Int. j. adv. multidisc. res. stud. 2024; 4(3):306-315

Received: 27-03-2024
Accepted: 07-05-2024

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Compressive Strength Characterization of Aged Stacked Sandcrete Masonry Blocks: Advancing Building Industry Practices and Quality Control

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Abstract
The work addresses development of a sampling chart for long-term strength and durability characterization of aged stacked sandcrete blocks produced from sea sand, which appears to have significant gaps in literature. Buildings constructed with sea sand blocks in the region experienced serviceability complications with massive deterioration and degradation of strength in blockwalls that appears in powder form with associated cracks and exhibits failure modes in the buildings due to high salinity. Sangana located within latitude 4.3839° North; longitude 5.9938° East and Amassoma latitude 4.9731° North; longitude 6.1090° East in the Niger Delta area of Nigeria. A total of 288 samples, including 144 each of stacked River Sand and Sea Sand blocks of ages 10 and 6 years respectfully were investigated. The stacked blocks for River Sand and Sea Sand shows a strength loss of 44.13% and 62.97% respectfully, due to exposure direction to driving rain and North-East trade winds. These conclusions open a wider scope and opportunities for research into sea sand masonry units and walls.

Keywords: Sampling Chart, Sandcrete Blocks, River Sand, Sea Sand

Introduction

This research relies on magnanimous real-life observations from my involvement in project monitoring, inventory and documentation activities in Bayelsa State Government of Nigeria within 2012 to 2020. Selected locations in Akassa communities and Amassoma all in Bayelsa State Nigeria are used in this study. The experience of abandoned or aged stacked sandcrete blocks and building projects cuts across the country Nigeria and under developed countries. The Bayelsa State in the equatorial rain forest belt is of special interest for its characteristics of oil exploration activities resulting to torrential rains, acid rain, and high temperatures especially in communities along the oil rich coastal region of Niger Delta, Nigeria (Wenapere and Ephraim 2009; Sri Lakshmi *et al*., 2017) [39, 38].

An examination of projects in the region shows that abandoned or aged sandcrete blocks and uncompleted block buildings / works are subjected to varyingconditions of exposure and their possible combinations. These include sandcrete blocks exposed on one, two or more faces to seasonal alternate wetting and drying, driving rain, and insolation. In addition, these exposed blocks, whether in the works or storage stacks on site, simultaneously also experience stressesdue to their self-weight and the weight of the overbearing layers. This work on the Compressive Strength Characterization of Aged Stacked Sandcrete Masonry blocks will add to the Body of knowledge in Sandcrete block works.

Research on sandcrete blocks made with river sand, including short-term exposures, has been conducted by a large number of researchers, and the technical literature is sufficiently extensive in this regard (Abrams and Paulson, 1991; Wenapere and Orumu 2021; Sheikh *et al*., 2017; Ikechukwu 2012; Wenapere and Yabefa, 2021; Oyekan and Kamiyo. 2011; Abdou, *et al*., 2006; Aderibigbe, *et al* 2017, Aiyewalehimi and Tanimola 2013; Aguwa, 2010; TMS 402/602, 2016; Osunade and Fajobi 2000; Masia, *et al*., 2002; Kucche *et al*., 2015; Tanaz *et al*., 2020; Songsong *et al*., 2022; Sarah *et al*., 2021; Singh and Munjal, 2017; Rahgozar and Hosseini 2017; Phaiju and Pradhan, 2018) [1, 40, 37, 18, 41, 25, 2, 3, 6, 7, 33, 36, 35, 34, 32, 30, 29, 28, 27, 26].

However, to guarantee the proper decision making on the re-useability of exposed elements, long-term investigations of River Sand Sandcrete (RS) and Sea Sand (SS) sandcrete blocks are presented in this study. Unfortunately, there are much fewer research studies on the effects of the technical qualities of sandcrete blocks exposed to long-term environmental agents, and

none on sandcrete blocks produced using sea sand. In this regard, project sites with history of long suspension or abandonment naturally provide live opportunity for such a study for both categories of blocks RS (River Sand) and SS (Sea Sand) as the case of this study.
One of the major constraints in structural integrity studies in the Niger Delta region of Nigeria is the absence of historical records about building projects. This includes the lack of authorized design calculations, drawings, specifications details, and even dates. These difficulties are encountered even during the forensic audit, analysis and investigation of structural failures and collapses. The approving, development control and monitoring agencies need to develop and maintain harmonized projects inventories with a view to creating a comprehensive and reliable database.

Research gap

The in-depth review of previous studies in the field of masonry blocks has revealed several research gaps that have not been adequately addressed. The history of stacked sandcrete blocks' strength is not established. The strength history of stacked sandcrete blocks has not been thoroughly studied. Understanding the evolution and development of stacked sandcrete blocks over time, including the techniques, materials, and construction practices employed in different periods, is an area that requires further investigation that this study will address.

Materials and Methods

Sample description

The research utilized various sources of materials, which can be categorized into two. Namely: Materials and field areas. A total of 288 block units, including 144 Aged River Sand (ARS) sandcrete block specimens, 144 Aged Sea Sand (ASS) sandcrete blocks. As shown in Plates 1 and 2. The aged sandcrete blocks made from sea sand and river sand were obtained from Sangana and Amassoma communities, respectively. These blocks served as reference samples for comparative studies and evaluations of the long-term strength and durability of sandcrete blocks. The production history including the mix ratio and age of the blocks were previously noted and used in this research. The field area used for the research is Sangana – Akassa located within latitude 4.3839° North; longitude 5.9938° East and Amassoma latitude 4.9731° North; longitude 6.1090° East in the Niger Delta area of Nigeria. This field area likely represented the specificcoastal region in the Niger Delta where the study was conducted. The field area is selected based on its relevance to the research objectives and the presence of buildings constructed using sandcrete blocks.

