Review on Lightweight Concrete Using LECA

Mithra M[1], Dr. I. Padmanaban[2]

[1]PG Student, Department of Civil Engineering, Sri Krishna College of Technology, Tamil Nadu, India
[2]Professor and Head, Department of Civil Engineering, Sri Krishna College of Technology, Tamil Nadu, India

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Abstract - *Light Expanded Clay Aggregate is one of the artificial lightweight aggregates which has wide range of application. Clay is used for manufacturing of lightweight aggregates. The use of waste clay generated by major infrastructure development projects for manufacturing the lightweight aggregates has a positive impact on the environment. This paper reviews the manufacturing process of expanded clay aggregate and the influence of processing conditions on its physical and mechanical properties. It also reviews secondary materials that can be incorporated into concrete containing expanded clay aggregates to enhance its properties. The variation in fresh, hardened and durability properties of concrete with variation in the proportion of expanded clay aggregate is also discussed. The utilization of expanded clay aggregates in concrete increases workability, fire resistance, sound and thermal insulation. On the contrary, its incorporation reduces density, strength, elastic modulus and resistance to freeze thaw action of concrete.*

***Key Words*: Lightweight concrete, LECA, lightweight aggregate concrete, sand lightweight concrete, structural lightweight concrete.**

1. INTRODUCTION

Concrete is the oldest widely used construction material in the world. The properties of concrete depends mainly upon the properties of ingredients. It has high compressive strength, lesser corrosive and weathering effects. But, its high density increases the weight of structure, thereby affecting the construction cost. This drawback of concrete can be reduced by incorporating lightweight aggregates into concrete instead of conventional coarse aggregates. Light Expanded Clay Aggregate (LECA) is one such lightweight aggregate manufactured artificially heating clay in a rotary kiln at 1200°C. LECA is round in nature and contains continuous pores in it. LECA can be used in the production of lightweight blocks, concrete, partition panels, heat insulation tiles, thermal roofing plaster and also as aggregates in concrete. Structural lightweight concrete can be defined as concrete whose density is less than 1850 kg/m^3 and possess a minimum compressive strength of 17 MPa. The use of LECA in concrete has many positive impacts and few negative impacts which may be reduced by using certain secondary materials.

This objective of this paper is to review the properties of LECA, its processing conditions and its influence on the properties of concrete. In addition, the review provides insight on the secondary materials that can be incorporated into concrete for enhancing the properties of expanded clay aggregate concrete.

2. REVIEW OF LITERATURES

Ming Kun Yew, Ming Chian Yew, Jing Han Beh (2020) experimented on the partial replacement of coarse aggregates with light expanded clay aggregates. Five mixes were made with replacement percentages as 50%, 60%, 70%, 80% and 90%. The fresh and hardened properties of concrete was studied. As the percentage of replacement increased, the density of concrete decreased but the workability of concrete increased. Compressive strength, split tensile strength and flexural strength was decreasing with increasing proportion of light expanded clay aggregates. It was concluded that, 70% replacement of conventional aggregates with expanded clay aggregates provided optimum results.

D.Srinivasarao, T.Nagalakshmi, E.Anjireddy, R.Dinesh, B.Saiganesh, M. Suresh Kumar Reddy (2019) studied the variation in properties of lightweight concrete in which the cement was replaced by 40%, 50% and 60% of fly ash. The addition of flyash increased the mechanical properties (compressive strength, flexural strength) with age.

Bamdad Ayati, Veronica Ferrándiz-Mas, Darryl Newport, Christopher Cheeseman (2018) reviewed the properties of clay from which the lightweight aggregates were made. An ideal clay lightweight aggregate for use in concrete must be roughly spherical, 4–14 mm in diameter, strong and porous. The porous structure of clay is a major factor determining the density, water absorption and strength of concrete. The high temperature during manufacturing of light expanded clay aggregate resulted in formation of continuous pores thus increasing the porosity of aggregate. If the temperature was raised above the pyro-plasticity range, decrease in pore size and porosity was observed. The slow cooling of LECA while manufacturing enhanced the crushing strength of aggregates.

Alaa M. Rashad (2018) reviewed the properties of light expanded clay aggregates used as fine aggregate and coarse aggregate in concrete. The workability of the concrete was found to be increasing with increased content of prewetted LECA as coarse or fine aggregate. The higher water absorption of LECA has negative impact on the workability of concrete. But, the round nature of LECA has positive effect on the workability of concrete. Also, the introduction of LECA reduced segregation. The incorporation of LECA as coarse aggregates and/or fine aggregates reduced the density of concrete. This was due to the low specific gravity of LECA in comparison with the normal weight aggregate. Also, the density of concrete containing LECA increased with increased in compressive strength. The addition of prewetted LECA in concrete reduced creep and shrinkage. As the replacement proportion of expanded clay aggregates increased, the mechanical strength of concrete was reduced. The use of coarse and fine LECA in concrete further reduced the strength of concrete. LECA possessed lesser crushing strength and were porous. The round shape of LECA resulted in reduction of bond strength with the surrounding concrete when compared with conventional coarse aggregates. The addition of expanded clay aggregates in concrete resulted in increased water absorption and reduced chloride penetration in concrete. The fire resistance of concrete was enhanced on addition of LECA. This might be due to the exposure of LECA to high temperature during manufacturing and also due to the low thermal expansion of LECA. The reduction in resistance to freezing and thawing was observed, which might be due to the high water absorption of expanded clay aggregates. The porous structure of LECA, low density and low thermal conductivity led to the improvement of sound absorption and thermal insulation properties of the concrete. The replacement of silica fume in concrete containing LECA enhanced the mechanical strength and chloride penetration resistance. But, a decrease in slump was observed.

