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Cellular Light Weight Concrete Blocks – A Review

Enithkumar. A. N[1], Saran. S. P[2], Dr. V. Selvan[3]

PG Student[1,2], Associate Professor & Head[3],
Department of Civil Engineering, Kumaraguru College of Technology, Coimbatore – 641049, Tamilnadu, India.

ABSTRACT

Cellular Lightweight Concrete (CLC), also referred to as Foamed Concrete, stands out as a crucial cement variant in construction due to its manifold benefits and versatile applications, surpassing conventional concrete. Its composition involves a blend of Portland concrete, sand (with or without fly ash), and a stable foam. The resulting lightweight concrete exhibits surprisingly low density in comparison to standard cement, ranging from 300kg/m3 to 1850kg/m3. The widespread adoption of Cellular Lightweight Concrete is attributed to its reduced density while maintaining quality comparable to regular blocks. Its formation relies on effectively dispersing air uniformly throughout the cement mixture. This comprehensive review paper extensively covers raw materials, manufacturing processes, the characteristics of cellular concrete, different CLC types, and their applications, especially in the realm of geotechnical uses.

Keywords : Cellular lightweight concrete, CLC blocks, foam, density.

1. INTRODUCTION

Cellular Lightweight concrete (CLC) stands as a remarkable human innovation widely applied across various construction domains. Its multitude of applications, including frames and floors, curtain walls, shell roofs, folded plates, bridges, offshore oil platforms, and precast structures, holds immense significance. CLC exhibits a strength that is 25 to 35% lighter compared to standard concrete. Cellular Lightweight Concrete (CLC) blocks have a history spanning several decades, originating in Europe during the 1920s as an initial form of insulating material. Over time, their evolution continued through the mid-20th century, drawing recognition for their lightweight characteristics and excellent insulation capabilities. However, it was in the later periods, specifically the 1970s and 1980s, that CLC blocks garnered increased attention and popularity, propelled by advancements in foam technology and construction methodologies. Over time, these blocks became popular worldwide due to continuous progress in manufacturing methods, raw materials, and the acknowledgment of their benefits: lower density, excellent thermal insulation, and effortless construction without compromising strength. The persistent evolution and improvements in producing CLC blocks have established their reputation as a sustainable and effective construction material in modern building practices.

2. LITERATURE REVIEW

Parea Rusan Rangan,Miswar Tumpu and Yohans Sunarno states that, It was feasible to blend PCC cement, sand, and stone dust to form a mortar that, when mixed with foam, generated lightweight concrete exhibiting commendable compaction. The escalation in the compressive strength of lightweight concrete bricks from 3 to 28 days illustrated that the harmonious interaction of all utilized ingredients facilitated a smooth concrete hardening process during binding. The volume weight of cellular lightweight concrete (CLC) gradually increased by 0.66 gram/cm3 over time when employing stone dust as a substitute for fine aggregate. In instances where 50% stone dust was utilized, the volume weight value rose by 2% to 0.67 gram/cm3, and by 4% to 0.68 gram/cm3 for 100% stone dust. Despite its volume weight range spanning 0.600 to 1,800 gram/cm3, this lightweight brick can still be classified as such. Stone dust, possessing robust bonding capabilities, can serve as a fine aggregate replacement in cellular lightweight concrete (CLC) mixtures, enhancing compressive strength. The optimal compressive strength, at 24.62 kg/cm2 after 28 days, is achieved by substituting 100% stone dust, aligning with Indonesian standards for lightweight concrete bricks in infilled walls. However, the influence of foam agents, inducing pores in lightweight bricks, prevents the compressive strength from meeting the criteria for utilization in wall pairs.

H Maizir , R Suryanita and R Arditama mentions that , Greater density corresponds to increased compression in the index properties of CLC bricks. Augmenting the cement content in the mixture leads to heightened compressive strength. The rise in compressive strength over 28 days between Variation 1 and Variation 2 is approximately 24.5%.

Mukul Rathore and Anik Gupta specifies, The specimen utilized for various tests has been detailed in the aforementioned examinations. This chapter centers on the performance of Cellular Lightweight Concrete (CLC), with all test methods previously outlined in the preceding chapter. The results presented herein pertain to the compressive strength test, density, and water absorption for diverse mixes of Cellular Lightweight Concrete. The steel reinforcement amount employed in the CLC block measured 1513.53 mm2, whereas the requisite steel reinforcement for brick masonry amounted to

1681.64 mm2. Consequently, the savings achieved through CLC blocks approximate 168.1 mm2, equivalent to 8.635 kg. Furthermore, this study underscores that incorporating fly ash into foamed concrete significantly enhances its properties. It is noteworthy that a substantial portion of cleaner production efforts is imperative in India. Therefore, CLC blocks may serve as a viable alternative to burnt clay bricks in construction, offering advantages in terms of general construction properties and environmental friendliness.