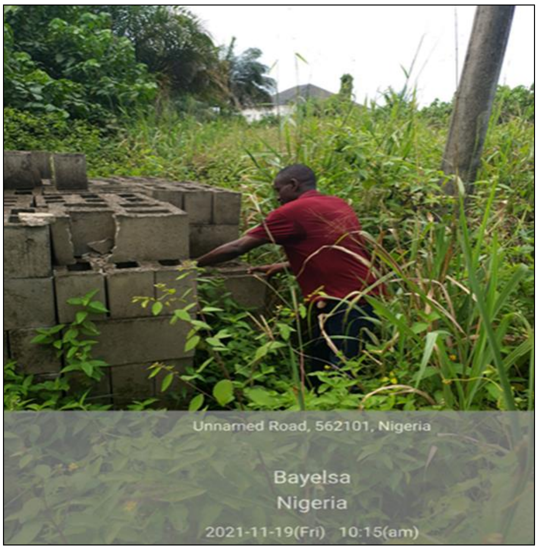


Plate 1: Aged Sea Sand (SS) sandcrete blocks at Sangana

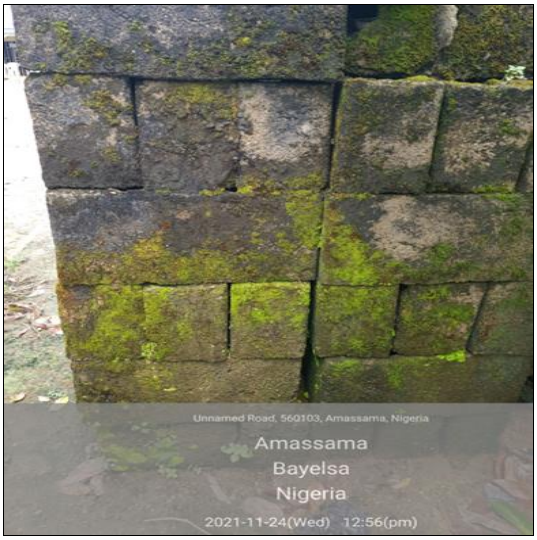
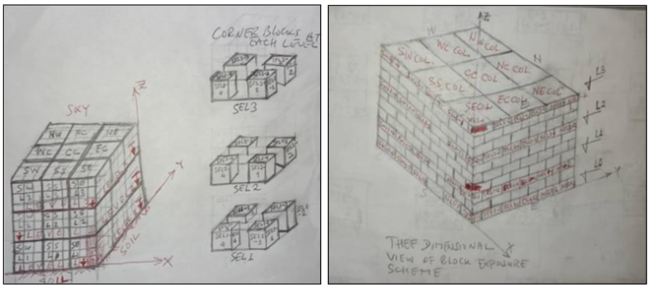


Plate 2: Aged Stacked River Sand (RS) blocks at Amassoma

Methods of study design

The study designed field inspection and sampling charts for the aged Sandcrete Blocks Exposed to Seasonal alternate wetting, drying, driving rain and flood. The charts are designed based on the direction of exposure and layers of stack. As illustrated in Fig 1. They were properly labelled as sea sand sandcrete or River sand sandcrete aged blocks. The charts are shown in Figures 2 to 9 for both sea and river sand aged blocks.



(a) (b)

Fig 1: (b) Model Block Work (a) Model Block Work Sections

Note:
SSE= Sea sand blocks in South East direction exposure,
SEC= Sea sand blocks in East Central direction of exposure,
SNE=Sea sand blocks in North East direction of exposure,
SSS= Sea sand blocks in South- South direction of exposure,
SCC= Sea sand blocks in Central Core direction of exposure,
SNC =Sea sand blocks in North Central direction of exposure,
SSW= Sea sand blocks in South West direction of exposure,
SWC = Sea sand blocks in West Central direction of exposure,
SNW = Sea sand blocks in North West direction of exposure,
RSE= River sand blocks in South East direction exposure,
REC= River sand blocks in East Central direction of exposure,
RNE=River sand blocks in North East direction of exposure,
RSS= River sand blocks in South- South direction of exposure,
RCC= River sand blocks in Central Core direction of exposure,
RNC =River sand blocks in North Central direction of exposure,
RSW= River sand blocks in South West direction of exposure,
RWC = River sand blocks in West Central direction of exposure,
RNW = River sand blocks in North West direction of exposure.

SNWL0-4	SNWL0-3	SNCL0-4	SNCL0-3	SNEL0-4	SNEL0-3
SNWL0-1	SNWL0-2	SNCL0-1	SNCL0-2	SNEL0-1	SNEL0-2
SWCL0-4	SWCL0-3	SCCL0-4	SCCL0-3	SECL0-4	SECL0-3
SWCL0-1	SWCL0-2	SCCL0-1	SCCL0-2	SECL0-1	SECL0-2
SSWL0-4	SSWL0-3	SSSL0-4	SSSL0-3	SSEL0-4	SSEL0-3
SSWL0-1	SSWL0-2	SSSL0-1	SSSL0-2	SSEL0-1	SSEL0-2

Fig 2: Showing sampling chart of ground level Lo of aged sea sand sandcrete blocks of SW, SS, SE, EC, NE, NC, NW, and WC direction of exposure

SNWL1-4	SNWL1-3	SNCL1-4	SNCL1-3	SNEL1-4	SNEL1-3
SNWL1-1	SNWL1-2	SNCL1-1	SNCL1-2	SNEL1-1	SNEL1-2
SWCL1-4	SWCL1-3	SCCL1-4	SCCL1-3	SECL1-4	SECL1-3
SWCL1-1	SWCL1-2	SCCL1-1	SCCL1-2	SECL1-1	SECL1-2
SSWL1-4	SSWL1-3	SSSL1-4	SSSL1-3	SSEL1-4	SSEL1-3
SSWL1-1	SSWL1-2	SSSL1-1	SSSL1-2	SSEL1-1	SSEL1-2

Fig 3: Showing sampling chart of level L1 of aged sea sand sandcrete blocks of SW, SS, SE, EC, NE, NC, NW, and WC direction of exposure

SNWL2-4	SNWL2-3	SNCL2-4	SNCL2-3	SNEL2-4	SNEL2-3
SNWL2-1	SNWL2-2	SNCL2-1	SNCL2-2	SNEL2-1	SNEL2-2
SWCL2-4	SWCL2-3	SCCL2-4	SCCL2-3	SECL2-4	SECL2-3
SWCL2-1	SWCL2-2	SCCL2-1	SCCL2-2	SECL2-1	SECL2-2
SSWL2-4	SSWL2-3	SSSL2-4	SSSL2-3	SSEL2-4	SSEL2-3
SSWL2-1	SSWL2-2	SSSL2-1	SSSL2-2	SSEL2-1	SSEL2-2

Fig 4: Showing sampling chart of level L2 of aged sea sand sandcrete blocks of SW, SS, SE, EC, NE, NC, NW, and WC direction of exposure

SNWL3-4	SNWL3-3	SNCL3-4	SNCL3-3	SNEL3-4	SNEL3-3
SNWL3-1	SNWL3-2	SNCL3-1	SNCL3-2	SNEL3-1	SNEL3-2
SWCL3-4	SWCL3-3	SCCL3-4	SCCL3-3	SECL3-4	SECL3-3
SWCL3-1	SWCL3-2	SCCL3-1	SCCL3-2	SECL3-1	SECL3-2
SSWL3-4	SSWL3-3	SSSL3-4	SSSL3-3	SSEL3-4	SSEL3-3
SSWL3-1	SSWL3-2	SSSL3-1	SSSL3-2	SSEL3-1	SSEL3-2

