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**Research Paper**

# Evaluating The Compressive Strength of Sandcrete Hollow Blocks Produced in Selected Block Moulding Industries in Five Local Government Areas of Delta State, Nigeria.

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***ABSTRACT***
*This study evaluated the physical and mechanical properties of commercial sandcrete blocks produced in five Local Government Areas (LGAs), Warri South, Uvwie, Okpe, Ughelli North, and Isoko Southall in Delta State, Nigeria to assess their compliance with regulatory construction standards. A comprehensive field survey and laboratory testing program were conducted across twenty commercial block factories to determine block yields per bag of cement, mix ratios, dry bulk density, 24-hour water absorption capacity, and individual 28-day compressive strengths for standard hollow masonry sandcrete blocks.The production metrics revealed that local block factories optimize financial gains by using lean material ratios of 1:12 and 1:13. This resulted in high block yields ranging from 33 to 48 blocks per bag 40 to for 225mm (9-inch) (mean of 38 blocks/bag). Laboratory experimental outcomes showed that the dry bulk density of the sampled blocks ranged from 1,595 kg/m³ to 1,715 kg/m³, with an overall study mean of 1,671 kg/m³, failing to meet the recommended minimum benchmark of 1,800 kg/m³.Conversely, water absorption testing demonstrated full compliance with durability thresholds, spanning from 9.11% to 10.82% (mean of 9.81%), which sits safely beneath the 12.0% maximum allowable limit specified by the Nigerian Industrial Standard. However, structural testing revealed that the individual compressive strengths fluctuated between 1.476 N/mm² and 1.695 N/mm², culminating in a grand mean compressive strength of 1.611 N/mm² across the region.When evaluated against regulatory guidelines, 100% of the commercial blocks sampled failed to achieve the 2.50 N/mm² minimum strength threshold required for non-load-bearing masonry under NIS 87 of 2014, and fell short of the 2.80 N/mm² Type B limit set by the British Standard. These findings indicate that commercial blocks sold in these markets are structurally deficient for safe engineering applications due to excessive sand-to-cement ratios and inadequate mechanical compaction.To mitigate the risk of structural failures, it is recommended that local manufacturers immediately restrict block yields to a maximum of 35 blocks per bag of cement by adopting richer mix designs (no leaner than 1:6 or 1:8). Furthermore, regulatory bodies like the Standards Organization of Nigeria (SON) must enforce strict quality control monitoring across local production yards.*

***Keywords:*** *Sandcrete Blocks, Compressive Strength, Bulk Density, Water Absorption, Block Yield, Nigeria Industrial Standard.*

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## I. Introduction

Sandcrete blocks have been used in numerous countries worldwide, including Nigeria, and have played a significant part in the construction industry (Korankye and Danso, 2024)Sandcrete blocks are precast composite heterogeneous masonry units made of cement, sand, and water that are moulded into various sizesand are commonly used in the construction of walls and structures (Alejo, 2020).They are typically composed of well-proportioned composite mixture of cement (the binding agent, usually Ordinary Portland Cement), well-graded sharp fine aggregates (sand), free from organic or clay impurities) and potable water used for hydration and are moulded into various sizes and shapescommonly used in the construction of walls and structures (Alejo, 2020).The mixture could be with or without Admixture**s (**to improve setting time or durability, though rarely used in informal block production (Bamisaye, 2007).When set in their normal aspect, sandcrete blocks are walling units whose dimensions exceed those of bricks (NIS 87: 2007). It is larger in all dimensions than what is required for bricks, but no dimension should be larger than 650 mm or the height should be six times the thickness or greater than the length(BS 6073, 1981).They are the most popular and economic masonry units for physical infrastructure in Nigeria, making up over 90% of the country's walling units (Adekunle et al., 2018). They are a carefully highly favoured for their local availability, affordability, and ease of productionIn Nigeria, building blocks are generally categorized into solid blocks and hollow blocks based on their internal composition. Solid Blocks are dense and heavy, often without any voids or with only minimal indentations. These blocks are typically used for areas that require high structural strength, such as foundations, retaining walls and load-bearing walls.Their mass gives them better soundproofing and thermal insulation qualities. However, the downside of solid blocks lies in their weight. They are more difficult to handle, costlier to transport, and take longer to install.

