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Review on Lightweight Concrete Using LECA And Foaming Agent

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ABSTRACT

Lightweight concrete has emerged as an effective material to reduce the self-weight of structures while maintaining sufficient strength and durability. This literature review examines prior experimental studies on lightweight concrete using Lightweight Expanded Clay Aggregate (LECA) and foaming agents. The reviewed works include studies replacing conventional aggregates with LECA and integrating foaming agents to form lightweight concrete. The methods adopted involved varying LECA proportions and foam contents, with specimens cured for 28 days before compressive strength, density, and workability tests. Results across studies consistently demonstrate that increasing LECA or foam content reduces density and compressive strength, though. LECA-based mixes maintain adequate mechanical properties for non-load-bearing applications. The combination of LECA and foaming agents yields ultra-light conceete with excellent thermal insulation, moderate strength, and improved workability. The review highlights the need for further research to optimize LECA-foam proportions for sustainable lightweight concrete design.

1. INTRODUCTION

Concrete is the most widely used construction material in the world due to its strength, durability, and versatility. However, conventional concrete is relatively heavy, which increases the dead load on structural members and limits its use in certain applications such as high-rise buildings and long-span structures. To overcome these limitations, the development of lightweight concrete (LWC) has become an important area of research in modern construction technology. Lightweight concrete can be produced either by introducing air voids within the mix or by using lightweight aggregates. Among various lightweight aggregates, Light Expanded Clay Aggregate (LECA) has gained popularity due to its low density, good thermal insulation, and high resistance to fire and chemical attack. On the other hand, foamed concrete utilizes a stable foam to create uniform air bubbles in the matrix, further reducing the density while maintaining adequate strength.This experimental study aims to investigate the combined effect of LECA and foaming agents on the mechanical and physical properties of lightweight concrete. The main objective is to achieve an optimal balance between reduced density and sufficient

compressive strength, making the material suitable for structural and non-structural applications. The study includes tests on workability, density, compressive strength, and water absorption to evaluate the performance of LECA-foamed lightweight concrete compared to conventional mixes.

2. LITERATURE REVIEW

A. *"EXPERIMENTAL STUDY ON LIGHTWEIGHT CONCRETE USING LIGHTWEIGHT EXPANDED CLAY AGGREGATE (LECA) AND EXPANDED PERLITE AGGREGATE (EPA)"*

Description: This experimental study focused on developing lightweight concrete for structural precast applications by partially replacing normal aggregates with Lightweight Expanded Clay Aggregate (LECA) and Expanded Perlite Aggregate (EPA). The experiment was conducted in two phases: first, varying the percentage of LECA, and second, combining the optimal LECA percentage (L60) with varying amounts of EPA. The key objective was to create a mix that achieved a low density while maintaining a minimum cube compressive strength of at least 18 MPa.

Conclusion: The combined use of LECA and EPA is effective in producing structural lightweight concrete, successfully lowering the density and increasing the slump value, despite the expected decrease in compressive strength.

B. "EXPERIMENTAL STUDY ON LIGHTWEIGHT CONCRETE USING LECA MATERIALS"

Description: The study conducted an experiment to produce lightweight concrete (LWC) suitable for reinforced precast concrete products by partially replacing normal coarse aggregate with Lightweight Expanded Clay Aggregate (LECA) and normal fine aggregate (sand) with Expanded Perlite Aggregate (EPA). The goal was to achieve a minimum cube compressive strength of 18 MPa (equivalent to LC16/18) at the lowest possible density. The experimental program consisted of two phases: the first phase varied LECA replacement (30%, 60%, 80%, and 100%), and the second phase introduced EPA replacement (5% to 75%) into the optimum LECA mix (L60). Density, cube compressive strength, and concrete quality via Ultrasonic Pulse Velocity (UPV) tests were measured.

Conclusion: The inclusion of LECA and EPA successfully produced lightweight structural concrete. The optimum concrete mix was found to be the L60EPA50 mix (60% LECA and 50% EPA replacements).

