International Journal of Civil and Structural Engineering Research ISSN 2348-7607 (Online)
Vol. 3, Issue 2, pp: (70-73), Month: October 2015 - March 2016, Available at: www.researchpublish.com

Behaviour of Shelled Compressed Earth Masonry Unit under Load

C. Egenti[1], J. M. Khatib[2]

[12]School of Architecture and Built Environment, University of Wolverhampton, Wulfruna Street, Wolverhampton, WV1 1LY, United Kingdom

Abstract: **Shelled Compressed Earth Blocks (SCEB) are compressed earth blocks with harder outer shell and inner core of less or no chemical stabilisation rammed into a single piece. The behaviour of the two different material layers when subjected to stress should be of concern in the general application of SCEB. This paper sets out to study how the two different layers co-work to resist applied load. A stress-strain test was conducted on shelled compressed earth blocks produced from the same soil type but different cement content using the optimum moisture content. The results revealed that the shell serves as a confinement resisting both lateral and axial load from the inner core and imposed load respectively.**

Keywords: **Shelled compressed earth, Weather resistance, Durability, Sustainability.**

I. INTRODUCTION

The durability of earth walls is dependent on how well the forces of erosion of its surface is resisted. The principal mechanism causing surface of earth walls is the release of the kinetic energy from rain drops impacting on the surface [1]. (Heathcote, 1995). Brooks *et al.* [2] (2003) corroborated this and further identified a second mechanism which is the erosion due to concentrated water flow on areas of the wall. The addition of cement, lime or bitumen to earth before compression changes the characteristic of earth from its unstable state of strength and volume with changing moisture conditions to a more suitable building material in the tropics [3], [4], [5], [6]. (Hammond, 1973; Hammond, 1991; Ayensu, 1996; Gidigasu, 1993). The weather resistant ability of earth walls is greatly improved when stabilised and compressed [7], [8].(May, 1984; Smith, 1987). The suitability of the above materials may be dependent on the composition of the soil as Cement is more suitable for a soil with a higher percentage of sand, while lime is more appropriate with a clayey soil as it reacts, though slowly, with clay to form a stable pozzolanic material [9] (Rigassi, 1985). However, the considerable amount of water required for lime and bitumen in process of production may restrict their use to adobe blocks and not compressed earth blocks that requires small amount of water for good compression [9] (Rigassi, 1985). The availability of these binders could also be a factor for a choice in local application. The presence of iron oxides in lateritic soil allows stabilization to occur efficiently with impressive hardening effect with little cement. There have been recommendations, in the literature, that 5 per cent to 8 per cent cement is required for the satisfactory performance of compressed earth walls [10], [11] (Venkararama and Jagadish, 1987; Asamoah-Boadu and Afukaar, 2001). However, the research conducted by Egenti *et al*. [12] revealed that, for the two soil types used for the research, 8 per cent and 12 per cent cement content are required for adequate surface resistance to weathering. The effort to reduce the overall use of cement led to the conception of shelled compressed earth block (SCEB) with an outer shell of optimum cement content while the inner core is with less or no cement [13](Egenti *et al*, 2014). This paper aims to study the behaviour of SCEB under load. Strain test was conducted by a progressive application of load.

II. MATERIALS AND METHODS

Strain and stress test is particularly relevant for a masonry unit of two material strength to observe how the two layers of different material strength behave or co-work in resisting applied load. The first Stress and Strain test was intended to assess the behaviour of shelled compressed earth block (SCEB) under load.

Several laboratory specimens of SCEB of shell composition of 10 per cent cement content and inner core of 0 and 3 per cent cement content (R10/0 and R10/3) were produced from Aviele laterite soil [12]. Load was exerted at the rate of 0.1

International Journal of Civil and Structural Engineering Research ISSN 2348-7607 (Online)
Vol. 3, Issue 2, pp: (70-73), Month: October 2015 - March 2016, Available at: www.researchpublish.com

N/mm^2 and in steps of 2KN with 60 seconds of rest to take displacement reading. Displacement read from digital gauge attached to the top steel block and stress/strain calculated [14].

III. RESULTS AND DISCUSSIONS

The results of measured displacement of different block type with increase in stress is shown in Table 1 and Figure 1.

