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COMPRESSIVE STRENGTH QUALITY ASSESSMENTS AND BATCHING ECONOMICS PARAMETERS OF SANDCRETE BLOCKS: OVBIOGIE FINE AGGREGATES AS CASE STUDY

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ABSTRACT

The article looked at the quality and economics of compressive strength of sandcrete blocks produced in Ovia North East Local Government of Edo State, Nigeria. A total of 84 sandcrete blocks were batched from mix ratios of 1:6 to 1:18 and cured for 7 to 28 days. Results obtained showed that the minimum number of sandcrete blocks per bag was 15.36 at ratio 1:6 and maximum units of 41.70 at ratio 1:18. While material production costs ranged from 396.57 naira to 791.65 naira, corresponding to 41.70 and 15.36 blocks cast per bag, the corresponding compressive strengths ranged from 0.122N/mm^2 to 1.404N/mm^2 at 28-day curing period. The results indicated that these sandcrete blocks were below the recommended minimum strengths of 3.45N/mm^2 and 2.45N/mm^2 as per NIS 87:2007 for both load and non-load bearing cases. They also did not meet the standards set by National Building Code, 2006, of 1.75N/mm^2.

1. INTRODUCTION

Principal structural components for supporting axial and lateral loads in Nigeria are masonry units, mainly sandcrete blocks usually of dimensions 225mm by 450mm by 225mm (thickness by length by height). Other thicknesses of these units include 150mm and 125mm [1] and [2]. Depending on structural configurations, sandcrete masonry units could be load bearing or non-load bearing members as well as being applied as partitions [3] and [4].

Sandcrete blocks are made from cement, fine aggregates (usually sand), and water [5], [6], and [7]. Curing for specified number of days is recommended before use. Twenty-eight days period is the normal recommended number of curing days to achieve sufficient strength for structural use [2].

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The common cementitious material used in producing the units is Ordinary Portland Cement (OPC) while the fine aggregate may be sand, free from clay or silt content to an allowable limit, while hydration water is usually from sources that are free from impurities which may affect their desired or design properties [8].

A vital production method is the batching process which means how the component ingredients are measured and mixed to produce the needed blend for casting. There are basically two of such methods viz weight (mass) and volumetric batching [9]. While the former is the recommended and a more accurate technique [9], the latter is allowed for small volume job specifications. Mechanical and manual methods of moulding are also available, with the former not only being less time consuming, but also confers more accuracy of the process which has profound impact on their structural properties [3] and [7].

Standard properties of these mansory units include the average or minimum compressive strength, water absorption, density, durability etc. [10]; standards and codes specify mixes needed to achieve required minimum compressive strength at service curing age. [11] recommends mix ratio of 1:6. In this part of the globe (Nigeria), Edo State in particular, enforcement of standards to ensure proper materials sourcing, batching, and curing is not practiced, leading to substandard products which hardly meet the specified minimum engineering requirements [12] and [13].

Batching, although done by volumetric methods and manually, are usually specified by the number of units that should be produced from a bag of cement in local construction industry in Edo State, Nigeria, especially for small- and medium-scaled construction activities. Recommended curing periods of up to twenty-eight days before deployment are usually not observed, three days of non-standard-cured blocks is the norm for construction projects.

While standards require batches to be specified in mix ratios, a mathematical model relating the number of units per cement bag, given their dimensions, to mix ratios has been derived from [14]. For quality assessment purposes, it becomes imperative to investigate the relationships between number of blocks per bag and mix ratios as well as the compressive failure strengths that result. With the foregoing in focus, field data of number of blocks cast per bag could be inputted into resulting data so as to ascertain the suitability of local practices of sandcrete blocks production and applications in Edo State, Nigeria, particularly in Ovia North East Local Government Area and its environs.

Construction failures in Nigeria is one of the major problems facing the industry and quality of materials has been identified as one of the major failure indices in construction activities [15]. Sandcrete blocks being one of the principal material elements used in the construction industry, a look at the level of quality assessment and assurance of their uses cannot be overemphasized.