Masonry units that have a core void area larger than 25% of the gross area are considered hollow blocks. Blocks with two cells are typically produced in Nigerian construction factories. Hollow blockshave voids or cavities that reduce their weight and improve insulation. These voids also make it easier to run electrical wiring or plumbing through walls, which simplifies the installation process. Hollow blocks, known for their lightweight nature, offer significant cost savings in both foundation and superstructure design, as highlighted by (Thora et al., 2015). Hollow blocks are commonly used in residential construction, especially in non-load-bearing walls or for interior partitions (Wilson et al., 2024). Sandcrete hollow blocks have a void running through them from top to bottom that takes up around one-third of their volume, yet solid blocks are completely devoid of voids.However, if not properly reinforced or filled, they may not offer the same strength as their solid counterparts.

Block dimensions are typically expressed in terms of length × width × height, and these values must align with national building codes to ensure safety and compatibility. The most popular sizes for sandcrete blocks are 9-inch hollow block typically measures around 450mm × 225mm × 225mm, while 6-inch hollow block might be around 450mm × 150mm × 225mm.The Nigerian Industrial Standards (NIS 87: 2007) defined two types of blocks,namely, load bearing blocks, andnon-load bearing blocks. They both have the option of being solid or hollow. The approved sizes for sandcrete blocks specified by the NIS are presented in Table 1.

**Table 1:** The approved sizes for sandcrete blocks

| Type | Work size (mm) Length × Height × Thickness | Web Thickness | Usage |
|---|---|---|---|
| Solid Block | 450 x 225 x 100 | – | For non-load bearing and partition walls |
| Hollow | 450 x 225 x 113 | 25 | For non-load bearing and partition walls |
| Hollow | 450 x 225 x 150 | 37.5 | For load bearing walls |
| Hollow | 450 x 225 x 225 | 50 | For load bearing walls |

When hardened, sandcrete blocks often have significant compressive strengths, and these strengths typically increase with density. Sandcrete hollow blocks should have a minimum strength requirement of 2.5 $N/mm^2$ for 150 mm and 3.45 $N/mm^2$ for 225 mm. Typical compressive strength obtained for different mix ratios and water-cement ratio for 450 × 150 × 225 (6 inches block) are shown in Table 2, (NIS 87, 2007).

**Table 2:** Compressive Strength of sandcrete block at 28 days

| W/C | 1:10 ($f_c$ at 28 days $N/mm^2$) | 1:8 ($f_c$ at 28 days $N/mm^2$) | 1:6 ($f_c$ at 28 days $N/mm^2$) | 1:4 ($f_c$ at 28 days $N/mm^2$) |
|---|---|---|---|---|
| 0.3 | 2.40 | 4.08 | 5.40 | 6.10 |
| 0.4 | 3.00 | 4.39 | 5.58 | 6.23 |
| 0.5 | 3.80 | 4.47 | 6.85 | 7.60 |
| 0.6 | 3.60 | 4.24 | 6.41 | 7.00 |
| 0.7 | 3.20 | 4.21 | 5.81 | 6.54 |

Source: (NIS 87, 2007).

From Table 2, the optimum water-cement ratio for maximum compressive strength in sandcrete blocks is 0.5. The mix ratio recommended by the NIS for sandcrete blocks in Nigeria is 1:8. For a 225mm hollow sandcrete block produced with a mix ratio of 1:8, the 28 days compressive strength is expected to be a minimum of 3.5 $N/mm^2$ under laboratory-controlled conditions. For 150 mm hollow block, a minimum compressive strength of 2.77 $N/mm^2$ should be expected after 28 days of curing(Thora et al., 2015).The recommendations in Table 3can be adopted in the production of 225 mm (9 inches) sandcrete blocks(NIS 87, 2007) and expressed in Figure 1.