Fig 5: Showing sampling chart of level L3 of aged sea sand sandcrete blocks of SW, SS, SE, EC, NE, NC, NW, and WC direction of exposure

The data collection methods for the aged sand sandcrete blocks (Sea Sand and River Sand) exposed to Seasonal Alternate Wetting, Drying and Driving Rain followed the designed sampling charts as presented in Figures 2 to 9. The aged Sea Sand (SS) Sandcrete blocks were identified, procured and labelled with sample identification numbers (SNWL0-4, SNWL0-3, SNCL0-4, SNCL0-3, etc.) as shown in the Plate 3 and Plate 4, were transported to Niger Delta University Structures Laboratory for analysis. A total of 486 blocks were procured, but only a total of 288 blocks of 144 blocks each were analyzed. The sea sand block samples were produced exactly September 3rd, 2015 at Sangana Town, while the River Sand Sandcrete blocks from Amassoma with a production history of March 11th, 2012. The charts give proper location of the block, direction of wind and other environmental factors that may likely affect the long-term strength of the blocks over the years. In order to remove repeated block samples at the column interfaces:

SE/EC; EC /NE; NE/NC; NC/NW; NW/WC; WC/SW; SW/SS and SS/SE, we spaced the contacting blocks or columns apart and concentrated on 3x3 columns at the corners and middle sections of the sandcrete block dump. The top row blocks do not represent virgin blocks since they have weathered. They therefore cannot serve as benchmarks for the blocks, but we need to retain them because we need their exposure category. In order to obtain blocks, representing the virgin conditions of exposure, we sampled both the top layer and the penultimate one immediately below top. Thus, we have 4 levels: Ground L0, First L1, Penultimate just below top L2 and Top L3. The variables are the condition of exposure to the environment (mild, moderate, severe, very severe as stated in Table 19 of BS 8110, Eurocode etc.) which are the major issues in the coastal communities of Niger Delta, Nigeria. The arrangement of these columns in the model block work is such as to simulate boundary conditions of exposure, prescribed in BS EN 1992-3: 2006 Eurocode 2. To minimize consumption of blocks while achieving the desired boundary conditions a T-configuration was chosen. The three-dimensional views of the model and block layouts are shown in Figs. 1.

Methods for the tests

The different samples were labelled, prepared and examined for predetermined parameters.. The machine used

(a) **(b)**

Plate 3: (a): Team members taking mass reading of block specimens (b): Crushing and taking reading in the Compressive Strength test was the HFI compression machine STYE-2000 Analogue Type Okhard Machine Tool in the Structures Laboratory as shown in Plate 4. The compressive strength results were compared to the National Building Code's (2006) [9] standards for a conventional sandcrete block in terms of strength

(a) **(b)**

Plate 4: (a) and (b) Aged River Sand Sandcrete Block Samples Collection at Amassoma

Results and Discussion

Compressive strength

The study examined the long-term strength and durability of aged River Sand (RS) and Sea sand (SS) sandcrete block units under the influence of seasonal alternate wetting, drying, and driving rain. This research area appears to be new in the analysis of sandcrete blocks as the reviewed and available works are short-term strength (Wenapere and Orumu 2021; Ewa and Ukpata, 2013, etc.) [40, 13]. An analysis of the short-term data revealed that (Ewa and Ukpata, 2013; Ikechukwu, 2012) [13, 18] the blocks' 28-day compressive strengths ranged from 0.23N/mm^2 to 0.58N/mm^2. This fall short of the 1.75N/mm2 minimum required for individual blocks by the Nigerian National Building Code (2006) [9] and the 2.0N/mm^2 minimum required for non-load bearing walls by the British Standard.

The results are presented in Tables 1 and 2 which both types of blocks experienced similar changes in strength over time as they were exposed to environmental conditions as presented in Table 3. Table 1 further shows the compressive strength test results for the aged stacked River Sand (RS) sandcrete blocks which is the control, while Table 2 shows the test results for aged stacked Sea Sand sandcrete blocks. The stacked block layers are from L0 to L3 with average strength loss of showed in Table 5 and 6 as 58.89% in SSE blocks, 56.86% SEC blocks, 65.40% in SNE blocks, 54.42% in SSS blocks, 57.06% in SCC blocks, 72.53% in SNC blocks, 62.35% in SSW blocks, 76.80% in SWC blocks and 62.38% in SNW blocks. The River Sand (RS) sandcrete blocks also lost strength due to exposure and over the period of abandonment showed in Table 6 and 7 as 56.25% in RSE, 37.93% in REC, 60.32% RNE, 40.98% in RSS, 34.27% in RCC, 37.12% in RNC, 41.19% in RSW

Table 1: Compressive strength test result for aged River Sand (RS) sandcrete blocks

S. No	Sample ident. marks	Layer L0 - Stress (N/mm^2)				Layer L1 - Stress (N/mm^2)				Layer L2 - Stress (N/mm^2)				Layer L3 - Stress (N/mm^2)			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	RSEL	1.14	1.71	1.14	1.28	2.02	1.57	2.14	1.28	1.42	1.71	1.42	2.42	2.42	2.14	1.14	1.14
2	RECL	2.56	1.14	1.00	2.56	2.42	1.00	2.42	2.56	2.56	1.71	1.71	2.42	2.42	0.85	1.14	1.14
3	RNEL	2.56	1.14	1.00	1.00	2.68	1.00	2.56	1.42	2.56	1.57	1.71	1.85	1.14	2.42	1.14	1.28
4	RSSL	0.85	1.14	2.56	2.42	1.00	1.57	2.28	2.28	0.85	1.42	2.42	2.42	2.42	0.85	1.14	1.14
5	RCCL	2.39	2.42	2.42	2.85	2.42	2.56	2.65	2.56	2.56	2.56	2.56	2.51	1.14	1.14	1.42	1.28
6	RNCL	2.56	2.42	1.00	2.42	2.68	2.62	2.54	2.59	2.56	2.56	2.76	2.51	2.45	2.14	1.14	1.28
7	RSWL	1.00	1.14	2.42	2.42	2.02	2.28	1.97	1.99	1.99	1.28	2.56	2.54	2.42	2.14	1.14	1.28
8	RWCL	1.00	2.56	2.42	1.28	2.14	2.05	2.22	1.85	1.99	2.28	2.28	1.71	2.42	1.00	1.14	1.28
9	RNWL	1.28	2.42	1.00	2.42	1.00	2.56	2.28	2.42	1.99	2.42	1.42	2.42	0.85	0.85	1.14	2.14