In assessing the level of compliance with approved standards, notably [11] and Nigerian Industrial Standard (NIS 87:2007), as reported by [16], publications by [3], [6], [16], [17], and [18] studied the quality of blocks produced in Edo and Delta States. The majority of findings was that the samples used for these tests fell short of the requirements for both load and non-load bearing applications at 2.50N/mm^2 and 3.45N/mm^2 respectively from NIS 87:2007 and 1.75N/mm^2 from [11].

From extensive literature review done, of which some were cited above, quality assessment studies of sandcrete blocks produced in Ovia North East Local Government Area of Edo State, Nigeria and its environs are rare. This creates a geographical study gap of quality assessments and assurances of one of the most important aspects of the thriving construction industry in the locality. Moreover, being that Ovia North East is geographically contiguous to the areas covered by existing literature, the possibility of non-compliance of blocks produced from its location is statistically high which justified the study carried out in this article about characterizing sandcrete blocks produced there for strength compliance.

In order to address this yawning gap in literature availability, this article looked at the batching properties of sandcrete blocks produced from fine aggregates samples got from one of the popular sources in the locality of study. It went further to do a comparative analyses outcome from two other locations where fine aggregates are sourced. This provided a more holistic data availability for sandcrete mansory blocks production in the aforementioned locality of research interest.

This article explored the quantitative connections between units of sandcrete blocks produced from one bag of OPC and compressive strength development at different curing periods. Also explored is the relationship existing between the number of units from one OPC bag and mix ratios of batching while also considering the economic material costs per unit of the blocks. With these data, the number of units (forty) per OPC bag used for local production of 125mm thick sandcrete blocks were correlated with its 28-day curing strength to determine if the recommended minimum compressive strengths were met with respect to [11] and NIS 87:2007.

A regime of curing periods considered were 7, 14, 21, and 28 days while the mix ratios ranged from ratio 1:6 to 1:18, increasing with value of 2 for fine aggregates components sourced from Ovbiogie, Ovia North East Local Government Area of Edo State, Nigeria. All batches were done volumetrically.

2. METHODS

2.1 Materials

Materials were OPC, 42.5 Grade, Dangote brand; fine aggregates from Ovbiogie, Ovia North East Local Government Area, Edo State, Nigeria; water from Civil Engineering Structural Laboratory Section in the University of Benin, Benin City, Edo State, Nigeria.

2.2 Apparatus and Equipment

A Universal Testing Machine (UTM) was the main equipment used for data acquisition (compressive strength) of samples at the end of curing ages.

2.3 Batching

For four curing periods of 7, 14, 21, and 28 days, seven mix ratio cases of 1:6, 1:8, 1:10, 1:12, 1:14, 1:16, and 1:18, three samples were batched and cast for each scenario giving a total sample size of 3 x 7 x 4 = 84 specimens. Each sample were of size 125 x 450 x 225mm^3 (thickness by length by height). A water-cement ratio of 0.55 was applied to the batches to determine the needed quantity of hydration water.

2.4 Models

2.4.1 Batching Number of Masonry Units Per Bag

If x:y:z (cement:fine:coarse) represent the mix ratio of a batched mix, by volume, then:

Number of sandcrete masonry units per bag is given as (with inference from [14]):

$$\left[\frac{1}{(lbh)-J}\right].\left[\frac{(x+K)M}{xD(1+W)}\right] \quad (1)$$

where:

l = length of block i.e 450mm

b = width of block i.e 125mm

h = height of block i.e 225mm

J = hollow volume of block i.e zero hollows

x = cement ratio i.e 1 for each computation

K = total aggregate ratio i.e y+z: z = 0 for no coarse aggregates; y inputted as 6, 8, 10, 12, 14, 16, and 18,

D = bulk density of cement (1440Kg/m^3)

M = mass per bag of cement (50Kg)

W = waste, bulking, shrinkage etc. factor (25%)

2.4.2 Batching Economics

With inference from [14], and if:

E_i = bulk density vector for binders,

H_i and N_i are binders and aggregate ratios by volume respectively,

R is defined as $\sum_{i=1}^{n} H_i + \sum_{i=1}^{j} N_i$, (2)

where R represents total batch mixes ratio,

Let P_i and Q_i represent the corresponding vectors for binder bags and aggregates trips per m^3 of batched mixes respectively,

$$\text{then } P_i = \frac{\left[\frac{H_i}{R}(1+W)E_i\right]}{M_i}, Q_i = \frac{\left[\frac{N_i}{R}(1+W)\right]}{V_{trip}} \quad (3)$$

M_i = vector for binder masses per bag.