**Table 3**: Production Specifications and 28-Day Strength of 9-Inch Hollow Blocks

| Cement | Sand | Mix-Ratio | Expected Number of Blocks per bag (9 inches hollow) | Expected Minimum Compressive Strength ($N/mm^2$) at 28 days using Manual Compaction |
|---|---|---|---|---|
| One bag | 3 wheelbarrows (12 head pans) | 1:6 | 15 | 5.6 |
| One bag | 3½ wheelbarrows (14 head pans) | 1:7 | 17 | 4.2 |
| One bag | 4 wheelbarrows (16 head pans) | 1:8 | 20 | 3.5 |
| One bag | 5 wheelbarrows (20 head pans) | 1:9 | 25 | 3.3 |

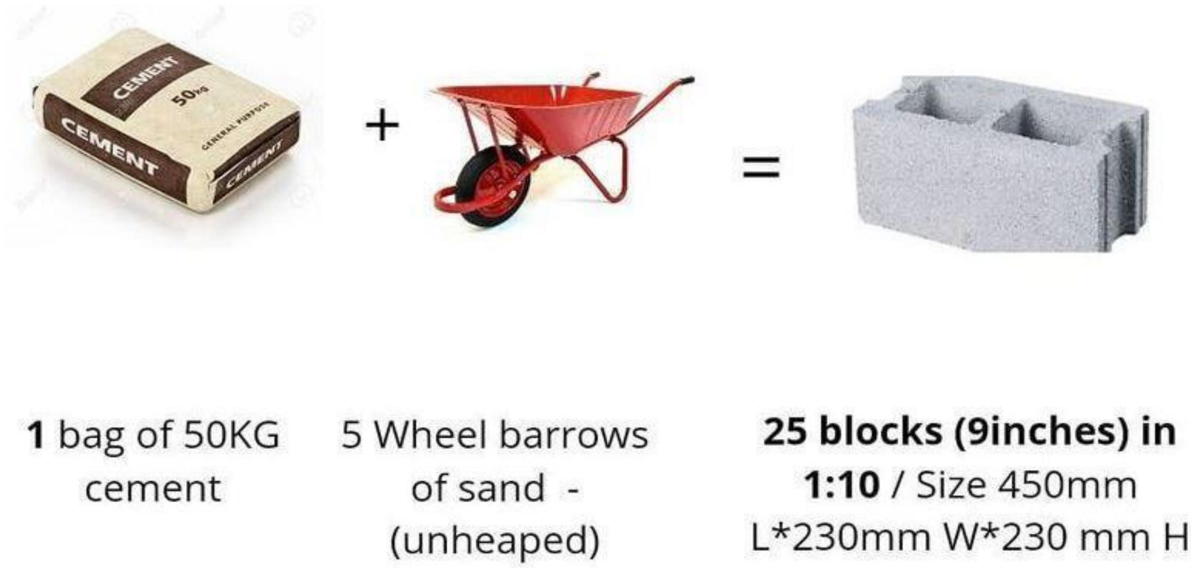


Figure 1: Mixing ratio of sand and cement using wheel barrow

### 1.1 Materials Used in the Production of Sandcrete Blocks

The following materials are used in the production of sandcrete blocks:

#### 1.1.1 Cement

Cement is a binder material that is used to hold the constituent aggregates (sand, gravels, etc.) together to form a composite matrix. Cement is a carefully controlled combination of lime, silica, alumina and iron oxide. However, compounds of lime are the main ingredients of cement.Different brands of Limestone Portland Cement available in Nigeria. Hydration reaction takes place whenever water is added to cement, which results in a significant heat release. When concrete hydrates, a gel is created that holds the aggregate particles together and gives concrete its strength and water tightness when it hardens. Ordinary Portland Cement (OPC) or Limestone Portland Cement are the most popular form of cement used in construction projects. When making sandcrete blocks, Portland cement must adhere to all the specifications given in EN 197-1:2011 and NIS 444-1:2003, respectively.

#### 1.1.2 Fine Aggregates

Fine aggregates are granular materials obtained by processing natural materials which pass through a sieve with a mesh size of 9.35 mm, almost totally pass through a sieve with a mesh size of 4.75 mm, and are mostly retained on a sieve with a mesh size of 200 (75 μm). For the production of sandcrete blocks, four different types of sand may be employed. They are river sand, sea sand, crushed stone sand, and pit sand. River sand is the most common in Nigeria.In terms of volume, sand makes up around 75% of the mixture. It serves as a filler and is a reliable predictor of the sandcrete block's anticipated compressive strength. The fundamental water to cement ratio is exceeded when using much finer sand because more cement and water are needed to coat the particles. The result is the production of weaker, more porous blocks. Too small natural dust grains can replace cement paste, cover grain surfaces, and form thin films, which hinder cement paste from lubricating the aggregates.