TABLE I: DETAILS OF DISPLACEMENT WITH PROGRESSIVE STRESS APPLICATION

Block Type	**Average displacements with progressive Stress application of 0 to 8.1 N/mm^2 (δ) mm**													
	0	**0.67**	**1.33**	**2**	**2.67**	**3.33**	**4**	**4.67**	**5.33**	**6**	**6.67**	**7.33**	**8**	**8.1**
R/10/0	0	0.56	1.05	1.58	2.08	2.51	2.91	3.29	3.63	4	4.41	0.56		
R/10/3	0	1.41	2.15	2.61	2.9	3.17	3.45	3.77	4.05	4.37	4.63	5.02	5.3	5.48

R/10/0 = SCEB with 10% cement content in shell and 0% cement in core; R/10/3 = SCEB with 10% cement in shell and 3% cement in core;

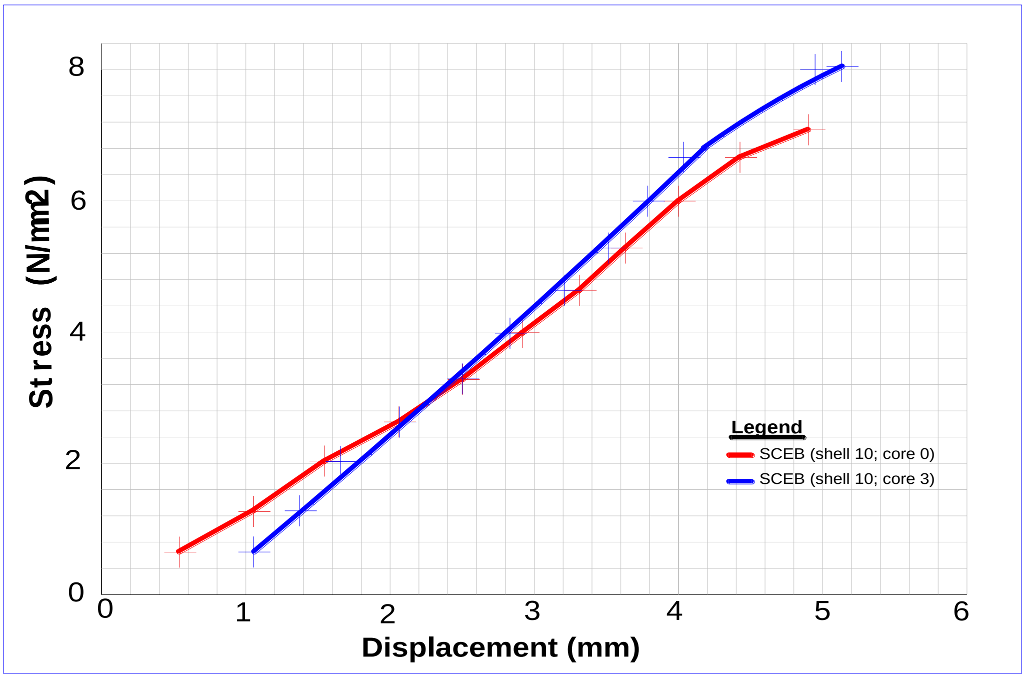

Fig. 1: Stress and displacement of different block types

The results of strain with the progression of applied stress until failure is shown in Table 2 and Figure 2.

TABLE II: DETAILED STRAIN DATA FOR DIFFERENT BLOCK TYPES

Block Type	**Strain with progressive Stress application of 0 to 8.1 N/mm^2 (δ) mm**													
	0	**0.67**	**1.33**	**2**	**2.67**	**3.33**	**4**	**4.67**	**5.33**	**6**	**6.67**	**7.33**	**8**	**8.1**
R/10/0	0	0.8	1.5	2.3	3	3.6	4.2	4.7	5.2	5.8	6.4	7.1		
R/10/3	0	1.9	2.9	3.5	3.8	4.2	4.6	5	5.4	5.8	6.1	6.7	7	7.3

R/10/0 = SCEB with 10% cement content in shell and 0% cement in core; R/10/3 = SCEB with 10% cement in shell and 3% cement in core.

