International Journal on Applications in Civil and Enviornmetal Engineering
Volume 2: Issue6: August 2016, pp 18-23. www.aetsjournal.com ISSN (Online) : 2395-3837

GEOTECHNICAL APPLICATIONS OF LIGHTWEIGHT CELLULAR CONCRETE'S PROPERTIES

MARUTHISWAMY A M[1]
Lecturer, Civil Engg Department, Government Polytechnic Kudligi(174), Kudligi,Bellary-583135.
maruthiswamycv008@gmail.com

NAGARAJA K [2]
Lecturer, Civil Engg Department, Government Polytechnic Kudligi(174), Kudligi, Bellary-583135.
nagarajk3762@gmail.com

Abstract - This paper deals the excellent combination of its low density and advantageous mechanical qualities, lightweight cellular concrete (LCC) has attracted considerable attention as a cutting-edge material for numerous geotechnical applications. This study explores the lightweight cellular concrete's mechanical characteristics as they relate to geotechnical applications. The purpose of the study is to describe the material's strength, elasticity, and durability with a particular emphasis on how it performs in various loading scenarios and applications.ey mechanical characteristics of LCC specimens were evaluated by experimental research. A set of standardised tests were used to determine the elastic modulus, compressive strength, and tensile strength. In order to evaluate LCC's resilience to environmental elements such chemical exposure and freeze-thaw cycles, durability tests were also conducted.According to the findings, lightweight cellular concrete has a special set of mechanical properties that make it perfect for geotechnical applications. Although LCC has a lesser compressive strength than ordinary concrete, its exceptional light weight results in less strain on the buildings and soils beneath them. Furthermore, LCC is suitable for applications requiring flexural resistance and load dispersion due of its relatively high tensile strength and elastic modulus.The study also emphasised LCC's durability capabilities, demonstrating its capacity to tolerate repeated loads and exposure to adverse environmental factors. This long-term stability potential of LCC is highlighted by its durability, which is important in geotechnical applications where resilience is crucial.In conclusion, lightweight cellular concrete is a good alternative for a variety of geotechnical applications due to its mechanical qualities. LCC is a versatile material that can support creative and sustainable solutions in soil stabilisation, embankment building, and other geotechnical scenarios due to its lightweight nature paired with adequate strength, elasticity, and durability. The results of this study provide important light on the mechanical behaviour of LCC, influencing engineering procedures and opening the door to its effective application in geotechnical engineering projects.

***Keywords* -** lightweight cellular concrete (LCC)

I. Introduction

A novel mix of low density and desirable mechanical qualities, lightweight cellular concrete (LCC) has emerged as an appealing option in the field of geotechnical engineering. Lightweight cellular concrete developed for geotechnical tasks is the subject of this study's investigation into its mechanical qualities. The cellular structure of LCC, which consists of multiple discrete air gaps inside the concrete matrix, makes for a lighter and more insulating material.

As the engineering community becomes more concerned with sustainable and efficient building methods, new materials that overcome the limitations of conventional ones are being investigated. With its outstanding light weight and versatile mechanical qualities, lightweight cellular concrete has gained interest as a possible solution to these problems in geotechnical applications.

The purpose of this research is to illuminate the mechanical behaviour of lightweight cellular concrete, especially in the geotechnical engineering setting. This investigation aims to provide light on the material's applicability in a variety of geotechnical contexts by assessing its suitability in terms of important mechanical parameters such compressive strength, tensile strength, elastic modulus, and durability.

The use of lightweight cellular concrete in geotechnical applications may significantly alter the standard practise of building. Geotechnical projects can benefit from increased load-bearing capacity, decreased settlements, and greater stability thanks to the rare combination of reduced density and appropriate mechanical performance.

Soil stabilisation and embankment construction both have difficulties with temperature extremes, which can be alleviated with the use of LCC's insulating properties.

This study plans to address a vacuum in the literature by conducting a series of experimental investigations and evaluations of the mechanical properties of lightweight cellular concrete for use in geotechnical applications. This study is useful for engineers, researchers, and practitioners in the field of geotechnical engineering since it sheds light on the material's behaviour under varying loading circumstances, hence facilitating the development of novel and long-lasting solutions.

Lightweight cellular concrete has the potential to positively impact geotechnical engineering practises, which will be explored in the next sections of this paper as we go into the experimental technique, results, debate, and conclusions. This study adds to the growing body of knowledge in the sector by investigating the mechanical properties of LCC, which will allow engineers to better plan and implement geotechnical projects.