V_{trip} = vector for volumes per trip of aggregate.

Taking the original fixed water-cement ratio (by mass) to be c, water per m^3 of mixed batches in litres =

$$c\frac{\left[\frac{H_i}{R}(1+W)E_i\right] x\ 1000}{G_w} = L_i \quad (4)$$

where W = waste, bulking, shrinkage etc. factor,

G_w = water density in Kg/m^3

The materials economics of batching were modelled as:

$$\sum_{i=1}^{n} P_i\,(N_c)(S)(A_i) \quad (5)$$

$$\sum_{i=1}^{j} Q_i\,(N_c)(S)(B_i) \quad (6)$$

$$\sum_{i=1}^{n} L_i\,(N_c)(S)(C_i) \quad (7)$$

S = volume of a single sandcrete block

N_c = number of sandcrete blocks under consideration

A_i = binders respective cost centres

B_i = aggregate respective cost centres

C_i = water respective cost centres

1t should be noted that in all cases i= 1,2,3, ------n or j as the case may be.

For this study, the following parameters were deployed (with i and j = 1 for single binder and aggregate), referenced as [19], [20], and [21]:

E_i = 1440kg/m^3 (cement); 1600kg/m^3 (fine);

H_i and N_i = 9m^3 (fine), 50kg (cement);

W = 25%,

S = 0.0127m^3, from a single masonry block dimensions,

N_c = 1;

A_i = 10,000.00 naira per bag (cement);

Bi = 90,000.00 naira per trip (fine);

C_i = 5.00 per litre (water) from 50,000.00 naira per 10,000.00 litre-tanker

c = 0.55.

Excel spreadsheets were used to compute outcomes from equations (1) to (7) and all material cost were based on market survey as at 25th day of April, 2025.

RESULTS AND DISCUSSION

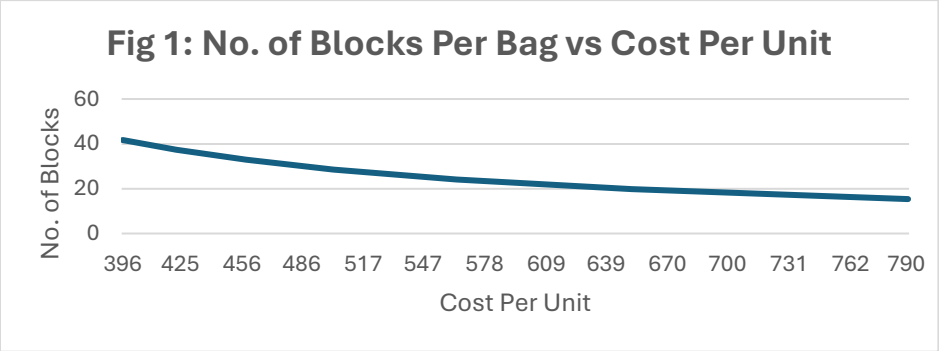
Table 1: Mix Ratios, Units Per Bag, Costs Per Unit, and Compressive Strength

Mix Ratios	No. of blocks Per Bag	Costs Per Unit (Naira)	Strength (N/mm^2)			
			7 days	14 days	21 days	28 days
1:6	15.36	791.65	0.934	1.268	1.340	1.404
1:8	19.75	652.64	0.788	1.089	1.146	1.194
1:10	24.14	564.18	0.658	0.914	0.966	1.007
1:12	28.53	502.94	0.513	0.717	0.758	0.795
1:14	32.92	458.03	0.356	0.512	0.544	0.572
1:16	37.31	423.69	0.270	0.378	0.409	0.424
1:18	41.70	396.57	0.080	0.112	0.117	0.122

From table 1, the mix ratios and number of units cast per bag were correlated in same direction. Number of units per bag was modelled from equation (1). The explanation for this is that as more fine aggregates were put per bag for casting of the units, more contents of materials were available for casting. The implication of this is, as the mix became richer in cement (lower mix ratios) per

unit, fewer blocks were cast from the materials per bag, signifying that higher number of units per bag gives higher numerical mix ratios. This could be put to use practically by applying the number of units cast from a bag to determine the corresponding mix ratios applicable to the batched mixes.

