Review on Structural Stability and Strength Analysis of Lightweight Cellular Concrete

Mr. Shankar Maryappa Dawane[1], Prof. Vaibhav Vilas Shelar[2], Prof. Vijay Shivaji Shingade[3]
[1]*Student, ME Structural Engineering, Trinity College of Engineering and Research, Pune, India*
[2,3]*Professor, Dept. of Civil Engineering, Trinity College of Engineering and Research, Pune, India*

***Abstract*— Concrete is most important construction materials. Concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as an aggregate that is bonded together by cement and water. Lightweight concrete maintains its large voids and not forming laitance layers or cement films when placed on the wall. This research was based on the performance of aerated lightweight concrete. Lightweight Cellular Concrete (LCC), known for its low density and thermal insulation properties, is increasingly used in modern construction. However, concerns remain regarding its structural stability and mechanical strength, especially when modified with foam agents and recycled materials. The incorporation of waste crushed CLC (Cellular Lightweight Concrete) blocks as a partial replacement for fine aggregates presents a sustainable solution to construction waste, but its impact on the structural performance of LCC is not fully understood. This study aims to analyze the structural stability and strength characteristics of LCC modified with varying proportions of foam agent and crushed CLC waste, to determine optimal mix ratios that balance sustainability with performance.**

***Index Terms*— CLC, Lightweight Cellular Concrete, waste, foam agents**

I. INTRODUCTION

Concrete is most important construction materials. Concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as an aggregate that is bonded together by cement and water. In upcoming years there has been an increasing worldwide demand for the construction of buildings, roads and an airfield which has mitigate the raw material in concrete like aggregate. In some ruler areas, the huge quantities of aggregate that have already been used means that local materials are no longer available and the deficit has to be made up by importing materials from other place. Therefore, a new direction towards Cellular Lightweight Concrete in building and civil engineering construction is used.

Lightweight concrete maintains its large voids and not forming laitance layers or cement films when placed on the wall. This research was based on the performance of aerated lightweight concrete. However, sufficient water cement ratio is vital to produce adequate cohesion between cement and water. Insufficient water can cause lack of cohesion between particles, thus loss in strength of concrete. Likewise, too much water can cause cement to run off aggregate to form laitance layers, subsequently weakens in strength.

A. Applications of Cellular Lightweight Concrete

1) Building Blocks: Blocks and panels can be made for partition and load bearing walls. They can be made with almost any dimensions.

2) Floor Screed: Foamed concrete can be used for floor screeds, creating a flat surface on uneven ground and raising floor levels.

3) Roof Insulation: Foamed Concrete is used extensively for roof insulation and for making a slope on flat roofs. It has good thermal insulation properties and because it is lightweight foamed concrete does not impose a large loading on the building.

4) Road Sub-Base: Foamed Concrete is being used road sub base on a bridge. Foamed concrete is lightweight so that the loading imposed on the bridge is minimized.

B. CLC Waste Block

Cellular Light Weight Concrete (CLC) is also known as a Foam Concrete. Cellular Light Weight Concrete (CLC) is a very light in weight that is produced like normal concrete under ambient conditions. CLC

Blocks area cement bonded material made by blending slurry of cement. It very lightweights with density ranging from 300 to 1800 kg/m3. Which was three times less weight than fly ash or clay brocks. It is Environment-friendly. Foam concrete is made by eco-friendly material as fly ash and other industrial waste material are used in part of manufacturing blocks to protect the environment. The production process of Foam concrete or its use does not release any harmful effluents to water, ground or air.

C. Concrete Foaming Agent

A concrete foaming agent is a chemical substance used to produce foam in concrete, resulting in a lightweight and insulating material. The foam is typically created by mixing the foaming agent with water and air, which is then incorporated into the concrete mix. This process helps in reducing the overall weight of the concrete while maintaining its structural integrity and providing additional benefits like thermal and acoustic insulation. Marjanol Concrete Foaming Agent is a specific brand of concrete foaming agent designed to create lightweight and durable foamed concrete. Like other foaming agents, it is used to produce foam, which is incorporated into concrete to reduce its density while maintaining essential properties like strength and insulation

II. STATE OF DEVELOPMENT

Zdenek P. Bazant et al. (2000) studied the concept of structural stability in engineering structures. The research explained elastic and inelastic behavior, static and dynamic response, creep stability, and fracture-induced instability. The study highlighted the importance of stability theory in civil and structural engineering applications. The authors emphasized recent developments in damage localization and fracture analysis for safer structural design.

Dhiraj Bhople et al. (2021) investigated the properties and applications of Cellular Lightweight Concrete (CLC). The study found that CLC has lower density and reduced dead load compared to conventional concrete while maintaining satisfactory strength. The research showed that the use of CLC blocks can reduce structural cost and steel consumption. It concluded that CLC is an economical and sustainable construction material.

Devansh Jain et al. (2019) evaluated the mechanical and physical properties of Cellular Lightweight Concrete (CLWC) using fly ash and silica fume. The study analyzed compressive strength, water absorption, and density for different mix proportions. Results indicated that fly ash and silica fume improved the strength and performance of CLWC. The research concluded that optimized mix design can enhance lightweight concrete properties for construction applications.