II. Preparing the Materials:

The first step in making lightweight cellular concrete (LCC) is to choose a cementitious binder, such as Portland cement.

1.Aggregates: Select light, low-specific-gravity aggregates to realise the targeted LCC density.Use a foaming chemical to introduce stable air bubbles into the concrete, which will eventually form a cellular structure.

2.Mixing in the Right Amounts:How much cement should be used, how much water should be used, and what size aggregate should be used are all mix design criteria that must be determined in order to produce LCC with the desired mechanical qualities and workability.

3. Prototype Actors:Use the prepared mix to cast cylindrical or prismatic LCC specimens to exact specifications.If fibres are needed, think about what kind to use (steel, synthetic), and how wide to cut them.

4.Treatment of Specimens: The specimens need to be cured in a controlled setting, usually a curing chamber or wet environment, to get the necessary level of hydration and mechanical qualities.

5.Assessment of Compressive Strength: Using a universal testing equipment, subject cylindrical specimens to uniaxial compression. A stress-strain curve can be created by applying a load at a consistent rate until failure and collecting the load and deformation data.

6.Flexure-based Strength Tests: Test the flexural strength of prismatic samples by bending them in three or four directions. Find the load that causes the material to bend the most.

7. A Test of Tensile Strength: Tensile strength of LCC can be estimated with the help of indirect tensile tests with Brazilian disc specimens. The tensile strength can be determined using standard formulas after a diametric compressive load has been applied until failure.

8.Method for Calculating Elastic Modulus: Get the elastic modulus from the straight line in the stress-strain graph that was generated by compressing the sample.

.III. Test Models

A) Straightforward Shear Testing

Specifically, a device from the Norwegian Geotechnical Institute (NGI) (Bjerrum and Landva 1966; Dyvik et al. 1987) was used for the DSS testing. The sample was consolidated to the ideal stress in this apparatus. Eleven static DSS tests were conducted for each batch, with four distinct consolidation stressors. To be more specific, we consolidated three samples to 25, 50, and 100 kPa, and two samples to 350 kPa. Specimens were subjected to un- drained strain-controlled shearing at a rate of 5%/h, as recommended in ASTM D6528-07 (ASTM 2007), until the logarithmic relationship between time and vertical deformation stabilised, indicating that primary consolidation was complete. After measuring the maximum shear strength or 25% shear strain, the shearing phase was completed. After being withdrawn from the equipment, the specimen was dried and weighed in a dry oven for at least 24 hours. Most LCC samples were back-pressure saturated by applying cell pressure through a triaxial test assembly and a permeameter linked to the sample. The previously disclosed method was utilised to perform a static DSS test on the saturated sample. Throughout sample collection, processing, and analysis, the sample was kept submerged in water. Several LCC samples were also evaluated under wet conditions and without back-pressure saturation. Saturated specimens yielded effective shear strength parameters that were comparable to those of partially saturated (i.e. damp) specimens. The constant-volume DSS device utilised in this research has the advantage of producing results that are comparable to those obtained with fully saturated specimens.

B) Isotropically Consolidated Triaxial Tests, Both Drained and Undrained

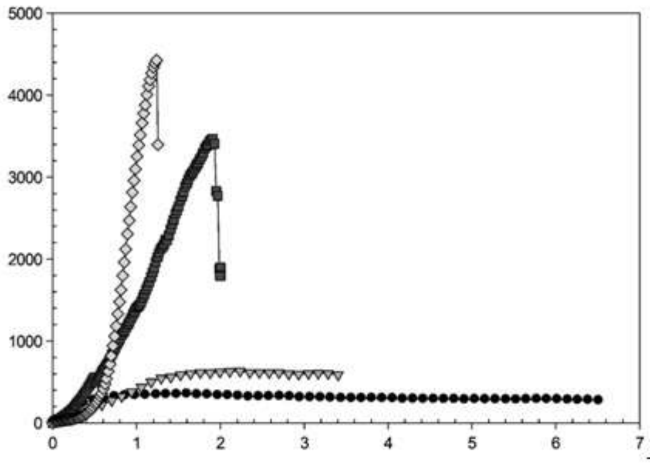
For the purpose of distinguishing between drained and undrained shear strengths, triaxial shear strength testing was conducted on cured, continuous (no apparent cracks) LCC. B levels tested to be as high as 0.94, with a wide range between samples. The loading rate was determined by combining consolidation rate measurements with testing data, as recommended by Bishop and Henkel (1967). Standard American Society for Testing and Materials D7181-11 (ASTM 2011a) and Bureau of Reclamations Standard USBR 5755 (USBR 1990) were followed as closely as possible when conducting isotropically consolidated drained (CID) triaxial testing. Like ASTM D4767-11 (ASTM 2011b), and USBR 5750 (USBR 1990), isotropically consolidated undrained (CIU) triaxial testing was conducted. The effective area of consolidated samples will be estimated using Method A. Because the samples were vesicular, filter paper wasn't necessary for pretreatment. The experiment was done with double membranes, and the data was corrected accordingly.