Situating the results of the relationship between units per bag and mix ratios, the trend is in line with the findings of [19] and [20] where Okuaihe and Evboneka were the sources of fine aggregates. [19] and [20] in their findings corroborated the values obtained from this study with the range of number of block units per bag going from 15.36 to 41.70 for the range of mix ratios of 1:6 to 1:18 respectively.



As shown in Figure 1, the variations between number of units per cement bag and the economic cost of materials in the course of production is an inverse one with costs ranging from 396.57 naira to 791.65 naira for 41.70 and 15.36 units. It means that there is reduction in costs as the number increased which implies also that increase in mix ratios results in less cost of production due to earlier discussed relationship between mix ratios and number of units (Table 1). Practically, the significance of Figure 1 is a link of number of units per bag to costs and invariably a correlation between costs and mix ratios (Table 1).

[19] and [20] in their studies also had similar results to Figure 1, but with the costs ranging from 379.09 to 775.83 and 449.03 to 839.11 (all in naira) respectively.

All cost values could be adjusted in the future using an average inflation value of 16.30% obtained from an averaging of inflation rate from 1960 to date in Nigeria [22].

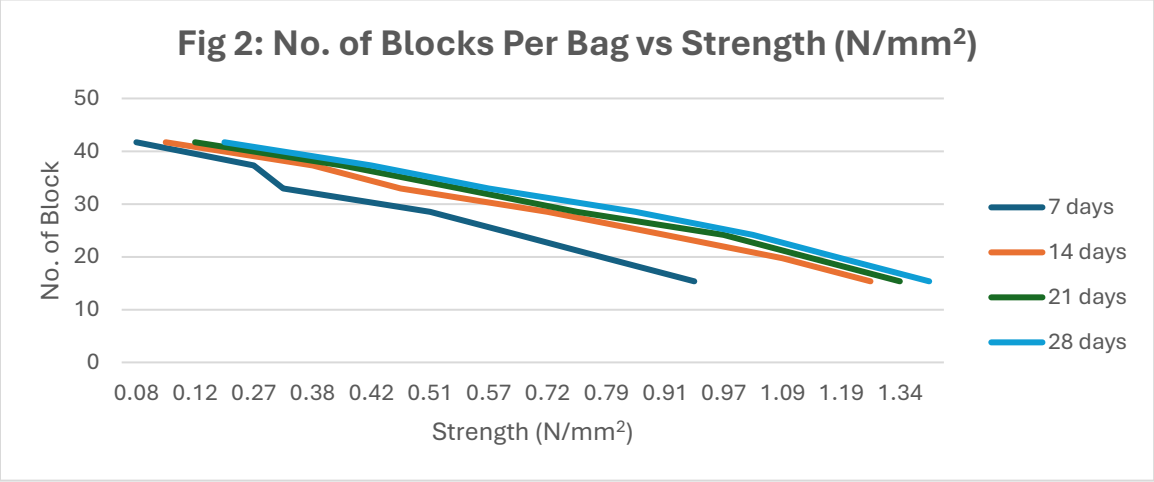
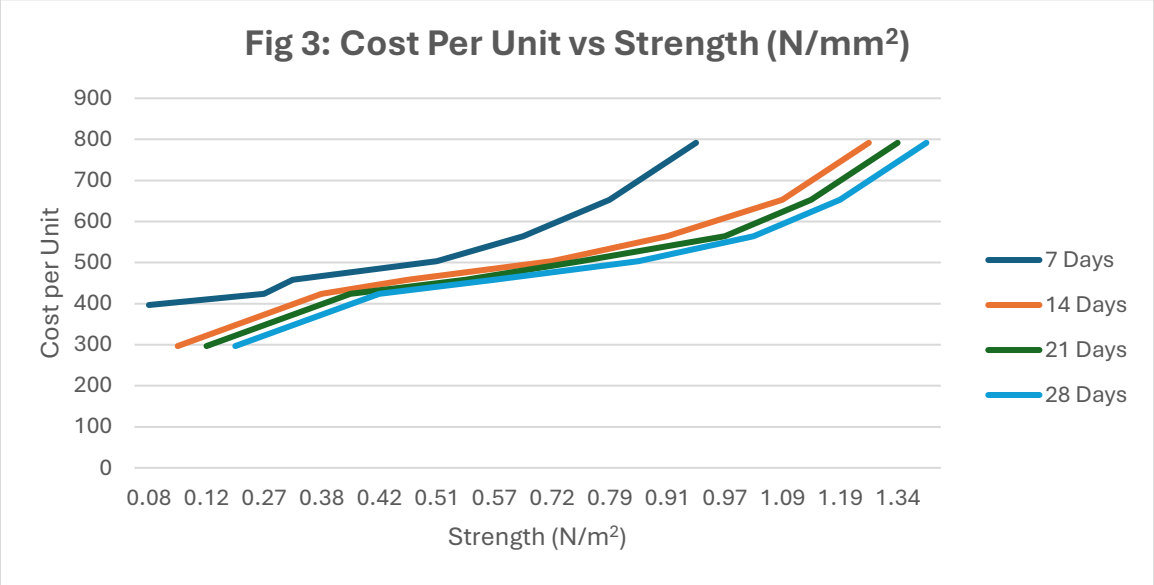