Reni Suryanita , Yohannes Firzal , Harnedi Maizir , Imam Mustafa , Mohd Fadzil Bin Arshad elaborates , High-temperature exposure in Cellular Lightweight Concrete (CLC) can result in discoloration, alterations in pore size, changes in volume weight, and variations in the compressive strength of the CLC. When subjected to elevated temperatures for 40 minutes, cellular lightweight concrete exhibited a significant decline in compressive strength. Specifically, there was a reduction of 42.3%, decreasing from 0.52 MPa to 0.3 MPa for a CLC mixture with a cement and sand ratio of 1:2. Similarly, there was a 25% decrease, dropping from 0.68 MPa to 0.51 MPa for CLC mixtures with a cement-to-sand ratio of 2:3.

Khalid Khan, Khan Shahzada, Akhtar Gul, Inayat Ullah Khan, Sayed M. Eldin & Mudassir Iqbal tells us that , The aim of this study is to assess the seismic performance of both confined and unreinforced Cellular Lightweight Concrete Block Masonry (CLCBM) walls. The Quasi-Static Reversed-Cyclic Loading (QSRCL) test was conducted on each specimen, and the obtained data underwent analysis to evaluate seismic performance parameters such as hysteresis loops, force–deformation relationships, energy dissipation, stiffness degradation, response modification factor (R), and deformation ductility factors (μd). The testing also involved observing the sequence and mechanism of damages.

Upon meticulous data analysis and interpretation of results, the following conclusions were derived: The specimens exhibited a hybrid failure mode, with the shear failure mode being predominant. Although the sequence of various failure modes differed, the Confined Masonry (CM) wall failed in diagonal shear, shear sliding, and rocking failure modes, while the Unreinforced Masonry (URM) wall failed in rocking, shear sliding, and diagonal shear modes. The CM wall system effectively enhanced the seismic performance of the URM wall, particularly in terms of its lateral load capacity. The seismic performance and capacity of the CM wall were significantly superior to those of the URM wall. Specifically, the CM wall exhibited a 102% increase in lateral load capacity, a 66.67% increase in elastic stiffness, and a 5.3% increase in displacement ductility compared to the URM wall. Confining elements had a notable impact on energy dissipation and stiffness degradation, particularly in later storey drifts where the effect diminished. Despite weak masonry units, no evident difference in ductility was observed between the two wall specimens. Confining elements substantially contributed to the deformation capacity of the CM wall compared to the URM wall. The study suggests that future research could explore the performance evaluation of CLCBM walls in the out-of-plane direction. Additionally, numerical modelling could be undertaken to validate the obtained results.

E.P Kearsley and P.J Wainwright proves , Porosity is primarily influenced by dry density rather than ash type or content. The compressive strength of foamed concrete was found to be associated with both porosity and age. A multiplicative model, such as the one formulated by Balshin, demonstrated the best fit for the results across all ages investigated. The impact of the ash/cement ratio is yet to be determined, and efforts should be directed towards establishing whether optimal ash contents exist at various ages and porosities. The equation derived by Hoff can be instrumental in this regard.

A. K. Marunmale and A.C.Attar elaborates that , The utilization of CLC bricks in Rat-Trap bond represents an innovative approach to efficient brickwork systems, offering numerous advantages over traditional methods. This technique minimizes material usage, reducing reliance on natural resources such as river sand and red soil, while incorporating waste materials like fly ash, making it an environmentally friendly construction material. Specifically designed for Rat-Trap bond wall construction, CLC bricks fill a gap in existing efforts, and the test results affirm their satisfactory performance, making them suitable for both non-load-bearing exterior and interior walls. The lightweight nature of CLC bricks in Rat-Trap bond not only lessens the structural dead load but also provides effective thermal insulation. Consequently, the future prospects for the development of CLC bricks in Rat-Trap bond appear promising as a commercially viable product.