IV. Testing and model validation

UC Test

The vesicular portions of cellular concrete were crushed under unconfined compression (UC) stresses, according to visual examination of the LCC samples. Vertical cracks were the first signs of failure; as axial load was applied continuously, bits of LCC material began to separate from the specimen in radial directions. This kind of failure behaviour is present in concrete cylinders.The typical stress-strain curves produced from the UC tests are displayed in Fig. 1 for each tested group of specimens. The Class-II and Class-IV specimens tested showed ductile behaviour, but the specimens with cast unit weights of 7.1 and 8.6 kN=m3 tended to show more brittle behaviour.

In particular, peak strength increased as material unit weight increased. As the test unit weight of the LCC specimens grew, a decrease in the strain necessary to reach this peak strength was also seen.A typical UCS of LCC curve is dependent on the unit weight of the material tested, as shown in Fig. 1. The correlation between the test unit weight and the measured UCS is depicted in Fig. 2. Each batch tested's results are shown separately. A lower UCS was produced by an increase in the air volumes present in lighter samples (samples with lower test unit weights) when compared to the denser samples.



Axial Stress Vs Compressive Strain

Fig 1: Stress Strain Curves from UC Test

As a result, as depicted in Fig. 2, the UCS reduces as the test unit weight of the specimen does. In Fig. 2, there is also a best-fit polynomial regression line connecting the UCS to the test unit weight. Eq. (1), where UCS is the unconfined compressive strength in kPa and is the test unit weight in kN=m3, provides the equation for the regression line. This regression line's coefficient of determination is 0.94. In Fig. 2, lines that correspond to 0.5 standard deviations () from the best-fit regression are also displayed. Except for one site, all of the data were found to fall inside the boundaries defined by these lines.

DS Test

According to the results of the DS tests, Fig. 3 depicts the shear stress versus horizontal displacement behaviour of the LCC specimens under four normal stresses. The LCC batch's outcomes had a cast unit weight of 7.1 kN=m3. All LCC specimens examined had identical shear stress versus horizontal displacement; more information may be found in Tiwari (2016). The Mohr-Coulomb failure envelopes from the DS tests are shown in Fig. 4. It is evident that as the test unit weight of the specimens increases, the cohesion intercept and total friction angle of the LCC specimens both increase significantly.

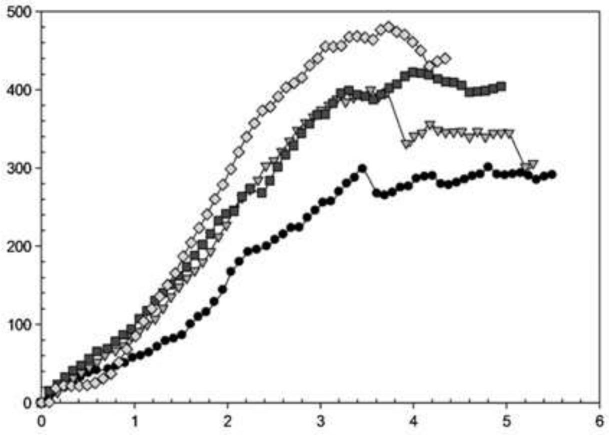


Fig 2: Horizontal Displacement Vs Shear Stress Curve

The friction angle of partially saturated LCC specimens obtained from the DS tests conforms to the phrase total friction angle employed in this study, which is noteworthy.