Note: Date Cast:11-3-2012; Test Date: 24 / 1/ 2022; Sample Location: Amassoma; Size of Sample/Block: 150 x 450 x 225; Volume of Sample 0.0079 m^3; Mix Ratio: 1:6

Table 2: Compressive strength test results for aged stacked Sea Sand (SS) sandcrete blocks

S. No	Sample Ident. marks	Layer L0 - Stress (N/mm²)				Layer L1 - Stress (N/mm²)				Layer L2 - Stress (N/mm²)				Layer L3 - Stress (N/mm²)			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	SSEL	0.28	0.57	0.28	1.00	0.57	1.57	0.85	1.85	1.14	1.28	0.57	1.91	1.14	0.57	0.43	1.00
2	SECL	1.00	0.28	0.85	1.00	1.85	0.57	1.00	1.85	1.79	0.71	0.85	1.91	1.28	0.85	0.57	1.28
3	SNEL	0.14	0.43	0.43	1.00	1.42	0.43	1.14	0.85	1.57	0.43	1.14	1.28	0.43	0.28	1.00	1.71
4	SSSL	1.28	1.14	1.57	1.00	1.00	0.43	1.88	1.85	0.85	0.43	1.88	1.97	0.57	0.57	1.00	1.57
5	SCCL	1.14	1.28	1.14	1.14	1.85	1.79	1.85	1.88	1.88	1.94	1.85	1.71	1.14	1.28	1.14	1.28
6	SNCL	1.00	0.94	1.00	1.00	1.85	1.85	1.42	1.42	1.85	1.85	1.00	1.00	0.14	0.57	0.43	0.43
7	SSWL	0.28	0.28	1.00	1.57	0.71	1.85	1.77	1.71	1.57	1.85	1.71	0.85	2.28	1.57	0.57	1.14
8	SWCL	0.43	1.00	1.00	1.00	0.43	1.82	1.85	1.00	1.28	1.85	1.71	0.97	0.43	0.85	0.57	0.28
9	SNWL	0.85	1.42	0.57	0.85	1.14	1.85	1.71	1.57	1.28	1.85	1.14	1.99	0.43	0.57	0.85	0.85

Note: Date Cast: 9/3/2015; Test Date: 24 / 1/ 2022; Sample Location: Sangana- Akassa; Size of Sample: 150 x 450 x 225; Volume of Sample: 0.0079 m^3; Mix Ratio: 1:6.

Table 3: Characterization of SS and RS sandcrete blocks by exposure conditions

S. No	Exposure Condition	Block Elements	Category
1.	Block elements, completely sheltered and under minimum preload	All interior blocks on levels 3: SEL 3 -3, ECL 3-3 &4, NEL 3-4, NCL 3- 1&4, NWL 3-1, WCL 3-1&2, SWL 3-2, SSL 3-2&3	Mild Exposure
	Block elements, completely sheltered and under average preload	All interior blocks on levels 2: SEL 2 -3, ECL 2-3 &4, NEL 2-4, NCL 2- 1&4, NWL 2-1, WCL 2-1&2, SWL 2-2, SSL 2-2&3	Moderate exposure
	Block elements, completely sheltered and under high preload	All interior blocks on levels 1: SEL 1 -3, ECL 1-3 &4, NEL 1-4, NCL 1- 1&4, NWL 1-1, WCL 1-1&2, SWL 1-2, SSL 1-2&3	Severe exposure
	Block elements, completely sheltered and under maximum preload with bottom face in contact with soil	All interior blocks on levels 0: SEL 0 -3, ECL 0-3 &4, NEL 0-4, NCL 0- 0&4, NWL 0-0, WCL 0-0&2, SWL 0-2, SSL 0-2&3	Very severe exposure
2.	Block elements, exposed on one face to seasonal wetting and drying and driving rain and under minimum preload	Intermediate external blocks on level 3: SE L3-2, EC L3-1, EC L3 mnb322, \E L3-1,NE L3-3, NC L3-2, NC L3-3, NW L3-2, NW L3-4, WC L3-3&4, SW L3-3,SW L3-1, SS L3-4, SS L3-1, SE L3-4;	1
	Block elements, exposed on one face to seasonal wetting and drying, driving rain and under average preload	All intermediate external blocks on level 2: SE L2-2, EC L2-1, EC L2-2, NE L2-1,NE L2-3 NC L2-2, NC L2-3, NW L2-2, NW L2-4, WC L2-3&4, SW L2-3,SW L2-1, SS L2-4, SS L2-1, SE L2-4	Moderate Exposure
	Block elements, exposed on one face to seasonal wetting and drying, driving rain and under high preload	All intermediate external blocks on level 2: SE L1-2, EC L1-1, EC L1-2, NE L1-1,NE L1-2 NC L1-2, NC L1-2, NW L1-2, NW L1-4, WC L1-2&4, SW L1-2,SW L1-1, SS L1-4, SS L1-1, SE L1-4	Severe Exposure
	Block elements, exposed on one face to seasonal wetting and drying, driving rain and under maximum preload with bottom face in contact with soil	All intermediate external blocks on level 0: SE L2-2, EC L2-1, EC L2-2, NE L2-1,NE L2-2 NC L2-2, NC L2-2, NW L2-2, NW L2-4, WC L2-2&4, SW L2-2,SW L2-1, SS L2-4, SS L2-1, SE L2-4	Very severe Exposure
3.	Block elements, exposed on two contiguous faces to seasonal wetting and drying, driving rain and under minimum preload	Corner blocks on level 3: SE L3-1, NE L3-2, NW L3-3 and SW L3-4	Moderate exposure
	Block elements, exposed to seasonal wetting and drying, driving rain on two contiguous faces and under average preload	Corner blocks on level 2: SE L2-1, NE L2-2, NW L2-3 and SW L2-4	Moderate exposure
	Block elements, exposed on two contiguous faces to seasonal wetting and drying, driving rain and under high preload	Corner blocks on level 1: SE L1-1, NE L1-2, NW L1-3 and SW L1-4	Severe exposure
	Block elements, exposed on two contiguous faces to seasonal wetting and drying, driving rain and under maximum preload with bottom face in contact with soil	Corner blocks on level 0: SE L0-1, NE L0-2, NW L0-3 and SW L0-4	Very severe exposure
4.	Block elements, exposed on one face to seasonal wetting, drying and insolation and under zero preload	All interior blocks on levels 4: SEL 4 -3, ECL 4-3 &4, NEL 4-4, NCL 4- 1&4, NWL 4-1, WCL 4-1&2, SWL 4-2, SSL 4-2&3	Moderate exposure
	Block elements, exposed on two faces to seasonal wetting and drying, driving rain and insolation and under zero preload	All intermediate block elements on level 4: SE L4-2, EC L4-1, EC L4-2, NE L4-1,NE L4-3 NC L4-2, NC L4-3, NW L4-2, NW L4-4, WC L4-3&4, SW L4-3,SW L4-1, SS L4-4, SS L4-1, SE L4-4	Severe exposure
	Block elements, exposed on three faces to seasonal wetting and drying, driving rain and insolation and under zero preload	Corner element on top floor level 4 seasonal: SE L4-1, NE L4-2, NW L4-3 and SW L4-4	Very severe exposure
5.	Blocks elements, exposed on four faces to seasonal wetting and drying, driving rain and insolation under zero preload	Blocks from additional minor heaps	
	Blocks elements, exposed on five faces to seasonal wetting and drying and insolation under zero preload	Blocks from additional minor heaps	
	Blocks elements, exposed on five faces to seasonal wetting and drying and insolation under zero preload	Blocks from additional minor heaps	

