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RESEARCH ARTICLE OPEN ACCESS

ASSESSMENT OF STRESS- STRAIN BEHAVIOUR OF SEA SAND SANDCRETE BLOCKWALLS WITH DIFFERENT MIX RATIOS

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Abstract:

Irrespective of the wide technical reports on masonry structures, especially concrete structures there appears to exist a serious gap in research on sandcrete blocks, particularly the stress-Strain characteristics of failure of sandcrete blockwalls using sea sand. And painfully it appears no such research based on the structural model of prototype block units, which therefore constitutes the major focus of this research work. The strength evaluation tests for the physical and mechanical properties of sandcrete block units and block walls were carried out in accordance with BS 5628(1978) and NIS 74(1976). The compressive strength of blockwall with model sandcrete blocks varied with the strength of the sandcrete block units, the mortar strength and the length to height ratio of block wall. The numerical values averaged 9.30N/mm^2, 9.10N/mm^2, 6.85N/mm^2 and 6.40N/mm^2 for 1:4, 1:6, 1:8 and 1:10 mixes respectively. Thus, a systematic analysis of the effects of mix ratio, water-cement ratio, block and mortar strength on the resistance and failure mechanism of sandcrete blockwall, reported herein, provides good evidence of the reproducibility of prototype behaviour of sandcrete block wall by its ¼ -scale model. These conclusions open a wider scope and opportunity for research into sandcrete masonry structures especially, where heavier and expensive facilities for full-scale tests are not available. This study of investigation of stress- strain behaviour of sea sand sandcrete blockwalls using different mix ratios is aimed at providing knowledge on sandcrete blocks usage as walling materials in the construction of buildings.

Keywords — Stress- Strain, River Sand, Sandcrete Blockwalls

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I. INTRODUCTION

Different type of studies has been conducted on the stress-strain behaviour of masonry, especially on concrete, but it appears to be very few works on Sandcrete blocks and possibly no work on sea sand blocks. Abrams, D. P. and T. J. Paulson, (1991) and other researchers developed a non-linear stress-strain relationship for the walls they tested. Nuruddeen Muhammad Musa (2021) reported Strength Evaluation of Textile Fabric Fibre-Reinforced Sandcrete blocks using Schmidt Rebound hammer to evaluate the effect of textile fabric fibre on the strength properties of hollow sandcrete blocks

Masia, M.J., Kleeman, P.W. and Melchers, R.E., (2002) found that the stress-strain curve varied with different types of mortar and unit. Ephraim, M.E. Chinwah J.G, Orlu I.D (1990) also found a variation in stress-strain behaviour and concluded that for design purposes different moduli should be used for the different types of masonry structures.

In the working stress range, the stress-strain relationship is essentially linear, although the modulus of elasticity is expected to vary with both materials and geometric configuration.

Stress-strain data were obtained from these test
The importance of housing in socio-Economic Development cannot be over emphasized. The great needs to reduce cost of buildings and therefore increase affordability and availability of housing for the ever-increasing population of the Nigerian citizenry has features as an important policy thrust of Government over the years. This has also continued to receive attention at the various works conferences of the Ministry of Works and Housing till dates,

However, while other local materials such as lateritic concrete and sandcrete are receiving some form of research attention, there appears to be little or no conscious research efforts in alternative building designs and appropriate construction technology development. The focus of this research therefore, is to investigate the structural adequacy and economic effectiveness of application of structural sandcrete hollow blocks for housing development using ¼ scale structural model.

Houses up to four floors using masonry unit in the form of concrete blocks and structural bricks as load bearing walls (without frame) have been in use for a very long time. This is also as reported by Kalluru.Rajasekhar, M.Praveen Kumar (2021) and Marco Breccolotti, Antonella D'Alessandro , Francesca Roscini, Massimo Federico Bonfigli (2015). Sandcrete blocks (hollow and solid) are extremely popular in Nigeria as walling material used in walls and partitions. Hallow blocks have the added advantage of increased stability, material economy and relative heat insulation than the solid block.