Figure 2 shows the relationship among the number of units per bag of sandcrete blocks cast for each curing number of days and their compressive strength. It shows that for each period, as the number increased, the strength had an inverse effect. From Table 1, since the number of units per bag is inversely proportional to mix ratios, it then implies that the latter also has an inverse direction with compressive strengths. These trends were got for all curing ages of 7, 14, 21, and 28 days. The highest strength at the maximum curing age of 28 days (the recommended age for loads application) was 1.404N/mm^2 while the lowest strength at same age was 0.122N/mm^2.

Situating above 28-day results alongside [19] showed that at 28 days, they got their corresponding values of maximum and minimum compressive strengths to be 1.240N/mm^2 and 0.120N/mm^2 respectively while [20] reported their figures as 3.058N/mm^2 and 0.378N/mm^2 respectively.

The implication of our strength figures at the service age of 28 days is that when matched against the statutory benchmarks of National Buildng Code, 2006 [11] and Nigerian Industrial Standard 87:2007 [3], [6], [16], [17], and [18], sandcrete blocks cast from Ovbiogie fine aggregates do not meet required standards both for load and non-load bearing structural applications, when casting from 15.36 to 41.70 units per cement bags. Evboneka fine aggregates sandcrete blocks, like those from Ovbiogie, do not meet the minimum required standards with regard to compressive strength for structural applications for same range of blocks cast per bag whereas sandcrete blocks made from Okhuaihe met NIS 87:2007 standard for non-load bearing blocks at 15.36 blocks per bag at 28-day curing, and also met Nigeran Building Code, 2006, standards at 15.36 and 19.75 blocks per bag at 28 days of curing.

For most load-bearing sandcrete blocks in Benin City, Edo State, Nigeria, units of 125mm thick masonry units are cast at 40 numbers per cement bag which, by the result of this study, indicates that such specifications do not meet the aforementioned practice standards.



Cost per unit correlated in same direction as ultimate failure strength in compression (Figure 3). It shows that as cost of batching increased, strength increased also. A maximum strength of 1.404N/mm^2 was got at 28 days curing age while the minimum for same age was 0.122N/mm^2 corresponding to 791.65 naira and 396.57 naira respectively.

The explanation for this trend is that as the mix ratios, as well as the number of units per cement bag, increased for a unit volume of sandcrete blocks, the cement content decreased, hence conferring a reduced strength per unit area in compression; however, for same unit volume, there were more quantities of fine aggregates and the increase cost of fine aggregates could not counter-balance the reduced cost of cement in the batches.

A utility value of these results is one where cost reduction by way of increased number of units per bag or mix ratios could be correlated with their reduced strength and ascertaining if the benchmark values have been met or not at a desired cost per unit value.