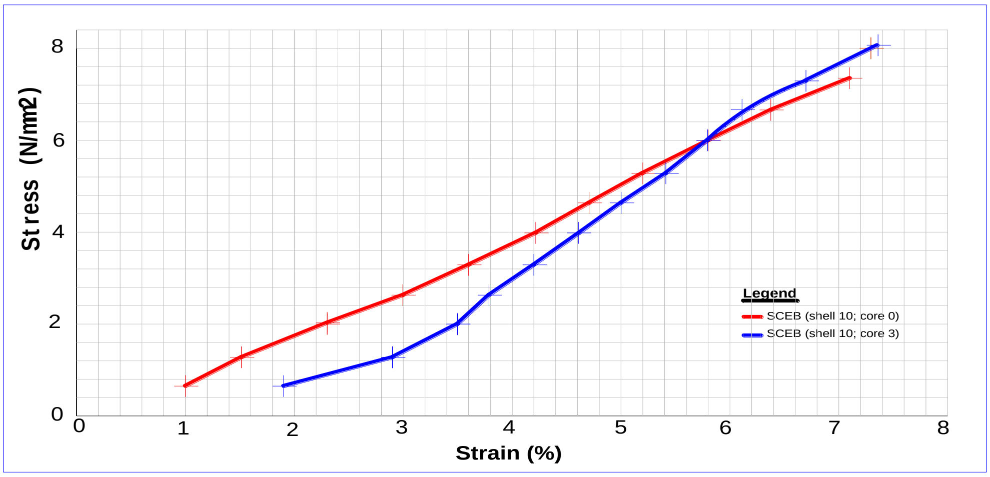

Fig. 2: Stress and strain of R/10/0 and R/10/3

Figures 1 and 2 show a normal progression of displacement and strain with increase in stress. The apparent difference in the strain curve of R/10/3 is attributable to variation in compaction pressure of the masonry unit, hence a higher strain at early stages of compression. SCEB with 10 per cent cement content in shell and 0 per cent cement in inner core (R/10/0) is more compacted, hence a consistent strain until failure at 7N/mm^2. However, the stress at failure of the R/10/3 is higher (8.1N/mm^2).

***Shear plane failure of Shelled Compressed Earth Block**:*

The shear of Shelled compressed earth block at the point of failure under a uniaxial compressive load can be appreciated in Figures 3 and 4. The shear pattern showed a significant pressure on the shell. The shear lines cut through the inner core (dark colour) and the outer shell (lighter in colour). This is an indication that the shell and the core co-worked together in resisting the load. The effect of the introduction of shell to the normal CEB had a significant effect on the compressive strength of the masonry unit. The nature of the shear failure showed an effective and supportive behaviour of the inner and outer layer co-working for loadbearing.

Fig. 3 Cracks on shell at failure

Fig. 4: Failure pattern of SCEB showing a shear of shell and core [13]

IV. CONCLUSION

Shelled compressed earth block is a resourceful derivative of compressed earth block. The study of how the shell an inner core works together in sustaining applied load was conducted in a strain test of R/10/0 and R/10/3. The results showed no unusual break or drop in the strain curve which indicate that the two different layers co-work together as a unit. The failure pattern also corroborated this with an apparent shear through the shell and core in evidence of direct impact on both layers.

REFERENCES

[1] Heathcote, K.A. (1995) Durability of Earthwall Buildings. *Construction and Building Materials* , 9(3), pp. 185-189.

[2] Brooks, K.N., Ffolliottet, P.F., Gregersen, H.M. and DeBano, L.F. (2003) *Hydrology and Management of Watersheds.* Second ed. Hoboken, USA: Wiley. p. 574.

[3] Hammond, A.A. (1973) Prolonging the life of earth building in the tropics. *Building Research Practice,* , BRRI CP/4pp. 154-163.

[4] Hammond, A.A. (1991) Housing in Africa, problems, prospects and strategies. *Journal of the Network of African Countries on Local Building Materials and Technologies* , 1(No. 4), pp. 1-6.

[5] Ayensu, A. (1996) Laterites as construction materials for rural housing. *New and Advanced Materials Emerging Technology Series* , 3pp. 42-45.

[6] Gidigasu, M.D. (1993) Lateritic Materials in Rural Housing Construction in Ghana, Final Report. *Laterite Housing Ghana Project* , 1pp. 23-98.

[7] May, G.W. (1984) Standard Engineering for earth buildings. *in* McHenry,P. G.(ed). *Adobe and Rammed Earth Buildings.* New York: John Wiley and Sons.

[8] Smith, R.G. (1987) *Small scale manufacture of stailised soil blocks* . Geneva: ILO Publications.

[9] Rigassi, V. (1985) *Compressed earth blocks: Manual of production–Volume 1.* (Translated by C. Norton.).Germany: GATE & BASIN.

[10] Venkararama, R.B. and Jagadish, K.S. (1987) Spray erosion studies on pressed soil blocks. *Building Environs* , 22(2), pp. 135-140.

[11] Asamoah-Boadu, N. and Afukaar, F.K. (2001) Application of earth building materials for low-income housing. *Journal of Applied Science and Technology (JAST),* 6(Nos. 1 & 2), pp. 40-45.

[12] Egenti, C., Khatib, J. and Oloke, D. (2013) Appropriate Design and Construction of Earth Buildings: Contesting Issues of Protection against Cost. *African Journal of Basic and Applied Sciences,* 5(2), pp. 102-106.

[13] Egenti, C., Khatib, J.M. and Oloke, D. (2014) Conceptualisation And Pilot Study Of Shelled Compressed Earth Block For Sustainable Housing In Nigeria. *International Journal of Sustainable Built Environment* [online], Available at: http://www.sciencedirect.com/science/article/pii/S2212609014000223;

[14] Egenti, C., Khatib, J. (2015) Strain in Compressed Earth Block with increase in Stress. *International Journal of Civil and Structural Engineering Research,* Vol. 3, Issue 2, (58-61), Available at www.researchpublish.com.