OBJECTIVE OF STUDY

1. To study the practical utilization of sandcrete blockwalls as load bearing members
2. To increased study and research into the quality of sandcrete materials, technology and workmanship of its application in buildings.
3. To verify and ensure the safety, durability, serviceability and reliability of sandcrete block building structures.
4. To add or contribute to bridge the gap of scanty information on the application of structural modelling to blockwalls, especially the sandcrete blockwalls.

DEFINITION OF PROBLEM

The study is justified based on the actuality of the need for more serious studies into the strength and deformations of sandcrete blocks materials and structures, especially in Nigeria where it enjoys extensive application. Such research will be geared towards development of greater evidence of the structural behaviour of sandcrete wall which when incorporated into design will provide greater guarantee of safety and reliability of the structure made from it. The problem being investigated can therefore be defined as that of determination of the structural characteristics of behavior and resistance of sandcrete blockwall under various conditions of loading based on structural models.

METHODOLOGY OF RESEARCH

This research work is intended as a contribution to bridge the gap of scanty information on the application of structural modelling to blockwalls, especially the sandcrete blockwalls. Its focus consists mainly in the application of similarity mechanics and laboratory models to determine the structural behaviour of sandcrete blockwall under various loading conditions. This research work is aimed at achieving the following objectives.

a) Produce model sandcrete blocks at the selected optimum water-cement ratios, cure and erect model blockwalls for compressive strength test.
b) Select and structure loading arrangement and instrumentation.
c) To determine the structural behavior of sandcrete blockwalls under compressive loads of ¼ scale model sandcrete units.

OPPORTUNITIES AND CONSTRAINTS

A proper structural model reproduces the physical and mechanical behaviour of the complete structure; hence it presents an opportunity for research workers to test sandcrete structures in the laboratories using reduced scale structural model.

Generally, the prime motivation to conduct experiments on structural model at reduced scales is to reduce the cost and proper engineering property determination. Cost reductions comes about from three areas:

- Reduction of loading equipment and associated restraint frames
- Reduction in the restraint and load reactant frames
- Reduction in cost of fabrication, preparation, and disposal of test structure after testing

The major limitations of using structural models in a design environment are those of time and expense. In comparing physical models with analytical models, we find that the analytical models are normally less expensive and faster, and we cannot expect physical models to replace analytical modelling of structures when the analytical model procedure leads to acceptable definition of behaviour of the prototype structure. Thus, physical models are almost always confined to situations where the mathematical analysis is not adequate or not feasible. However, the behaviour of a blockwall comprising sandcrete blocks with big hollows and bonded with yet another material (mortar) require complex mathematical analysis and modelling is indicated as a most feasible study approach.

As stated earlier the strength of blockwalls depend on the block strength, mortar type and length to height ratio of wall. In the present studies, three variants of mortar and block strength were investigated. However, the loading was limited to compressive loads only.

Further work will be required to determine the flexural strength of the sandcrete blockwall in line with BS 5628 (1978) and other relevant standards.

MATERIALS FOR THE TESTS

The materials used in this research were basically sea sand, obtained from a local source in Sangana Akassa Bayelsa State: Cement (Dangote cement brand) and water from the Niger Delta University borehole, a 450X 150 X 225mm steel block mould.

PREPARATION OF TEST SPECIMENS

Model Sandcrete Blockwalls

The model blockwalls were constructed in accordance with BS 5628 (1978) to a ratio of height to horizontal dimension of 1.6, which BS 5628 allows, and were carefully placed by adopting the vertical bonding technique Becica et al (1977).

Thus, the accuracy of this method is greatly dependent on workmanship. To give vertical and horizontal alignment, an alignment board was used. The horizontal lines were set at a predetermined height proving for unit height plus mortar joint. The plumb line establishes vertical reference. Mortar was then trowelled on to the face shells of pre-soaked units while adjoining units were placed accordingly with firm pressure, causing mortar to squeeze out of the joint. This movement allows for vertical and horizontal alignment and establishment of the joint thickness. Gentle tapping with the trowel was required to further consolidate joints. After the specimen was boned, it was removed from the casting frame, and all the joints were pointed using the tip of a small trowel, as care was taken to ensure complete joint filling.