Table 4: Compressive strength of aged Sea Sand Sandcrete Blocks at various layer and direction of exposure

Level of block	SSE	SEC	SNE	SSS	SCC	SNC	SSW	SWC	SNW
L0	1.00	1.00	1.00	1.00	1.14	1.00	1.57	1.00	0.85
L1	1.85	1.85	0.85	1.85	1.88	1.42	1.71	1.00	1.57
L2	1.91	1.91	1.28	1.97	1.71	1.00	0.85	0.97	1.99
L3	1.00	1.28	1.71	1.57	1.28	0.43	1.14	0.28	0.85

Table 5: % strength loss / gain Sea Sand (SS) sandcrete blocks

Level of block	% of fc at SSE	% of fc at SEC	% of fc at SNE	% of fc at SSS	% of fc at SCC	% of fc at SNC	% of fc at SSW	% of fc at SWC	% of fc at SNW
L0	-71.51	-71.51	-71.51	-71.51	-67.44	-71.51	-55.23	-71.51	-75.71
L1	-47.09	-47.09	-75.58	-47.09	-46.28	-59.30	-51.16	-71.51	-55.23
L2	-45.46	-45.46	-63.37	-43.83	-51.16	-71.51	-75.58	-72.32	-43.02
L3	-71.51	-63.37	-51.16	-55.23	-63.37	-87.79	-67.44	-91.86	-75.58
Average fc loss	-58.89	-56.86	-65.40	-54.42	-57.06	-72.53	-62.35	-76.80	-62.39

The aged blocks lost a total average strength of 62.97% over the period

Table 6: Compressive strength of aged River Sand Sandcrete (RSS) blocks at various layer and direction of exposure

Level of block	RSE	REC	RNE	RSS	RCC	RNC	RSW	RWC	RNW
L0	1.28	2.56	1.00	2.42	2.85	2.42	2.42	1.28	2.42
L1	1.28	2.56	1.42	2.28	2.56	2.59	1.99	1.85	2.42
L2	2.42	2.42	1.85	2.42	2.51	2.51	2.54	1.71	2.42
L3	1.14	1.14	1.28	1.14	1.28	1.28	1.28	1.28	2.14

Table 7: % strength loss / gain in River Sand (RS) sandcrete blocks

Level of block	% of fc at RSE	% of fc at REC	% of fc RNE	% of fc RSS	% of fc RCC	% of fc RNC	% of fc RSW	% of fc RWC	% of fc RNW
L0	-63.37	-26.74	-71.51	-30.81	-18.60	-30.81	-30.81	-63.37	-30.81
L1	-63.37	-26.74	-59.30	-34.88	-26.74	-25.93	-43.02	-47.09	-30.81
L2	-30.81	-30.81	-47.09	-30.81	-28.37	-28.37	-27.55	-51.16	-30.81
L3	-67.44	-67.44	-63.37	-67.44	-63.37	-63.37	-63.37	-63.37	-38.95
Average	-56.25	-37.93	-60.32	-40.98	-34.27	-37.12	-41.19	-56.25	-32.84

The aged river sand blocks lost a total average strength of 44.13 % over the period

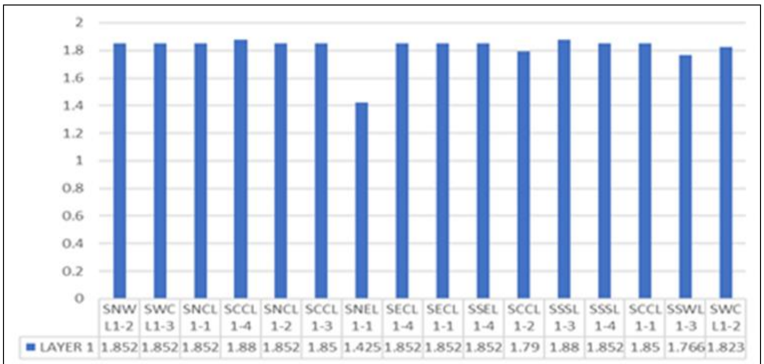


Fig 6: Chart showing comparison of compressive strength at layer L1 of sea sandcrete blocks

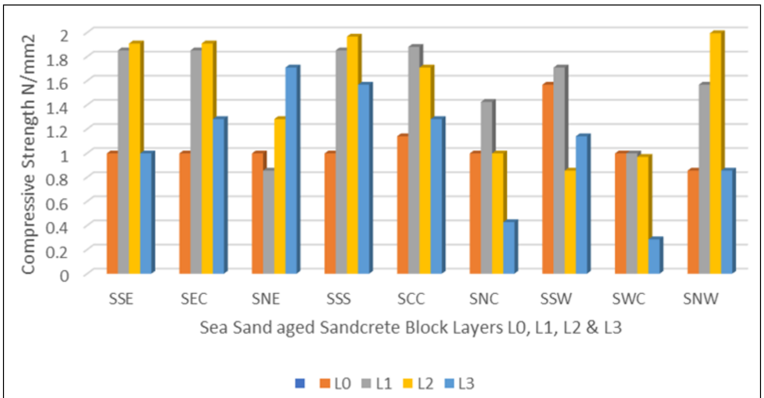


Fig 7: Chart Showing Comparison of Compressive strength at layer L0, L1, L2, and L3