##### 1.1.2.1Tests for Fine Aggregates

i. Sieve Analysis:Sieve analysis is a laboratory test that measures the particle size distribution of a soil by passing it through a series of sieves. Soil retained on it is termed as gravel fraction. A set of British Standard (BS) sieves of sizes: 1.0mm, 0.85mm, 0.60mm, 0.50mm, 0.30mm, 0.25mm, 0.18mm and pan and a weighing balance were used for the analysis. The sieves were arranged by keeping the largest aperture sieve at the top and smallest aperture at the bottom.The grading of soil is best determined by direct observation of its particle size distribution curve. Equation 1, is usually adopted in calculating the Uniformity coefficient $C_u$.

$$C_u = \frac{D_{50}}{D_{10}} (1)$$

where,

$C_u$ = the Uniformity coefficient,

$D_{60}$ = particle diameter corresponding to 60% finer on the cumulative particle-size distribution curve and

$D_{10}$ = particle diameter corresponding to 10% finer on the cumulative particle-size distribution curve.

If$C_u$ < 4.0 the soil is poorly graded; if > 4.0 the soil is well graded. Well graded sands should be usedfor the production of sandcrete blocks.

ii Specific Gravity:The weight of a particular volume of fine aggregate (sand) to the weight of an equivalent volume of water is known as its specific gravity. Sands have a specific gravity of about 2.65. Specific gravity is considered to be a measure of strength or quality of a material.To carry out a specific gravity test, the following procedure can be adopted. An empty density bottle will be cleaned, dried, weighed and designated ($W_1$). The bottle will be filled with one-third of the total volume of the sand sample, weighed and designated ($W_2$). The bottle is then filled with distilled water, weighed and designated ($W_3$). Then the content of the bottle is discarded and rinsed thoroughly. The bottle is then filled with distilled water to the meniscus, weighed and designated ($W_4$). The Specific gravity (G) is then calculated using the Equation 2:

$$G = \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)} \qquad (2)$$

iii Water: Water reacts with cement to produce the hydration reaction. The amount of water utilized in the mixing process has a significant impact on the workability and strength of sandcrete. To make concrete or sandcrete, water must be devoid of suspended solids, inorganic salts, acids, and alkalis, as well as algae, oil contamination, and acids and alkalis. It is advised to use potable water that complies with NIS 554:2007 standard when making sandcrete blocks.

**1.2Mechanical Properties of Sandcrete Blocks**

The mechanical properties that are frequently declared in sandcrete blocks are the bulk density, water absorption, and compressive strength(Dio& Morris, 2009).

i. Bulk Density:Density is the quantity of an element's or material's particles packed into a specific volume, Equation 3. The density of the substance increases with the degree of particle packing. Therefore, higher levels denote a similar level of compaction. Mathematically, this is the mass of the masonry unit divided by the dimensions volume:

$$\text{Bulk Density } = \frac{\text{mass of block (kg)}}{\text{dimensional volume of block}(m^3)} \qquad (3)$$

The density is masonry units is determined in accordance with BS EN 772-13:2000. In Nigeria, a minimum density limit of 1920 kg/m$^3$ is recommended for individual sandcrete blocks, and 2020 kg/m$^3$ for an average of three or more blocks.

ii. Water Absorption: This is the amount of water that a block unit will absorb when submerged for the specified amount of time in the water at room temperature. It is stated as a percentage of the dry unit of the block's weight. The weight of water absorbed when the block unit is partially submerged in water for one minute is the absorption rate. Additionally, it is also defined as the amount of water that a brick absorbs in the first minute after coming into contact with water.