S. Hemavathi and Karnan.D elobrates that,The examination of various characteristics of cellular lightweight concrete (CLC) blocks yielded results indicating that employing CLC blocks as a substitute for traditional bricks is advantageous. The compressive strength of these blocks surpasses that of normal bricks. CLC is available in different densities, with the 1800 kg/m3 density suitable for reinforcing structural elements. The incorporation of polymers in CLC enhances its tensile strength, making it a viable alternative to concrete. This project report delves into the detailed advantages of cellular lightweight concrete.The accompanying table presents a comparative analysis of different brick types, demonstrating that the use of cellular lightweight concrete blocks is more economical and worthwhile. Additionally, CLC blocks boast advantages such as fire resistance, thermal insulation, sound insulation, and low water absorption capacity, making them superior to normal bricks. The replacement of 70% fly ash results in the highest strength of 3.1 N/mm2, with a density of 800 kg/m3, compared to other ratios. Total replacement of fly ash with m-sand (i.e., 60% granite powder and 40% cement) also exhibits high strength at 2.03 N/mm2 with a density of 700 kg/m3 compared to 70% fly ash replacement.The use of CLC blocks is deemed eco-friendly and cost-effective, as it reduces cement consumption. This reduction in cement quantity not only lowers block costs but also diminishes the demand for cement, subsequently reducing CO2 emissions from cement manufacturing industries and contributing to a more environmentally friendly manufacturing process. The adoption of CLC blocks in lieu of traditional bricks also reduces construction costs. In conclusion, this report asserts that CLC blocks can effectively serve as an alternative material to normal bricks. Looking ahead, the increasing demand for thermal plant fly ash, a substitute for cement in CLC blocks, is foreseeable, and this project demonstrates that the use of m-sand (granite powder) instead of fly ash is a cost-effective process with all the benefits of cellular lightweight concrete blocks.

Irfan Ullah , Salman Hamad , Lal zaman , Inayat Ullah Khan and Khalid Khan explains , In this study, a compressive test was conducted on control and reinforced samples constructed from CLC block masonry, using a universal testing machine. The results were scrutinized, leading to the following conclusions. The compressive strength values were nearly identical for both samples. Additionally, the elastic modulus values fell within the range of 19000 psi, exhibiting similar characteristics for both samples. The findings indicate a marginal improvement in the overall parameters of the prism posttesting. This marginal improvement is attributed to the occurrence of screws pulling out during the test, a phenomenon caused by the weakness of the masonry unit in compression. Despite the lack of significant capacity improvement, the initial appearance of cracks in the plaster during the test serves as a crucial warning indicator before further masonry crushing occurs.

Erwin Sutandar , Asep Supriyadi , and Cek Putera Andalan specifies ,The examined compositions encompassed cement quantities of 200 kg/m³, 250 kg/m³, 300 kg/m³, 350 kg/m³, and 400 kg/m³. The conducted research revealed that the cement composition plays a pivotal role in influencing the physical and mechanical properties of concrete masonry bricks, impacting factors such as the success rate of CLC brick manufacturing, volume weight, compressive strength, among others.The research outcomes indicate that the CLC masonry concrete brick formulations meeting the criteria for CLC bricks comprised cement proportions of 250 kg/m³, 300 kg/m³, 350 kg/m³, and 400 kg/m³. Conversely, the 200 kg/m³ cement sample is not recommended for use in successful CLC masonry brick production due to observed drying shrinkage after just 1 day.The utilization of different cement compositions ranging from 200 kg/m³ to 400 kg/m³ significantly influences the physical and mechanical properties of the produced CLC masonry concrete bricks, as detailed in Table 4. The average volume weight ranges from 749 to 895 kg/m³, with the lightest variant observed in the sample using 350 kg/m³ of cement. The average compressive strength after 28 days spans from 0.56 to 1.28 MPa, with the highest compressive strength found in the sample utilizing 300 kg/m³ of cement. The average modulus of elasticity after 28 days falls within the range of 45.74–98.64 MPa, with the highest value achieved using 350 kg/m³ of cement.Comparing the results in Table 4 with previous studies outlined in Table 2, similarities are noted in compressive strength and volume weight, while distinctions are observed in thermal conductivity, modulus of elasticity, and drying shrinkage.The findings suggest that an increase in cement usage in the manufacturing of CLC masonry concrete bricks does not necessarily lead to a corresponding increase in compressive strength. Instead, it results in a more pronounced volume weight. The optimal outcome, as deduced from the examination of mechanical and physical properties with varying cement amounts, is achieved with the use of 350 kg of cement

K. Krishna Bhavani Siram explains ,The production of clay bricks constitutes a significant contributor to air pollution in developing nations. The primary environmental concerns center around enhancing the combustion efficiency of existing kilns and transitioning to more advanced and efficient kiln designs. The manufacturing process of clay bricks necessitates substantial energy for burning, primarily due to the emission of CO_2 gas. This study underscores that the incorporation of fly ash into foamed concrete has the potential to substantially enhance its properties. Given the pronounced need for cleaner production initiatives in India, Cellular Lightweight Concrete (CLC) blocks emerge as a viable substitute for traditional burnt clay bricks in construction. This substitution proves advantageous not only in terms of general construction properties but also in promoting eco-friendliness.