Results of the test performed on various mixes at water–cement ratio of 0.5 investigated are presented in Tables 1 to 4. Sandcrete blocks like many other structural materials appear to have elastic properties to some extent under load. This means that under increasing loads, stresses and strains are expected to increase. The strain readings were taken with DEMEC mechanical strain gauge placed at middle two-thirds of the blockwalls height. Strain readings recorded were taken immediately after loading, as shown in Plate 1 during testing of walls.

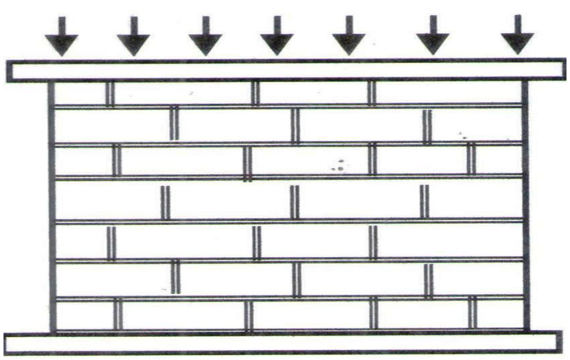

Figure 1: Loading Perpendicular to Bedding

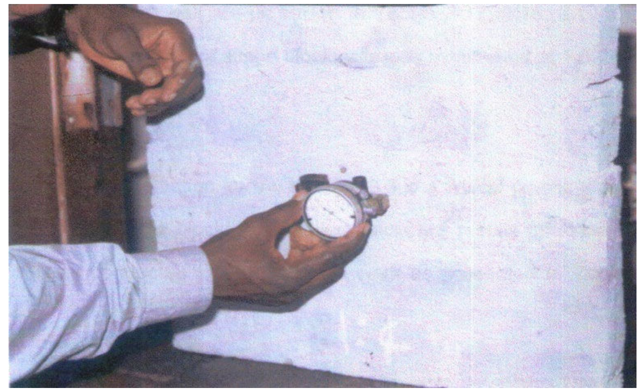

PLATE 1: MEASUREMENT OF STRAINS (X-DIRECTION)

The loads were applied uniformly over the whole area of the top of the panel.

The platen through which the load was applied was restrained against rotation to produce a flat-ended condition as shown in Figure 1.

Generally, the load was applied at an increasing rate. The individual test results for the model wall are as shown in Tables 1 to 4.

The height to length of all the blockwalls was maintained at 1.6.

TEST RESULTS

The Tables below are results obtained from the various tests conducted in this research work as presented in Tables 1 – 4

Table 1: Stress- Strain Behaviour of Model Blockwall for Mix 1:4 (L/H= *1.6)*

S/No.	Applied load KN	Compressive Stress N/mm²	Lateral Strain (x-Direction) (X10⁻⁵)	Longitudinal Strain (y – Direction) (X10⁻⁵)
1.	10.0	0.59	3.32	11.84
2.	25.0	1.48	7.60	30.40
3.	50.0	2.96	15.34	60.38
4.	100.0	5.90	29.30	115.40
5.	157.0	9.30	44.40	177.60
6.	150.0	8.9	56.02	223.2
7.	126.5	7.5	67.14	264.33

Table 2: Stress- Strain Behaviour of Model Blockwall for Mix 1:6 (L/H= 1.6)

S/No.	Applied load KN	Compressive Stress N/mm²	Lateral Strain (y-Direction) (X10⁻⁵)	Longitudinal Strain (x – direction) (X10⁻⁵)
1.	10.00	0.59	20.20	5.67
2.	25.00	1.48	51.04	14.65
3.	50.00	2.96	87.50	24.50
4.	100.00	5.90	155.40	43.90
5.	153.00	9.10	230.98	65.60
6.	145.00	8.9	285.00	81.80
7.	138.40	8.2	303.00	92.00

Table 3: Stress- Strain Behaviour If Model Blockwall For Mix 1:8 (L/H= 1.6)

