of admixture is 1.06

IV. METHODOLOGY

4.1 Mix design

With the material testing results the design mix is prepared for M40 grade of concrete by maintaining the maximum water cement ratio and minimum cement content as specified in IS 456: 2000. The relative proportion of various ingredients of concrete were designed by following IS 10262: 2019. M1 denotes the reference mix whereas M2, M3, M4 and M5 denote the experimental mix.

Figure2. Concrete mixer

Mix	Cement (Kg)	Coarse Aggregate (Kg)	Fine Aggregate (Kg)	Leca (Kg)	Water (Kg)
M1 0% leca	420	973.24	912.27	0	190
M2 20% leca	420	778.59	912.27	133.44	205
M3 40% leca	420	583.94	912.27	266.89	220
M4 60% leca	420	389.29	912.27	400.33	235
M5 80% leca	420	194.65	912.27	533.78	250

Table 5 Mix proportion of M40 for $1m^3$

4.2 Specimen casting and testing

The materials were loaded in the mixer and mixed for few minutes. Freshly prepared mixes were casted for each mix in standard molds. All the casted moulds were cured in the curing tank. The cured concrete blocks were tested for compressive strength as per IS : 516 – 1959.

Figure 3. Casting of concrete

4.3 Compressive strength

The testing is carried out on 150x150x150mm cube specimens. The result is noted down for 3rd and 7th day.

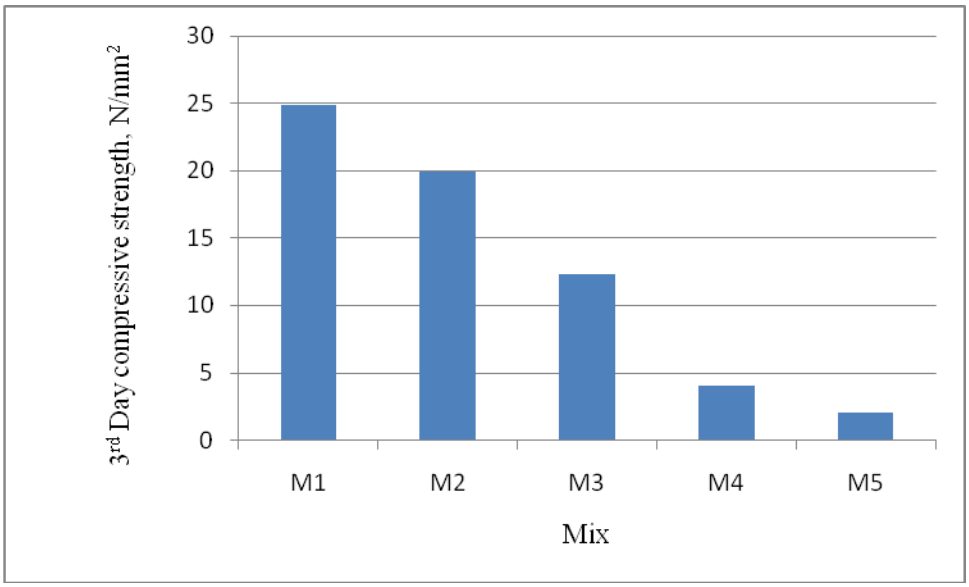

Chart 1 - Compressive strength test results -3rd day

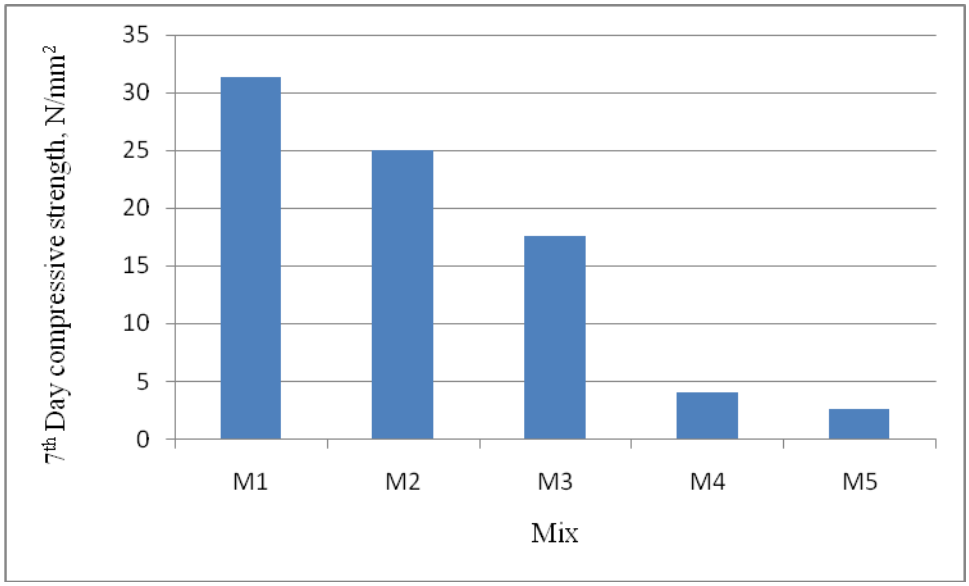

Chart 2 - Compressive strength test results – 7th day

V. RESULTS AND DISCUSSION

With reference to the chart 1 & chart 2, following discussions are made:

- For LECA, with increase in percentage of LECA there is decrease in compressive strength of the concrete.
- The maximum compressive strength was obtained 25N/mm^{2}at 20% of LECA which is 80% of conventional concrete.
- This design mix can also be used for structural purposes.

VI. CONCLUSION

1. The water absorption of LECA is 10.5%.
2. The maximum compressive strength is obtained 25N/mm^2 at 20% of LECA.
3. While using LECA, mix has to be designed for one grade greater than the required grade of concrete.
4. Addition of LECA decreases the density of concrete and also aids in internal curing.
5. The use of LECA in the concrete produced more workability without segregation.
6. The overall performance of the concrete can be increased by the addition of silica fume, granulated blast furnace slag and steel fiber.

REFERENCES

[1] C. chaitanya , P. Prasad , D. Neeraja et al.,Effect of LECA on mechanical properties of self-curingconcrete Materials today, https://doing.org/10.1016/j.matpr.2019.07.640

[2] A.M. Rashad, Lightweight expanded clay aggregate as a building material / Construction and building materials 170 (2018) 757-775, https:doing.org/10.1016/j.conbuildmat.2018.03.009

[3] M.C.S.Nepomuceno et al.,Mix design of structural lightweight self-compacting concrete incorporating coarse lightweight expanded clay aggregates/Construction and Building Materials166 (2018)373-385,https://doing.org/10.1016/j.conbuildmat.2018.01.161

[4] 4.T.Sonia , R.Subashini, Experimental Investigation on Mechanical Properties of Light Weight Concrete Using Leca , IJSR,ISSN:2319-7064

[5] M.Mahdy, Structural Lightweight Concrete Using Cured LECA,ISSN: 2277-3754, IJEIT 2016

[6] H. Costa et al., Influence of lightweight aggregates concrete on the bond strength of concrete -to- concrete interfaces / Construction and Building Materials 180 (2018) 519-530

[7] K.H.Mo et al., Bond properties of lightweight concrete / Construction and Building Materials 112 (2016) 478-496 , http://dx.doi.org/10.1016/j.conbuildmat.2016.02.125

[8] P. Shafigh et al.,A comparison study of the fresh and hardened properties of normal weight and lightweight aggregate concretes/ Construction and Building Materials 15 (2018) 252-260 ,

[9] https://doing.org/10.1016/j.jobe.2017.11.02