Chao Sun , Yu Zhu , Jian Guo , Yamei Zhang and Guoxing Sun examis ,the mechanical and physical properties of foamed concrete utilizing SS, PS, and AS foaming agents led to the following conclusions: The stability and strength of foam generated by SS, AS, and PS exhibited significant variations. SS foam demonstrated superior stability and strength in the air compared to PS and AS foam, potentially contributing to enhanced performance, especially with SS-600. It is noteworthy that SS foam is characterized as a nanoparticle-stabilized foam.

3. SUMMARY

CLC Blocks or Foamed concrete blocks exhibits compressive strength complying with IS code regulations, along with water absorption percentages within the specified limits. Its density, lower than burnt clay bricks and conventional concrete, lessens the load on columns, indirectly reducing the required amount of reinforcement. Concrete incorporating fly ash maintains a density akin to normal concrete. However, the introduction of a foaming agent induces a reduction in weight and dry density, transforming it into lightweight concrete.

REFERENCES

1. Rangan, P. R. (2023). Stone dust as replacement for fine aggregate in cellular lightweight concrete (CLC): Volume weight and compressive strength. *Materials Research Proceedings*. https://doi.org/10.21741/9781644902592-27
2. Suryanita, Reni & Firzal, Yohannes & Maizir, Harnedi & Fadzil, Mohd & Arshad, Bin. (2021). Experimental study on performance of cellular lightweight concrete due to exposure high temperature. International Journal of GEOMATE. 21. 20-27. 10.21660/2021.83.6287.
3. Gupta, Anik & Rathore, Mukul. (2016). Comparative study and performance of cellular light weight concrete.
4. Suryanita, Reni & Firzal, Yohannes & Maizir, Harnedi & Fadzil, Mohd & Arshad, Bin. (2021). Experimental study on performance of cellular lightweight concrete due to exposure high temperature. International Journal of GEOMATE. 21. 20-27. 10.21660/2021.83.6287.
5. Khan, Khalid & Shahzada, Khan & Gul, Akhtar & Khan, Inayat & Eldin, Sayed & Iqbal, Mudassir. (2023). Seismic performance evaluation of plastered cellular lightweight concrete (CLC) block masonry walls. Scientific Reports. 10.1038/s41598-023-37159-0.
6. Kearsley, Elsabé & Wainwright, P.J. (2002). The effect of porosity on the strength of foamed concrete. Cement and Concrete Research. 32. 233-239. 10.1016/S0008-8846(01)00665-2.
7. Marunmale, A.K., & Attar, A.C. (2014). Designing , Developing and Testing of Cellular Lightweight Concrete Brick (CLC) Wall built in Rat-Trap bond.

8. S.Hemavathi, Karnan.D. (2020). Experimental study on fly ash based cellular light weight concrete using m-sand. International Research Journal of Engineering and Technology (IRJET) Volume: 07 Issue: 06, June 2020.

9. Irfanullah, & Hamad, Salman & Lalzaman, & Khan, Inayat & Khan, Khalid. (2022). Comparative Study on the Strengthening of Cellular Lightweight Concrete Block (CLC) Masonry. International Journal of Management Science and Engineering Research. 5. 3.

10. Sutandar, Erwin & Supriyadi, Asep & Andalan, Cek. (2018). Effect of Cement Variation on Properties of CLC Concrete Masonry Brick. MATEC Web of Conferences. 159. 01015. 10.1051/matecconf/201815901015.

11. K.Krishna, Bhavani Siram. (2012). Cellular Light-Weight Concrete Blocks as a Replacement of Burnt Clay Bricks. International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249-8958 (Online), Volume-2 Issue-2, December 2012.

12. Sun, Chao & Zhu, Yu & Guo, Jian & Zhang, Yamei & Sun, Guoxing. (2018). Effects of foaming agent type on the workability, drying shrinkage, frost resistance and pore distribution of foamed concrete. Construction and Building Materials. 186. 833-839. 10.1016/j.conbuildmat.2018.08.019