S/No.	Applied load KN	Compressive Stress N/mm²	Lateral Strain (x-Direction) (X10⁻⁵)	Longitudinal Strain (y – direction) (X10⁻⁵)
1.	10.00	0.59	9.85	28.97
2.	25.00	1.48	23.00	70.98
3.	50.00	2.96	48.00	148.60
4.	100.00	5.90	98.50	303.00
5.	116.00	6.85	112.30	348.80
6.	114.80	6.80	123.40	403.20
7.	99.60	5.90	132.00	451.90

Table 4: Stress- Strain Behaviour of Model Blockwall for Mix 1:10 (L/H= 1.6)

S/No.	Applied load KN	Compressive Stress N/mm²	Lateral Strain (x-Direction) (X10⁻⁵)	Longitudinal Strain (y – direction) (X10⁻⁵)
1.	10.00	0.59	26.99	112.00
2.	25.00	1.48	67.77	275.80
3.	50.00	2.96	135.30	551.60
4.	100.00	5.90	271.90	1122.90
5.	108.00	6.40	454.50	1298.70
6.	101.00	6.00	460.00	1320.00

STRESS - STRAIN RELATIONSHIP

The graphs in figure 2 demonstrated an approximately linear stress- strain relationship extending to about 90 percent of the maximum strength of the sandcrete walls tested in this study. This is followed by a non-linear segment of the curve up to the point of failure which was more clearly expressed for blockwall made with 1:6 and mixes sandcrete blocks.

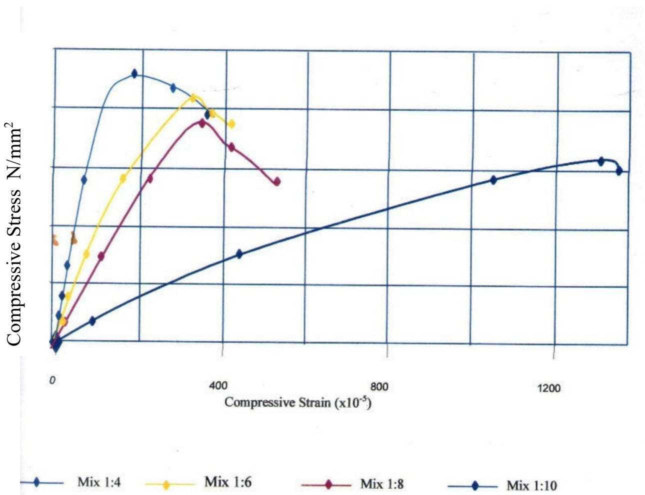

Figure 2: Stress- Strain Curves for Blockwall of Various Mixes At 28 Days and W/C = 0.5

The stress-strain curves for the various blockwall types SBW-1, SBW-2 SBW- 3 and SBW-2 tested are shown in on Figure 2, the maximum of major characteristics values are tabulated in Table 5

Table 5: Failure Loads and Stress-Strain Characteristics of Model Sandcrete Blockwalls

Mix Ratio	Lateral Strain x-Direction (x 10^{-5})	Longitudinal Strain Y-Direction (x 10^{-5})	Compressive Strength N/mm^2	Modulus of Elasticity, (kN/mm^2) $E = \frac{\sigma y}{\varepsilon x}$	Poisson's Ration, υ $\upsilon = \frac{\varepsilon x}{\varepsilon y}$
1:4	67.14	264.33	9.30	20.950	0.25
1:6	92.00	303.00	9.10	13.870	0.28
1:8	132.00	451.90	6.85	6.100	0.32
1:10	460.00	1320.00	6.40	1.890	0.35

CONCLUSION

The analysis of tests results of compressive strength of ¼ model sandcrete masonry blockwalls as a function of strength of the block units and mortar strength show that:

1. Sandcrete blockwalls exhibit a linear stress-strain relationship almost up to the maximum strength, after which, a decrease in strength was observed. The measured longitudinal and transverse strains decreased from the stronger mix of 1:4 to the weaker and mix of 1:10.
2. The maximum strains varied within narrow limits of 264.33 x 10^{-5} for 1:4 and 1:10 mixes. The compressive strength showed a reversed trend with maximum values of 9.30, 9.10, 6.85 and 6.40N/mm^2 for 1:4, 1:6, 1:8 and 1:10 mixes respectively.
3. The modulus of Elasticity ranged from 20.95N/mm^2 for 1:4 and 1:10 mixes. The corresponding value for Poison's ratio were 0.25 and 0.35.