Summary of key findings is:

1. There is same direction correlational relationship between mix ratios and number of units produced per bag of cement ranging from 15.36 to 41.70 for ratios 1:6 to 1:18 respectively.
2. We had an inverse trend between number of blocks cast per bag and material cost per unit, cost per unit ranging from 396.57 naira to 791.65 naira corresponding to units per bag of 41.70 to 15.36 respectively
3. Like findings 2. above, for curing age of 7, 14, 21, and 28, as number of units per bag increased the compressive strength reduced. Particularly, for 28 days curing duration, at 15.36 and 41.70 units per bag, we had 1.404N/mm^2 and 0.122N/mm^2 strength values respectively.
4. From finding 3. above, blocks cast from Ovbiogie fine aggregates are not suitable for both load and non-load bearing structural applications as recommended by National Building Code, 2006, and Nigerian Industrial Standard, NIS 87:2007.
5. With increasing cost per unit of producing sandcrete blocks, the compressive strength also increased.
6. Comparatively, out of the three sources of fine aggregates for sandcrete blocks making in Ovia North East Local Government Area of Edo State, Nigeria, viz Okhuaihe, Evboneka, and Ovbiogie, only those sourced from Okhuaihe met a part of NIS 87: 2000 standard: non-load bearing cases at 15.36 blocks per bag at 28-day curing period. Again, only Okhuaihe fine aggregates scaled the National Building Code, 2006, compressive strength hurdle at 15.36 and 19.75 blocks per bag at 28-day curing period.

CONCLUSION

This study has shown that mix ratios have proportional relationship with the number of mansory block units which could be produced from a bag of cement whereas as the latter increased, cost of producing units of the masonry blocks reduced. Moreover, compressive strengths were reduced while increasing the number of units per bag of cement for samples when cured for 7, 14, 21, and 28 days. It was also found out that increasing material cost of production per unit had the effect of also increasing the compressive strength. Sandcrete block units made from Ovbiogie fine aggregates are not safe, with respect to compressive strength parameters, for structural applications (load and non-load bearing) as they failed to meet the required minimum standards. The usual practice of deploying 40 block units cast per bag for both load and non-load bearing structural applications failed to meet minimum standards at 28 days service period.

By way of recommendation, in order to meet the required standard, a mix ratio richer than 1:6 should be investigated using same methodologies deployed in this article to arrive at lower than 15.36 units per bag. This may give some strengths which could meet the requirements for structural applications.

REFERENCES

[1] Agbi, G. G., Akpokodje, O. I., and Uguru, H. (2020): Compressive Strength of Commercially Produced Sandcrete Blocks within Isoko Metropolis of Delta State, Nigeria, Turkish Journal of Agricultural Engineering Research (TURKAGER), 1 (1), p. 92

[2] Alejo, A. O. (2020): Comparison of Strength of Sandcrete Blocks Produced with Fine Aggregates from Different Sources, Nigerian Journal of Technology (NIJOTECH), Volume 39, Number 2, April 2020, pp. 332 - 333.

[3] Akpokodje, O. I, Agbi, G. G., Uguru, H, and Nyorere, O. (2021): Evaluation of the Compressive Strength of Commercial Sandcrete Blocks in Two Metropolises of Delta State, Nigeria, Applied Journal of Physical Science, Volume 3 (2), April 2021, pp. 61- 62.

[4] Ibrahim, M, Yerima, M. A, Danbuba, Z., Masud, A. Y., and Ibrahim, M. A. (2025): Quality Assesment of Commercial Sandcrete Hollow Blocks Produced in Kaura District, Abuja, Nigeria, Arid Zone Journal of Engineering, Technology, and Environment, Volume 21 (1), p.157.

[5] Abubakar, M. and Omotoriogun, V. F. 2022): Quality Assesment of Commercial Sandcrete Blocks in Minna Metropolis, Niger State, Nigeria, Nigerian Journal of Technology (NIJOTECH), Volume 41, Number 2, March 2022, p. 222.