C. "OPTIMIZATION OF DIFFERENT MIX-PROPORTIONS OF FOAM CONCRETE"

Description: This experimental study focused on the Optimization of Different Mix-Proportions of Foam Concrete. Foam concrete, a type of Lightweight Concrete (LWC), was prepared using OPC and PPC cement. The key variable was the ratio of foaming agent to water, which was tested in three different percentages: 90:10, 80:20, and 70:30 (foam:water). The main objective was to determine the ratio that provides a lighter weight while achieving better strength. The resulting concrete mixtures were evaluated based on their compression, flexural, and split tensile strengths.

Conclusion: The study successfully determined the optimum mix for foam concrete among the trials (PCF3W7, PCF2W8, PCF1W9). The PCF2W8 (80:20 foam:water) trial exhibited the highest 28-day compression strength of . The general trend observed was that lesser foaming agent resulted in better mechanical properties, but only up to the 20% foam content ratio (PCF2W8). The PCF2W8 mix is recommended as a suitable design for application in non-load-bearing structures. Specifically, this lightweight concrete is considered suitable for use in highway construction areas such as footpaths, kerbs, and separators.

D. "A REVIEW PAPER ON THE PROPERTIES OF FOAM CONCRETE"

Description: This document is a review paper on the properties and applications of Foam Concrete (FC), an aerated Lightweight Concrete (LWC) that lacks coarse aggregate. FC is valued for its high strength-to-density (typically), which helps reduce the dead load on structures, weight ratio and low save energy, and lower construction costs. The review aims to investigate FC's properties, study the influence of partial cement replacement with fly ash, and evaluate the concrete's strength. FC is produced by mixing a pre-formed foam (created from a foaming agent and water) into a cement-based slurry, with density determined by the foam-to-slurry ratio.

Conclusion: The review concluded that most research on FC primarily focuses on foam features rather than its overall properties. For FC to be utilized in structural, non-structural, or semi-structural components, compressive strength must remain the primary design focus. Future studies should prioritize enhancing the concrete's durability to resist aggressive environments. Improvements in mix design are necessary, specifically by selecting the most appropriate foam agent to ensure a uniform distribution of pores and utilizing supplementary materials like fly ash to enhance workability.

E. "Lightweight foamed concrete with foam agent addition"

Description: This experimental study investigated the properties of lightweight foamed concrete (LFC) fabricated using ternary cementitious composites (Flue Gas Desulfurized Gypsum (FGD), Fly Ash (FA), and OPC). The research focused on the influence of varying foam agent addition (0 to 7wt%), foam stabilizer, and polypropylene fiber (PPF) on the LFC's performance. The key properties examined were density, thermal conductivity, flexural strength, and compressive strength.

Conclusion: 1. Increasing the content of the foam agent rapidly decreased the density, thermal conductivity, and mechanical strength (flexural and compressive) due to the generation of high porosity. 2. The addition of a foam stabilizer positively affected both the heat insulation performance and mechanical strength by improving the concrete's pore structure. 3. PPF addition also improved the flexural and compressive strength of the foamed specimens. 4. However, using excess fibers proved to be counterproductive, leading to a decline in mechanical properties due to the aggregation of PPF within the composite matrix.

F. "Experimental Study On Light Weight Concrete Using Leca"

Description: This experimental study investigated the production of Lightweight Concrete (LWC) by partially replacing conventional coarse aggregate with Lightweight Expanded Clay Aggregate (LECA). The M30 grade concrete was tested with LECA replacement levels of 20%, 40%, 60%, 80%, and 100%. The main objective was to compare the density and key strength properties (compressive, split tensile, and flexural strength) of the resulting Lightweight Aggregate Concrete (LWAC) against conventional concrete. The project aimed to achieve benefits like reduced self-weight in structures (especially tall buildings or those on weak soils) and overall construction economy.