Anubhav Kumar Hindoriya et al. (2016) studied the properties, applications, and production methods of lightweight cellular concrete blocks. The paper explained that cellular concrete has low density, good thermal insulation, and sound insulation properties. The authors highlighted that lack of awareness about its behavior limits its wider application. The study concluded that lightweight cellular concrete has strong potential in modern construction industries.

Gagandeep et al. (2019) carried out an experimental study on the strength characteristics of Cellular Lightweight Concrete. The research focused on replacing fly ash with sand and quarry dust to improve compressive strength. The findings showed that lightweight concrete reduces dead load and improves thermal insulation and fire resistance. The study concluded that quarry dust and sand can effectively enhance the strength of CLC blocks.

Vikash Bhatt et al. (2023) studied the characteristic strength of Cellular Lightweight Concrete using different composite material proportions. The research emphasized that CLC blocks help in reducing the dead weight of buildings. The study evaluated density and mix ratios according to IS 2185 (Part-4) 2008 standards. The authors concluded that proper proportioning of materials improves the structural performance of CLC.

Riyal Yadav et al. (2023) reviewed the properties and applications of lightweight foam concrete. The study reported that foam concrete reduces structural dead load, construction cost, and energy consumption. It also highlighted the compressive strength range of 6 MPa to 14 MPa and the importance of stable air bubbles in concrete. The review concluded that foam concrete can serve as a sustainable alternative to conventional concrete.

Sagar Dhengare et al. (2015) studied Cellular Lightweight Concrete and its role in sustainable construction. The research explained that lightweight concrete improves workability and reduces dead weight due to the presence of air voids. The authors discussed the historical use of lightweight aggregates such as pumice in construction. The study concluded that CLC blocks provide environmental and structural benefits in the building industry.

R. Theenathayalan et al. (2024) investigated Lightweight Cellular Concrete using Sodium Lauryl Sulphate (SLS) and fly ash as stabilizers. The study evaluated foam stability, density, and compressive strength of LWCC. Results showed that aerosol-based LWCC achieved higher compressive strength of 16.8 MPa with good density characteristics. The research concluded that aerosol-based LWCC has strong potential for structural construction applications.

Susan Tighe et al. (2020) reviewed the potential use of Lightweight Cellular Concrete in pavement applications. The study examined mechanical properties such as compressive strength, elasticity, water absorption, and freeze-thaw resistance. The authors found that LCC can be effectively used as a pavement subbase material due to its low density and sustainability benefits. The paper recommended further field studies to evaluate long-term pavement performance.

Akash Singh et al. (2023) reviewed the properties and advantages of foam concrete in civil engineering. The study highlighted that foam concrete has a high strength-to-weight ratio and low density, which reduces dead load and labor cost. The research also discussed the role of stable foam in improving concrete performance. The authors concluded that foam concrete is a sustainable and economical alternative to traditional concrete.

Binod Tiwari et al. (2017) studied the mechanical properties of Lightweight Cellular Concrete for geotechnical applications. The research evaluated shear strength, permeability, earth pressure coefficient, and compressive strength at different densities. Results showed that engineering properties of LCC depend significantly on density. The study concluded that lightweight cellular concrete is suitable for earth-retaining and geotechnical structures.

Yajun Liu et al. (2024) presented a comprehensive review on foam concrete for lightweight construction applications. The study discussed porosity, thermal conductivity, strength, fire resistance, durability, and acoustic properties of foam concrete. The review identified the need for standardized testing methods and further research on long-term structural performance. The authors concluded that foam concrete has wide potential in modern sustainable construction.

Virendra Sahu et al. (2018) studied fly ash-based Cellular Lightweight Concrete and its environmental benefits. The research focused on reducing concrete density while maintaining adequate strength. The study also examined the use of glass as a partial replacement for cement. The authors concluded that fly ash-based CLC is a sustainable, economical, and eco-friendly construction material.

E. Karthik et al. (2022) reviewed foam concrete and its properties such as low density, thermal insulation, and acoustic insulation. The study discussed the influence of water-cement ratio and different foaming agents on foam concrete performance. The authors highlighted that lightweight foam concrete is widely used due to its insulation and moderate strength properties. The review concluded that proper selection of materials and mix proportions improves foam concrete quality.

III. CONCLUSION

From detailed literature review many previous researchers study the replacement of cement by various type of cementations materials and try to improve compressive strength of concrete. Form previous studies foaming agent were used only in CLC block casting, instead of that use foaming agent with minimal percentage of cement to create light weigh concrete with conventional concrete mix design in further study. Many of the past studies on the focus about the recycled aggregate to avoid unnecessary dumped demolished concrete in fertile land. The authors found that the density of recycled concrete decreased with an increase in the rate of change of all levels of water cement, Therefore, for that examination, the CLC recycled aggregate will be mixed with cement paste and dried for two to three days then, use as a replacement.

Further studies are encouraged to explore durability, long-term performance, and cost-efficiency of LCC in real-world construction scenarios

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