R. Ayswarya, P. Iswarya, M. Priyanka, K. SathyaPriya (2018) experimented on M40 grade concrete with varying percentage of replacement of conventional coarse aggregates with expanded clay aggregates. Five different mix proportions were made with percentage of replacement of coarse aggregates as 0%, 20%, 40%, 60% and 80%. The addition of LECA reduced the density of concrete and also enhanced the workability of the concrete. The compressive strength of each mix was determined after 3rd and 7th day of curing. With increasing percentage of replacement of LECA, decrease in compressive strength was observed. The workability of lightweight concrete was reported to be decreasing with increase in expanded clay aggregate which is contradictory to the previous works. The density of concrete reduced with increased expanded clay aggregate content.

T. Divya Bhavana, Rapolu Kishore Kumar, S. Nikhil, P. Sairamchander (2017) experimented on conventional concrete in which the coarse aggregate was replaced with expanded clay aggregate by 0%, 25%, 50%, 75% and 100%. The concrete also contained 10% silica fume and 1.6% poly vinyl alcohol fibers. Compressive strength and flexural strength of concrete specimens were observed after 7 and 28 days of curing. The compressive strength and split tensile strength of concrete was decreasing with increased proportion of expanded clay aggregates.

T. Sonia , R. Subashini , R. Banupriya (2016) experimented on the partial replacement of M25 grade concrete whose mix design was obtained using IS 10262:1982. Five different mixes were made with 20%, 40%, 60%, 80% and 100% replacement percentage of coarse aggregate with LECA. As the percentage of replacement increased, the density and strength of concrete decreased linearly. The compressive strength of concrete after 60% replacement of coarse aggregate was less than 25 N/mm^2. But, the strength of concrete containing 100% LECA was greater than 17 N/mm^2 and hence it can be used as structural lightweight concrete.

Murat Emre Dilli, Hakan Nuri Atahan, Cengiz Sengül (2015) presented a comparison between the strength and elastic properties of conventional concrete and lightweight concrete containing expanded clay aggregates. Three concrete mixes were made with conventional coarse aggregate and two types of expanded clay aggregates. The dry unit weight and compressive strength of concrete after 28 and 120 days of curing. In general, the density of concrete increased with increase in its compressive strength. High water absorption of expanded clay aggregates provided better internal curing even for concrete with low water-cement ratio. As the strength of concrete increased, the modulus of elasticity of concrete also increased.

A. Ardakani, M. Yazdani (2014) studied the relation between density and elastic modulus of lightweight expanded clay aggregates. The modulus of elasticity of concrete reduced exponentially with increase in LECA volume fraction which was due to low density of LECA. The relation between modulus of elasticity and density of LECA was found to be linear. The addition of LECA in concrete increased the Poisson ratio of concrete.

Michala Hubertova, Rudolf Hela (2013) experimented on the durability of lightweight concrete made of expanded clay aggregates. Five mix designs were made with constant proportion of combination of lightweight expanded clay aggregate and natural dense stone, with changes in the admixture used. Mix I-A contained black coal flyash by replacing 40% volume of cement. Mix I-B and Mix I-C was obtained from Mix I-A by replacing 5% volume of cement with metakaolin and micro silica respectively. Mix I-D was obtained by replacing 40% volume of cement with micronized limestone. The specimens were subjected to compressive strength test after 180 days. Also, the effect of carbon dioxide, sulphates, chloride ions, diesel oil were studied. From the experiments, it was observed that the mix I-A possessed much resistance to carbon dioxide and sulphates. Mix I-B was more resistant to corrosion than the other concrete mixes. Thus, the replacement of cement with black coal flyash and metakaolin was found to increase the durability of concrete containing porous expanded clay aggregates.

3. CONCLUSIONS

From the literature review carried out, following conclusions were arrived:

- The heating and cooling process during manufacturing of expanded clay aggregates affects porosity and strength of the aggregates.
- The use of expanded clay aggregate in concrete resulted in increased workability which was due to the spherical nature of the aggregates. The higher water absorption of expanded clay aggregates had negative impact on the workability of concrete. The resistance to segregation was also improved.
- The incorporation of LECA reduced creep and shrinkage of concrete.
- The replacement of conventional coarse aggregates by light expanded clay aggregates resulted in the reduction of density, strength and modulus of elasticity of concrete. An increase in density of concrete with increase in compressive strength of concrete was observed. The increased fineness of LECA increased the density of concrete and hence increased the compressive strength of concrete.
- LECA enhanced the fire resistance of concrete due to its low thermal expansion and exposure to high temperature at the time of manufacturing.
- The resistance to freezing and thawing was reduced when LECA was incorporated into the concrete.
- The utilisation of LECA in concrete enhanced the sound insulation and thermal insulation of concrete.
- The durability of lightweight concrete containing expanded clay aggregates can be enhanced by using mineral admixtures like black coal fly ash and metakaolin.
- The replacement of cement with silica fume in concrete containing LECA enhanced the compressive strength and chloride penetration resistance.

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