Conclusion: The study concluded that the use of LECA successfully leads to a reduction in the density and dead weight of the concrete compared to conventional concrete. This reduction in weight helps to lower construction costs, particularly foundation expenses. From the experimental investigation on lightweight concrete using Lightweight Expanded Clay Aggregate (LECA) as a partial replacement for conventional coarse aggregate, it is expected that: 1. Reduction in Density: The replacement of natural coarse aggregates with LECA significantly reduces the overall density of concrete—by approximately 15–25% depending on the percentage of replacement. This reduction lowers the dead load on structural members, making it suitable for high-rise and precast construction. 2. Compressive Strength: Concrete mixes containing up to 20–30% LECA can achieve compressive strengths comparable to conventional M20–M30 grade concrete (around 25–30 N/mm^2 at 28 days). Beyond this percentage, strength tends to reduce gradually, but the values remain adequate for non-load-bearing or light structural applications. 3. Workability and Durability: LECA improves the workability of fresh concrete due to its smooth and porous surface. Pre-soaked LECA also enhances internal curing, contributing to long-term durability and reducing shrinkage cracks. 4. Thermal and Acoustic Performance: The porous structure of LECA provides excellent thermal insulation and sound absorption, making it suitable for energy-efficient buildings and acoustic applications. 5. Optimal Replacement Level: Based on literature, an optimal LECA replacement of 20–40% offers a good balance between reduced weight and sufficient strength. If combined with other lightweight materials such as Expanded Perlite Aggregate (EPA), densities as low as 1800 kg/m^3 can be achieved while maintaining a compressive strength above 18 MPa. 6. Sustainability Aspect: The use of LECA in concrete supports sustainable construction by reducing the consumption of natural aggregates, lowering transportation energy, and enhancing thermal efficiency of buildings.

G. "Behavior of One Way Foamed Concrete Slabs Using Different Types of Reinforcement (AL-Saidi & Harba)"

Description: Foamed concrete slabs were made, some mixes included LECA aggregate in addition to the foam. Reinforced with either normal steel or GFRP. They looked at how adding LECA affected mechanical behaviour under load (slabs). Dry density ~1800-1900 kg/m^3

Conclusion: Adding LECA improved compressive strength (e.g. from ~35 MPa to ~42 MPa), modulus, flexural strength etc. The slabs with LECA had better ultimate load vs slabs without. So combining LECA + foam + reinforcement seems promising for structural elements.

H. "Mechanical properties of lightweight expanded clay aggregate (LECA) concrete (Issa & Al-Asadi)"

Description: Studied concrete using LECA as lightweight coarse aggregate (full replacement) with mineral admixtures like silica fume. Looked at compressive strength, modulus etc. Density ~1823 kg/m^3 in some mixes

Conclusion: LECA concretes reached compressive strengths up to ~32 MPa, and the mechanical properties (tensile, modulus) could satisfy structural light-weight concrete requirements. Mineral additives (silica fume etc.) help significantly.

I. "Comparing Properties of Foamed Concrete and Lightweight Expanded Clay Aggregate Concrete at the Same Densities (Ahmadi, Reisi, Sajadi)"

Description: Eight mixes, with both foamed concrete (FC) and LECA-aggregate concrete (LAC), at densities: 1400, 1600, 1800, 2000 kg/m^3. Tested compressive, flexural strength, water absorption, microstructure, thermal conductivity.

Conclusion: At higher densities (1800-2000 kg/m^3) FC had ~7.3% higher compressive strength vs LAC. But at lower densities (1400-1600), LAC was up to ~36.9% stronger. FC showed higher flexural strength across densities, but also higher water absorption. Thermal conductivity was similar (less than 5% difference).

J. "High Strength Lightweight Foam Concrete"

Description: This study focuses on developing high-strength lightweight foam concrete using animal-based foaming agents and locally available materials like fly ash, GGBS, gypsum, and quarry dust. Five different mix ratios were tested. The concrete was dry cured (not immersed in water) to maintain bubble structure. The goal was to reduce the weight of concrete while maintaining strength for structural and block applications.

Conclusion: Mix 5 gave the highest compressive strength (up to 17 MPa). Foam concrete continues to gain strength after 28 days. Suitable for partition walls and CLC blocks. Can be developed further for structural use due to its lightweight and good strength.

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