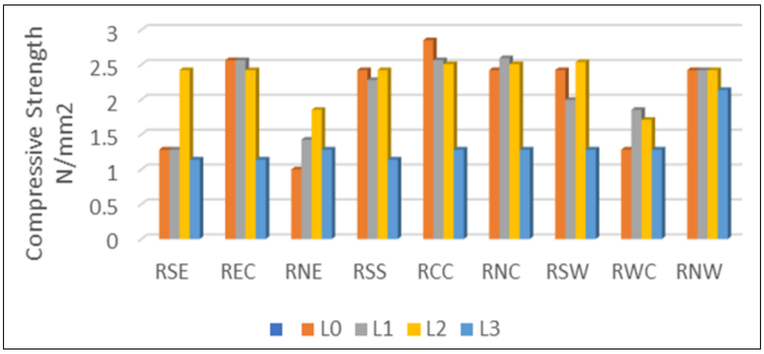


Fig 8: Chart Showing Comparison of Compressive strength of River Sand (RS) at layer L0, L1, L2, and L3

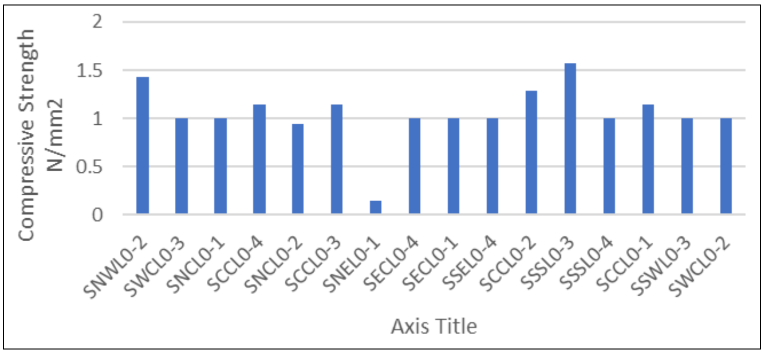


Fig 9: Chart Showing Comparison of Compressive strength at layer L0

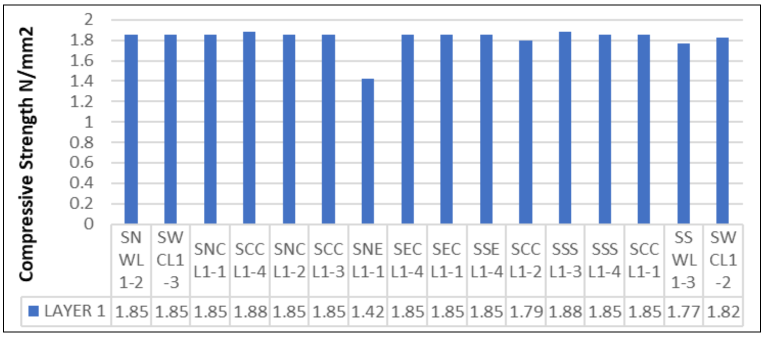


Fig 10: Chart Showing Comparison of Compressive strength at layer L1

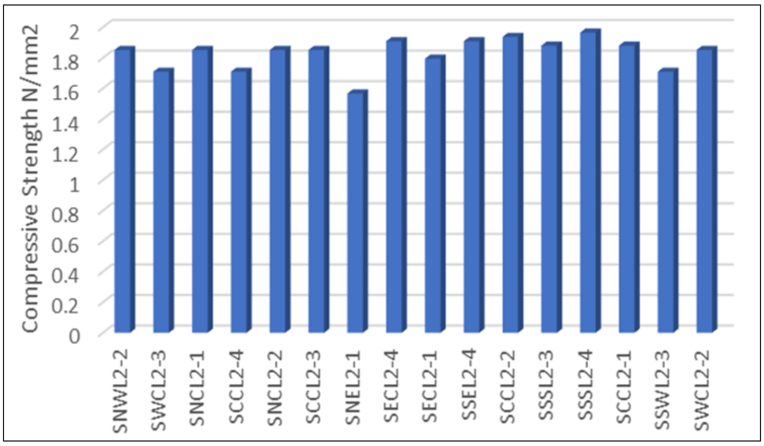


Fig 11: Chart showing comparison of compressive strength at layer L2

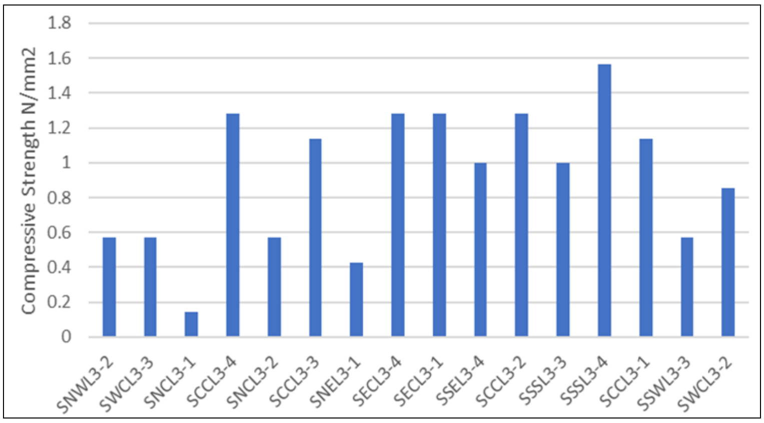


Fig 12: Chart showing comparison of compressive strength at layer L3

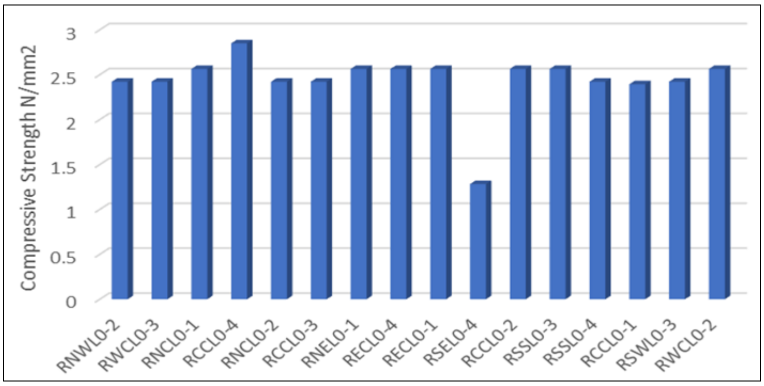


Fig 13: Chart showing comparison of river sand sandcrete blocks compressive strength at layer L0

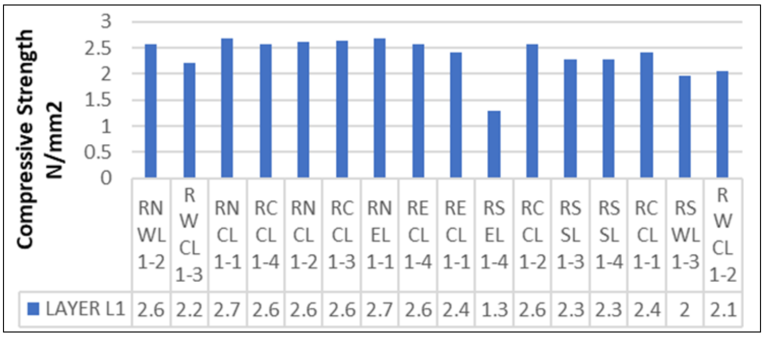


Fig 14: Chart showing comparison of river sand sandcrete blocks compressive strength at layer L1