RECOMMENDATIONS

The above conclusion has substantiated the applicability of the Code of Practice recommendation in respect of use for models for analysis and design, with reference to ¼ scale model. The unique contribution of this research is the extension of the codes recommendation to sandcrete masonry structures, thus opening the potential, scope an opportunity for research in sandcrete masonry structures especially in Nigeria and elsewhere sophisticated and heavy equipment are not available for prototype scale tests. To this end, model tests are recommended to study the strength durability and failure mechanism of the masonry structures in other stressed states including flexure, shear, dynamic loading and their combination such that the national concern on building collapses will ultimately receive a practical solution.

REFERENCES

Abrams, D. P. and T. J. Paulson, (1991), "Modeling Concrete Masonry Building Structures at One-quarter Scale", Structural journal of the American Concrete Institute, No. 88-S50, Vol.88, No .4, pp. 475- 485.

Becica, I.J. and Harris, H.G. (1977), "Evaluation of Techniques in the direct modeling Of Concrete Masonry Structures", Structural Models laboratory Report No.M77-1, Department of Civil Engineering Drexel University, Philadelphia,

British Standard Institution (1978), "Structural Use of Masonry. Part 1. Unreinforced masonry". BS 5628 (London, BSI).

Ephraim, M.E. Chinwah J.G, Orlu I.D (1990) "Mechanism Approach to Composite Frame and Infill". Proceedings of the second international Conference on Structural Engineering Analysis and Modeling (SEAM 2), University of Science and Technology, Kumasi Ghana, Vol. 1 pp 13 -26

Kalluru.Rajasekhar, M.Praveen Kumar (2021), Stress-Strain Behaviour Of Confined Normal Grade Concrete; International Journal of Professional Engineering Studies Volume Viii /Issue 3 / Mar 2017 Ijpres

Masia, M.J., Kleeman, P.W. and Melchers, R.E., (2002) "Soil Structure Interaction Modeling of Mansonry for Reliability Studies" 17th Australasian conference on the Mechanics of Structures and Materials, Gold Coast, Queensland, Australia.

Marco Breccolotti, Antonella D'Alessandro , Francesca Roscini, Massimo Federico Bonfigli (2015) INVESTIGATION OF STRESS - STRAIN BEHAVIOUR OF RECYCLED AGGREGATE CONCRETE UNDER CYCLIC LOADS Environmental Engineering and Management Journal July 2015, Vol.14, No. 7, 1543-1552 http://omicron.ch.tuiasi.ro/EEMJ/ "Gheorghe Asachi" Technical University of Iasi, Romania

Nuruddeen Muhammad Musa (2021) "Strength Evaluation of Textile Fabric Fibre-Reinforced Sandcrete blocks using Schmidt Rebound hammer", Civil Engineering Department, Kano University of Science and Technology, Wudil , Proceedings of the 19th International Civil Engineering Conference and AGM at Asaba, 13th – 15th October 2021.

Ndubura E.E (2000), "Flexural Strength of Mortars Stabilized with vegetable fibres as low-cost materials for farm structures". Journal of Agricultural Engineering and Technology.

Nigerian Industrial Standard NIS 74; (1976) "Specification for burnt clay building units".

Osunade J. A., and Fajobi (2000) "Some Engineering Properties of laterite/Cement Masonry blocks made with hand-operated moulding machine granite fine and admixtures as factors" Journal of Agric. Engineering and Tech., pp. 44-50.

Proceedings of the 8th conference of the National Council on Housing, Federal Ministry of Works and Housing, Calabar, 17th September 1997.

Proceedings of the 8th conference of the National Council on Housing, Federal Ministry of Works and Housing, Kwara State, July 1997.

Stroven P. (2002) "Damage in Compressed Masonry due to Stress Release". Proceedings of the Fourth International Conference on Structural Engineering Analysis and Modeling (SEAM 4), University of Science and Technology, Kumasi, Ghana, Vol. 1, pp. 162-17.