DSS Test

The results for a Class-II Batch-2 sample at a consolidation pressure of 100 kPa are presented in Fig. 5, together with typical curves for shear stress against shear strain and pore water pressure versus shear strain obtained from the constant-volume DSS test. All LCC specimens responded similarly, and Tiwari (2016) describes this response. The shear strain needed to reach the peak strength decreased as the normal stress increased, and vice versa for the shear stress. Likewise, when the test unit weight of the LCC specimens grew, so did the peak shear stress. As the test unit weight grew, the shear strain needed to obtain the peak strength dropped.

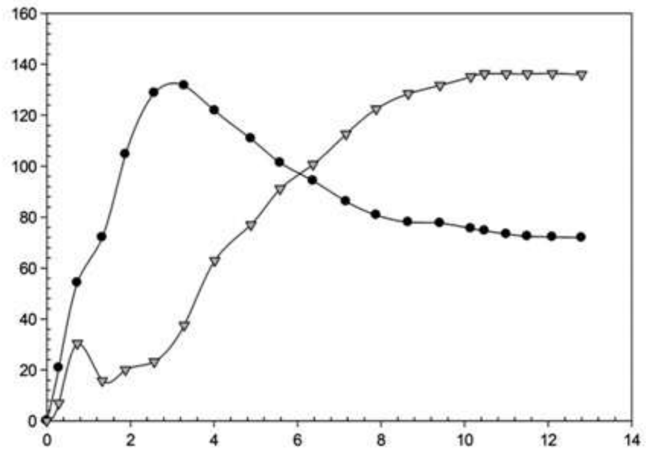


Fig.3: Shear Strain Vs Shear Stress

Figure 3 depicts the relationship between the tested LCC materials' undrained strength ratios, which are shear strength normalised by consolidation pressure. The value of the undrained strength ratio remains relatively constant when the consolidation pressure is higher than about 150 kPa. In comparison to materials with greater test unit weights, LCC materials with lower test unit weights often have slightly lower undrained strength ratios. In Fig. 7, the effective stress failure envelope is depicted, and the effect of the test unit weight of the LCC is taken into account by looking at the effective stress results obtained in the DSS device. The cohesion intercept was determined to be 36 kPa, and the effective friction angle was 35°. The graphic also includes lines that represent 0.5 standard deviations () from the failure envelope. All of the acquired data points, as can be seen, fell within these boundaries

V. Backfilling of mechanically stabilised earth walls with LCC

Current retaining/mechanically stabilised earth (MSE) wall design does not incorporate cohesion because it is widely regarded as a transient property of granular materials. When calculating the external stability of retaining/MSE walls for long-term conditions, it is recommended, at this stage of development, to use an effective friction angle of 35° and disregard cohesion. The effective friction angle may be increased by up to 40 degrees for Class-II or Class-IV materials. 7.1 kN=m3 unit weight of casting and 8.6 kN=m3 unit weight of casting The normal stresses on LCC are less than 400, 500, and 1,000 kPa, correspondingly.

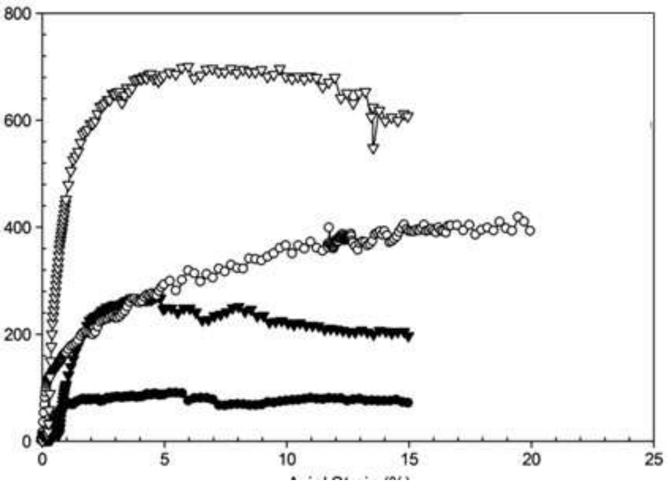


Fig.4: Axial Strain Vs Deviator Stress

Depending on engineering judgement regarding duration and bearing conditions, it may be appropriate to include cohesion in temporary construction cases. Although LCCs in typical wall conditions have a low probability of saturation, saturation is essential for accurate measurements of volume change during drained tests and generated pore pressures during undrained testing [ASTM STP977 (ASTM 1988)]. Given these considerations and assumptions, it is believed that using the effective friction angle measured under near-saturated laboratory conditions is a conservative approach. The substantially greater cohesion obtained with the DS test for unsaturated LCCs suggests that LCC backfills may be temporarily self-supporting and may not result in significant earth pressures under short-term conditions. Due to the possibility of long-term material degradation and/or saturation under field conditions, which were beyond the scope of this study, it is recommended that a traditional earth pressure approach employing an effective friction angle from saturated testing (i.e. 35°) be used to evaluate the external stability of an MSE wall.