[6] Nyorere, O., Akwenuke, M, and Tachere, O. Z. (2023): Investigation into the Mechanical Properties of Commercial Sandcrete Blocks Produced in Nigeria: A Case Study of Warri Metropolis, Turkish Journal of Agricultural Engineering Research (TURKAGER), 4 (2), pp. 251, 252.

[7] Ambrose, E. E., Etim, R. K., and Koffi, N. E. (2019): Quality Assessment of Commercially Produced Sandcrete Blocks in Parts of Akwa Ibom State, Nigeria, Nigerian Journal of Technology (NIJOTECH), Volume 38, Number 3, p. 586.

[8] Omoregie, A. and Alutu, O. E. (2006): The Influence of Fine Aggregates Combinations on Particle Size Distributions, Grading Parameters, and Compressive Strength of Blocks, Canadian Journal of Civil Engineering, 33 (10), 1271 – 1270, 2006, pp 9 – 11.

[9] Franklin, S. O. and Kaboro, P. N. (2024): Batching Methods and their Influence on Properties of Concrete- A Limited Study, International Research Journal of Engineering and Technology (IRJET), Volume 11, Issue 01, January, 2024, p 159.

[10] Shetty, M. S. (2005): Concrete Technology: Theory and Practice, S. Chand and Company, New Delhi, India, pp. 298, 350, 355, 510.

[11] National Building Code (2006), Federal Republic of Nigeria, First Edition, Lexis Nexis Butterworths, Durban, South Africa, p. 317.

[12] Anigbogu, N. A. and Anunike, E. B. (2014): Standard of Materials Specifications, their Implementation, and Enforcement on Building Construction Projects in Nigeria, ATBU Journal of Environmental Technology, 7, 1, December, 2014, p. 43.

[13] Ichendu, C., Ejike, A., Irimiagha, G. F. (2024): A Review of Negligible Factors Inimical to Building Failures in Nigeria: Architectural View, Studies in Art and Architecture, Volume 3, Number 3, September 2024, p. 37

[14] Dutta, B. N. (2007): Estimating and Costing in Civil Engineering, Twenty Sixth Edition,UBS Publishers, New Delhi, India, p 480.

[15] Oke, A. E. (2011): An Examination of the Causes and Effects of Building Collapses in Nigeria, Journal of Design and Built Environment, Volume 9, December, 2011 pp 44, 46.

[16] Edobor, O. K. (2023): Proliferation of Sandcrete Block Industries in Nigeria: A Quality Assessment of Industrial Mould Blocks in Benin City, Edo State, Nigeria, International Journal of Functional Research in Science and Engineering, Volume 1, Issue 2, Semptember 2023, pp. 66, 67.

[17] Ebhodaghe, E. D. (2024): Proliferation of Sandcrete Block Industries in Nigeria: A Quality Assessment of Industrial Mould Blocks in Benin City, International Journal of Functional Research in Science and Engineering, (3) 1, 2024, p 11.

[18] Agbi, G. G., Akpokodje, O. I., and Uguru, H. (2020): Compressive Strength of Commercially Produced Sandcrete Blocks within Isoko Metropolis of Delta State, Nigeria, Turkish Journal of Agricultural Engineering Research (TURKAGER), 1 (1), p. 91.

[19] Onorimuo, E. R. and Omorowa, C. O. (2021): Characterizing the Compressive Strength and Properties of Sandcrete Blocks, Bachelor of Engineering Project, Civil Engineering Department, University of Benin, Benin City, Nigeria, pp. 34, 55 - 61.

[20] Ikponmwonsa, A. and James, F. W. (2021): Characterizing the Compressive Strength Properties of Sandcrete Blocks Using Okhuaihe FineAggregates, Bachelor of Engineering Project, Civil Engineering Department, University of Benin, BeninCity, Nigeria, pp 33, 57 - 71.

[21] Ikonne, C. S. and Atemire, J. O. (2021): Characterizing the Compressive Strength Properties of Sandcrete Blocks Using Ovbiogie Fine Aggregates, Bachelor of Engineering Project, Civil Engineering Department, University of Benin, Benin City, Nigeria, pp 31, 47 - 62.

[22] Macrotrends (2025): Historical Inflation in Nigeria since 1960, Retrieved from www.macrotrends.net