The procedure for obtaining the water absorption of masonry units is described in in EN 772-11:2011.It is expressed mathematically as;

$$\text{Water absorption } = \frac{\text{(mass of saturated block (kg} - \text{mass of dry block (kg)}}{\text{volume of block }(m^3)} \qquad (4)$$

The water absorption rate is determined by measuring the decrease in mass of the saturated block and surface dry sample. To achieve this, block samples whose weights had been taken in the dry state and noted as ($M_1$), were fully immersed in water. The time taken for full immersion was noted, and a period of twenty-four (24) hours was allowed to elapse. After 24 hours, the weight of the wet block samples was recorded as ($M_2$). The difference between the dry and wet weights of each block was calculated by subtracting the dry weight from the wet weight. The percentage absorption was calculated using the Equation below.

$$\text{Water absorption (\%)} = \left[\frac{(M_2 - M_1)}{M_1}\right] \times 100 \qquad (5)$$

The ASTM C140 recommended maximum water absorption capacity of 240 kg/m$^3$. The maximum water absorption specified by the Nigerian Standard is 12%.

**1.3Compressive Strength**

A compressive strength test is used to assess the quality of a block unit and its response to curing. It is described as the unit's capacity to sustain an axial load that is applied to either the block's bed face or its edge or the ratio of the crushing load that a sample can sustain to its net area. The declared compressive strength of the block by the manufacturer shall be the characteristic 5% fractile $f_c$ or the mean 50% fractile $f_m$.

The compressive strength of sandcrete blocks should be evaluated in accordance with EN 772-1:2000. When the anticipated compressive strength is less than 10 N/mm$^2$.The crushing machine,Figure 2 is used in the test and the compressive strength is obtained using Equation 6.


Figure 2: Compressive strength test machine

$$Compressive\ strength = \frac{maximum\ crushing\ load\ (N)}{\text{minimum surface area}\ (mm^2)} \quad (6)$$

Sandcrete hollow blocks have a minimum strength requirement of 2.5 N/mm$^2$ for 150 mm and 3.45 N/mm$^2$ for 225 mm, (NIS 87, 2007). The factors affecting this property are water-cement ratio, degree of compaction, fine aggregate (grade, texture and shape characteristics), cement type, the efficiency of curing, amount of mixing water, and mix proportion. In research conducted in Nigeria, the NIS's specified compressive strength for 150 mm (6 inches) sandcrete blocks at 28 days of curing was not met by either manually or mechanically operated methods (though a mix ratio of 1:9 was adopted in the study). Both manually and with the aid of a vibrating machine, nine (9) inches sandcrete blocks were produced, and they met all Nigerian Industrial Standards specifications. However, blocks made using a vibrating machine had a larger compressive strength than those made by hand. The vibrating block moulding machine produces sandcrete blocks with the highest compressive strength of all the techniques used because it achieves appropriate compaction. Additionally, compared to the other two methods, the vibrating machine-produced sandcrete blocks absorbed more moisture. Another study from Ghana found that using compaction in the vertical orientation with motorized vibration satisfies the required standards.

**1.3.1 Compressive strength requirements and standards**

Compressive strength is the principal mechanical property of sandcrete blocks and a key determinant of their structural integrity and suitability for load-bearing or partitioning applications. The compressive strength requirement of a block reflects not just its ability to carry imposed loads but also to withstand long-term environmental exposure without failure. Physical conditions such as method and days of curing, duration of time, temperature, compaction methodand quality of constituent materials,etc, will also contribute to the strength of the block (Dio, 2009).A block with insufficient strength can lead to cracking, spalling, and ultimately, partial or full structural failure (Olusola & Bello, 2012). Many regulatory bodies have set standards strength of blocks as in Table 4.

**Table 4:** Compressive strength standards for sandcrete/concrete blocks.

| Standard/body | Block type | Min. Strength (N/mm²) | Remarks |
|---|---|---|---|
| NIS 87:2004 (Nigeria) | Load-bearing hollow block<br>Non-load-bearing hollow block.<br>Solid block | 3.5<br>2.5<br>5.0 | 28-day strength for structural use.<br>For partition walls only.<br>Denser and stronger blocks |
| BS 6073-1:2008 (UK) | Load-bearing block | 7.0 | Higher quality control standards |
| ASTM C90-14 (USA) | Load-bearing concrete block | 13.1 | For reinforced and unreinforced masonry |
| Common Market Practice in Nigeria | Load-bearing (observed in field) | 1.0 -2.5 | Many blocks fall short of the NIS standard |

Omoregie (2012) claims that there is evidence to suggest a wide variation in compressive strength from one block manufacturer to another and also within block samples from a single source. This problem has been attributed to poor quality control and substandard constituent materials.