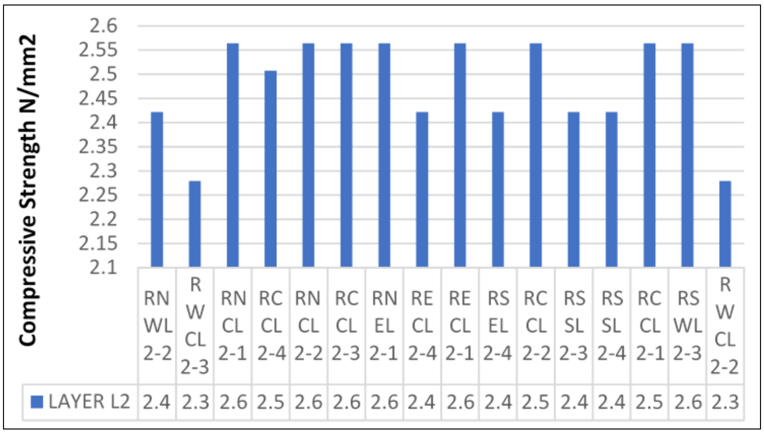


Fig 15: Chart showing comparison of river sand sandcrete blocks compressive strength at layer L_2

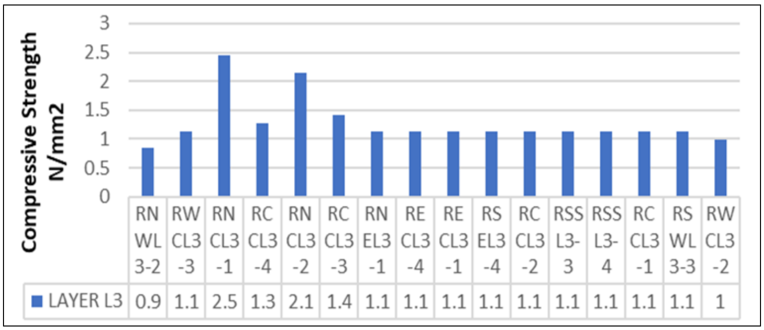


Fig 16: Chart showing comparison of river sand sandcrete blocks compressive strength at layer L3

Conclusions

The results of the aged block for both River Sand and Sea Sand shows a similar pattern with the middle L1 and L2 layer blocks with better strength values. These conclusions open a wider scope and opportunity for research into sea sand with locally sourced mud sandcrete masonry units.

The long-term strength and durability of aged River Sand (RS) and Sea sand (SS) sandcrete blocks units exposed to seasonal alternate wetting, drying and driving rain was examined and observed that the results of the aged block for both River Sand and Sea Sand shows a similar pattern with the middle L1 and L2 layer blocks with better strength values.

The long-term strength and durability of aged River Sand (RS) and Sea sand (SS) sandcrete blocks units exposed to seasonal alternate wetting, drying and driving rain also shows similar strength lose and gain across the stacked aged blocks. That the top row blocks do not represent virgin blocks since they have weathered. They therefore cannot serve as benchmarks for the blocks, but we need to retain them because we need their exposure category. In order to obtain blocks, representing the virgin conditions of exposure, we sampled both the top layer and the penultimate one immediately below top. Thus, we have 4 levels: Ground L0, First L1, Penultimate just below top L2 and Top L3. The variables are the condition of exposure to the environment (mild, moderate, severe, very severe).

Contribution to knowledge

The research has made the following contributions to the body of knowledge:

1. The aged sandcrete blocks, both sea sand and River sand exposed to seasonal alternate wetting, drying and driving rain shows similar strength reduction patterns; and sampling chats were developed for building Engineers for the re-useability of aged blocks.
2. From the study of aged sandcrete, Corner blocks on level 2: SE L2-1, NE L2-2, NW L2-3 and SW L2-4 for both sea and river sandcrete blocks are moderate exposure condition with weak compressive strength. While Corner blocks on level 0: SE L0-1, NE L0-2, NW L0-3 and SW L0-4 has Very severe exposure with lower compressive strength.
3. The findings of the study contributed to the development of sustainable and durable building practices in the Niger Delta region.

References

1. Abrams DP, Paulson TJ. Modelling Concrete Masonry Building Structures at One-quarter Scale. Structural Journal of the American Concrete Institute, No. 88-S50. 1991; 88(4):475-485.
2. Abdou L, Saada RA, Meftah F, Mebarki A. Experimental investigations of the joint-mortar behavior. Mechanics Research Communications. 2006; 33(3):370-384.
3. Aderibigbe Yinka Wasiu, Ataguba Oguche Clement, Abuh Noah Makoji, Ichado Jacob. Assessment of Properties of Sandcrete Blocks Produced by Commercial Block Industries in Idah, Kogi State, Nigeria International Journal of Scientific Engineering and Science. 2017; 1(3):8-11.
4. Akinkunmi Joel Olukunle. The Sustainability Solution of Earth as Buildings Material: Case of Gbongan Rural Communities in Osun State South West Nigeria. British Journal of Earth Sciences Research. 2022; 10(3):37-46. Print ISSN: 2055-0111 (Print)
5. Ashwini Manjunath BT, Karthick TR, Manjunath MS, Lakshmi K. Partial Replacement of Sea and Desert Sand in Place of River Sand for Mortar in Construction. GRD Journals- Global Research and Development Journal for Engineering. 2017; 2(7).
6. Aiyewalehimi EO, Tanimola MO. Strength properties of commercially produced sandcrete blocks in Akure, Ondo State. International Journal of Engineering Science Inventions. 2013; 2(5):22-33.
7. Aguwa JI. Performance of laterite-cement blocks as walling units in relation to sandcrete blocks. Leonardo Electronic Journal of Practices and Technologies. 2010; (16):189-200.
8. Ashwini Manjunath BT, Lakshmi Kiran MS, Sahana CK. Use of Sea Sand in Partial Replacement of River Sand in Concrete for Construction. Volume 3, Issue 6, June – 2018 International Journal of Innovative Science and Research Technology, 2018. ISSN No:-2456-2165 IJISRT18JU362 www.ijisrt.com
9. Building Code. Federal Republic of Nigeria, National Building Code, st Edition. Nigeria, 2006.
10. BS EN 1996: Eurocode 6: Design of masonry structures.
11. BS EN 197-1:2011 Cement. Composition, specifications and conformity criteria for common cements.
12. Dhansekar M, Page AW, Kleeman PW. The failure of brick masonry under biaxial stresses. Proc. Inst. Civil Engineers, Part 2. 1985; 79:195-313.
13. Ewa DE, Ukpata JO. Investigation of the Compressive Strengths of Commercial Sandcrete Blocks in Calabar, Nigeria. International Journal of Engineering and Technology. 2013; 3(4):477-482.