VI.Conclusion

The objective of this investigation was to characterise lightweight cellular concrete (LCC) for possible use in earth-retaining structures. Diverse LCC samples with four distinct unit weights were subjected to shear testing with a variety of testing devices and conditions. This enabled the measurement of shear strength parameters, permeability coefficients, and earth pressure coefficients at repose. Effective stress failure bands for saturated LCC samples tested with constant-volume drained simple shear (DSS) showed an average efficient friction angle of 35° and cohesion of 36 kPa.Consistent with the DSS test outcomes, triaxial tests (both constant isotropic uplift (CIU) and constant isotropic depressurization (CID)) on back-pressure saturated LCC samples revealed an average effective friction angle of 34° and cohesion of 78 kPa.Ko values ranged from 0.20 to 0.30, whereas Poisson's ratio values ranged from 0.20 to 0.30.Class-II and Class-IV materials exhibited significant deformation when vertical stresses exceeded 300 kPa and 700 kPa, respectively. On the basis of these results, it is suggested that cohesion be disregarded and the effective friction angle of 35° for saturated LCC be applied to the materials analysed in this study. Due to the earth fill used in structures such as mechanically stabilised earth (MSE) walls, it is suggested that the external stability of earth-retaining structures be evaluated using Rankine's actively earth pressure theory. In addition, to ensure the internal stability of MSE walls and when applying Coulomb's actively earth pressure coefficients, it is recommended to measure the interface contact between reinforce and LCC materials separately. The results of the study provide helpful insights into the behaviour of LCC under varying conditions and offer recommendations for its use in earth-retaining structures. By taking into account known friction angles and cohesive characteristics, designers can make accurate choices for ideal structural design and assessment of stability.

REFERENCES

[1] Bishop, A. W., and Henkel, D. J. (1967). *The measurement of soil properties in the triaxial test*, Edward Arnold Publishers, London.

[2] Bjerrum, L., and Landva, A. (1966). "Direct simple shear tests on a Norwegian quick clay." Geotechnique, 16(1), 1–20.

[3] Caltrans. (2013). "Notice to bidders and special provisions for construction on State Highway in Contra Costa County in and near Martinez from Arthur Road undercrossing to 0.5 mile north of Mococo overhead." *Project No. 0400000967*, Sacramento, CA.

[4] Chandra, S., and Brentsson, L. (2003). *Lightweight aggregate concrete science, technology and applications*, Standard Publisher Distributors, Göteborg, Sweden.

[5] Dyvik, R., Berre, T., Lacasse, S., and Raadim, B. (1987). "Comparison of truly undrained and constant volume direct simple shear tests." Geotechnique, 37(1), 3–10.

[6] EF (Engineered Fill). (2015). "Elastizell specification section 0223." ⟨http://elastizell.com/fillspec.html⟩ (Apr. 13, 2015).

[7] Geotac (Geotechnical Test Acquisition and Control). (2005). "TruePath version 5.4.4." Houston.

[8] Maruyama, R. C., and Camarini, G. (2015). "Properties of cellular concrete for filters." *IACSIT Int. J. Eng. Technol.*, 7(3), 223–22810.R. Lakshmi and K. Rajan, "Closed Loop Control of the Two Switch Serial Input Interleaved Forward Converter Fed DC Drive"., The International Journal of Science & Technology, Vol. 2, Issue 3, pp. 45-48, 2014.

[9] Maruyama, R. C., and Camarini, G. (2015). “Properties of cellular concrete for filters.” *IACSIT Int. J. Eng. Technol.*, 7(3), 223–228.

[10] Narayanan, N., and Ramamurthy, K. (2000). “Structure and properties of aerated concrete: A review.” *Cem. Concr. Compos.*, 22(5), 321–329.

[11] Zaidi, A. A. M., Rahman, A. I., and Zaidi, N. H. A. (2008). “Behavior of fiber reinforced foamed concrete: Indentation test analysis.” *Proc., Seminar on Geotechnical Engineering*, Johore, Malaysia, 92–101.