### 1.3.2 Compressive Strength of Sandcrete Blocks

The compressive strength of sandcrete blocks is affected by the mix proportion, quality of material used in making them, size, shape, and the mode of manufacture (i.e. hand or machine mould). The strength of the block will contribute to the strength of the units used in a structure. For example, walls built with poor quality blocks that falls short of the standard strength are likely to fail, thereby causing severe damage to the structure and sometimes even loss of lives and properties. This shows that there is need to know the compressive strength of blocks. And in order to minimize the huge loss of money by the block users in the course of handling and transporting substandard blocks, a standard information on the mix proportion and the quality of materials to be used in achieving the desired strength of structure, will certainly be useful to block manufacturers, block users and building designers (Nene, 2009). The recommended compressive strength for sandcrete in the British standard is 3.5N/mm$^2$ and NIS standard is 2.5N/mm$^2$ (Omopariola, 2014). Adekunle et al., (2018) observed that the compressive strength of sandcrete materials increases with increased cement content.

## 1.4Production of Sandcrete Blocks

The top three methods of sandcrete blocks production are:

1. Hand ramming compaction moulds.
2. Manual tamping compaction frame.
3. Motorized vibration machine.

All three methods employ both horizontal and vertical orientations in production. It is rare to see block manufacturing industries employing all three forms of production. Every block production industry typically uses only one orientation for the creation of block units for a specific type of compaction mechanism. During production, several manufacturers employ various compaction techniques with various orientations.

### 1.4.1 Hand Ramming Compaction Moulds

This is the commonest approach of block moulding in the rural areas of Nigeria. The equipment comprises of a steel mould box that has been prefabricated and moulded to the required size of the block, Figure 2. It is designed so that when the cement and sand mixture is rammed together to create a sandcrete block, the resulting shape precisely fits the mould and so adheres to the necessary specifications. The compressed wet unit can be removed after hand ramming thanks to a detachable steel plate sitting at the bottom. The mould box has two curved steel handles that make it easier to remove the compacted unit. A wooden bat in the form of a chisel serves as the compaction tool. The cement-sand mixture is brought up against the flat end of the bat, which is then driven over it and inserted into the steel mould. The compacted unit is taken out by slamming the box upside down. In order to receive the block, the opening end is eventually supported by a wooden pallet. The unit is turned upside down, and a removable steel plate now rests on top of it.

Figure 2: Hand moulding of blocks

**1.4.2 Manual Tamping Compaction Frame**

This compaction technique uses a steel framework with a mould supported by four legs as its equipment shown in Figure 3. Although the exact finishing height varies depending on the manufacturer, it is often around 1.0 m high. The sole lever mechanism is attached to a base plate that accommodates the mould. The means of compaction is another plate (top plate) covering with an adjacent handle. When tamping, the top plate is always weighed down with a thick steel piece to apply pressure to the cement-sand mixture effectively.

Figure 3: Sandcrete block production machine

Pulling down the tubular length by the frame moves the lever system. When compaction is complete, this action raises the completed product for collection. The adjacent handle is used to aid with compaction. Depending on the needed level of consolidation, the operation is repeated at least four times. For stability, the legs are braced, and the compacting pressure varies.

**1.4.3 Motorized Vibration Machine**

The Motorized Vibration Machine, Figure 4.It is powered by a motor that is tucked away beneath the wooden pallet on which the mould is set. The diesel variants use a roller that is turned by a fan belt that is fixed over the motor. The fixture on the motor, a metallic mass, collides with the underside of the wooden pallet, causing actual vibration. The longest lever, which is typically on the right side of the machine, is used to remove the moulded unit.

Figure 4: Motorized Vibration Block Moulding Machine

Unskilled labour can operate this equipment because it is designed to be simple to use. Because of the little maintenance it requires, the design is ideal for remote locations. Furthermore, the machine can be designed to run by diesel engines as well as electric motors. For stability and safe handling, robust frames are used in its design. It is controlled by three levers, and a constant hydraulic pressure is generated. The structure is 1.85 metres high.
Actual compaction is accomplished by pressing down on the cement-sand mixture in the mould below with the "presser." The highest lever is used to achieve this. The vibration is turned off with a second lever. The final and longest lever on the right lifts the mould gradually to enable quick removal of the compacted unit. The amount of compacting pressure from the motorized vibration machine is fairly constant.