14. Ephraim ME, Chinwah JG, Orlu ID. 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. 1990; 1:13-26.
15. Fachrul Arya Sanjaya, Sapto Budy Wasono, Diah Ayu Restuti Wulandari. Analysis of Use Sea Sand as A Fine Aggregate Replacement to Strong Press Concrete International Journal of Engineering, Science & Information Technology (IJESTY). 2021; 1(3):1-6.
16. Hijab Mahmoud, Halilu A Hamma, Hadi A Abba. Compressive Strength of Marketed Sandcrete Blocks Produced in Yola, Nigeria. Journal of Engineering and Applied Sciences. 2010; 2.
17. lXu He, Jikai Zhou. Mechanical characteristics of sea-sand concrete in simulated marine environment' Construction and Building Materials. 2021; 274.
18. Ikechukwu UF. Compressive Strength and Costs of Sandcrete Blocks and blocks made with quarry dust in Nigeria: A Case study of Abakaliki Quarry Journal of Chemical, Mechanical and Engineering Practice. 2012; 2(3).
19. Jian Zhang, Tugen Feng, Fuhai Zhang, Wenbin Li. Experimental study on improvement of seawall filler materials composed of sea sand and sea mud. Marine, Journal of Georesources & Geotechnology. 2020; 38(2):193-203.
20. Jianzhuang Xiao, Chengbing Qiang, Antonio Nanni, Ka ijian Zhang. Use of sea-sand and seawater in concrete construction: Current status and future opportunities. Construction and Building Materials. 2017; 30:1101-1111.
21. Mohamad, *et al*. Failure Mode, Deformability and Strength of Masonry Walls 15th International Brick and Block Masonry Conference Florianopolis - Brazil – 2012, 2012.
22. Minghu Zhang, Xuezhen Zhu, Jinyan Shi, Baoju Liu, Z hihai Chaofeng Lian. Utilization of desert sand in the production of sustainable cement-based materials: A critical review. Construction and Building Materials. 2022; 327.
23. Musa Yetkin, Kürşat Esat Alyamaç, Yusuf Calayır. Investigation of Material Properties of Masonry Units Used in Brick Walls International Engineering and Natural Sciences Conference (IENSC 2019) 6-8 November 2019, Dicle University, Diyarbakır, Turkey, 2019.
24. NIS 87. Nigerian Industrial Standard for Sandcrete Blocks. The Standard Organization of Nigeria. (SON), 2000.
25. Oyekan GL, Kamiyo OM. A study on the engineering properties of sandcrete blocks produced with rice husk ash and blended cement. Journal of Engineering and Technology Research. 2011; 3(3):88-98.
26. Phaiju S, Pradhan PM. Experimental work for mechanical properties of brick and masonry panel. Journal of Science and Engineering. 2018; 5:51-57.
27. Rahgozar A, Hosseini A. Experimental and numerical assessment of in-plane monotonic response of ancient mortar brick masonry. Construction and Building Materials. 2017; 155:892-909.
28. Singh SB. Munjal P. Bond strength and compressive stress-strain characteristics of brick masonry. Journal of Building Engineering. 2017; 9:10-16.
29. Sarah Abduljabbar Yaseen, Keyou Chen, Ditao Niu, Christopher,Kin Ying Leung, Zongjin Li. Study of the influence of seawater and sea sand on the mechanical and microstructural properties of concrete. Journal of Building Engineering. 2021; 42.
30. Songsong He, Chujie Jiao, Yanfei Niu, Song Li. Utilizing of coral/sea sand as aggregates in environment-friendly marine mortar: Physical properties, carbonation resistance and microstructure, Case Studies in Construction Materials. 2022; 16.
31. Tanaz Dhondy, Alex Remennikov, Neaz Sheikh M. Benefits of using sea sand and seawater in concrete: A comprehensive review. Australian Journal of Structural Engineering. 2019; 20:280-289.
32. Tanaz Dhondy, Alex Remennikov, Neaz Sheikh M. Properties and Application of Sea Sand in Sea Sand–Seawater Concrete Journal of Materials in Civil Engineering. 2020; 32(12).
33. TMS 402/602. Building Code Requirements and Specifications for Masonry Structures, 2016 (Formerly ACI 530), 2016.
34. Kucche KJ, Jamkar SS, Sadgir PA. Quality of Water for Making Concrete. International Journal of Scientific and Research Publications. 2015; 5(1).
35. Masia MJ, Kleeman PW, Melchers RE. Soil Structure Interaction Modelling of Masonry for Reliability Studies. 17th Australasian conference on the Mechanics of Structures and Materials, Gold Coast, Queensland, Australia, 2002.
36. Osunade JA, Fajobi. 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, 2000, 44-50.
37. Sheikh Yusuf, Hamza Aliko, Saleh MA. The Importance of Compressive Strength in Sandcrete Block; CARD International Journal of Engineering and Emerging Scientific Discovery. 2017; 2(3):160-177. http://www.casirmediapublishing.com
38. Sri Lakshmi P, Rambabu Ch, Giri Prasad G, Nandamuru VIET, Andhra Pradesh. A Comparative Study on Partial Replacement of Sea Sand to the River Sand with Different Types of Cements. International Journal of Engineering Research & Technology (IJERT). 2017; 6(02).
39. Wenapere AD. Ephraim ME. Physco-mechanical behaviour of sandcrete block masonry units. Journal of Building Appraisal Vol. 4, No. 4 Spring 2009 Palgrave Macmillan, 2009. www.palgrave-journals.com/jba/
40. Wenapere AD, Orumu ST. Investigation of Failure Mechanism of Masonry Sandcrete Blockwalls Produced from River Sand. Vol-05 Issue 09, September- 2021 ISSN: 2456-9348, International Journal of Engineering Technology Research & Management IJETRM, 2021.
41. Wenapere AD, Yabefa BE. Cost and Materials Input Analysis of Commercially Produced Masonry Sandcrete Blocks in Nigeria (A case Study of Yenagoa, Bayelsa State, Nigeria). Vol-05 Issue 10, October - 2021 ISSN: 2456-9348, International Journal of Engineering Technology Research & Management IJETRM, 2021. (http://ijetrm.com/)