**1.5Quality Control Tips for Block Production**

The blocks are produced locally or in factories. The method of production of sandcrete blocks also significantly affects their quality, (Anosike&Oyebade, 2012).. The choice between local block production and factory-made options comes down to scale, budget, and project requirements. Local block making is cheaper but more variable in quality. Factory blocks ensure consistency and are subjected to quality control, making them ideal for critical structural parts of buildings. Locally produced blocks often lack adequate compressive strength due to poor cement ratios or substandard curing practices, while factory-made blocks, on the other hand, typically conform to higher quality standards, including better compaction, accurate sizing, and uniformity (Ubani, 2022). For durability and structural safety, factory-produced blocks are the preferred option in larger or multi-level projects. Some basic factors that should be considered in producing quality sandcrete blocks are:

i. Water, sand, and aggregates must be clean and devoid of organic contaminants.
ii. Ideally, the sand to be used for block production should be dry. When wet, the moisture content and the water absorption should be determined to effectively control the water-cement ratio.
iii. Cement and aggregate must be mixed until the colour is uniform.
iv. Only add enough water to the mixture to make it workable.
v. The wheelbarrows used for measurement (65-litre builder's wheelbarrows) should not be heaped.
vi. All mixtures should never be re-tempered by adding more water because doing so weakens the final product and should be used up within two hours of initial mixing.
vii. Complete compaction is required. Avoid too little or inadequate compaction since it reduces the strength of the block.
viii. Blocks need to be cured after demoulding. Curing is the process of keeping the blocks at an ideal temperature and moisture level to promote the hydration of the cement and the development of maximum strength. The curing period for blocks should be at least 14 days.

Blocks are essential for low-cost housing and infrastructural development. However, their quality, particularly in terms of compressive strength, varies significantly from one block moulding industry to another (Agunwamba et al., 2014;Ezeokonkwo&Oloruntoba, 2014; Suleiman et al., 2020). These blocks also vary in weight, which is a function of the type of material (sandcrete, concrete, etc.), moisture content, and block density. On the average, a 6-inch solid sandcrete block weighs between 13–18 kg and a 9-inch hollow block typically weighs between 20–25 kg (Anosike and Oyebade, 2012). The material composition of building blocks used in Nigeria is a key factor influencing the quality, size, strength, cost, and environmental performance (Suleiman et al., 2020).

The use of sandcrete blocks in Nigeria dates back to the colonial era, when modern construction methods began replacing traditional mud and adobe structures. With the growth of urbanization and an increasing demand for permanent, fire-resistant, and structurally stable housing, sandcrete blocks quickly became a preferred building material (Oyekan&Kamiyo, 2008). By the 1970s, commercial block moulding became widespread, with both manual and semi-automated methods being adopted across the country. Today, sandcrete blocks are a staple of the Nigerian construction industry and are used in residential, commercial, and public buildings. Sandcrete blocks plays a pivotal role in building construction due to its widespread adoption (Baiden and Tuuli, 2004). Their versatility and compatibility with reinforced concrete have ensured their dominance over other traditional building materials such as mud blocks and laterite bricks (Olaniyan et al., 2021). Sandcrete blocks serve as load-bearing walls in low-rise buildings, used for partitioning spaces and forming enclosures, acting as thermal and sound insulators, especially in multi-unit housing, providing structural stability and form the foundation for interior and exterior finishes (NIS 87:2007; Arum et al., 2015). The functionality and performance of sandcrete blocks directly affect the structural integrity and longevity of buildings. The strength of a block wall depends significantly on the quality of individual blocks, their alignment, the mortar used, and curing practices (Akinyele et al., 2022; Ettuet al., 2013). Due to their modular shape and ease of handling, sandcrete blocks contribute to faster construction times and reduced labour costs, particularly in mass housing schemes. However, poor quality blocks can lead to cracks, moisture seepage, or even structural failure, especially in walls that bear loads or resist lateral forces such as wind or earth pressure (Yakubu &Salihu, 2016). Factors like curing temperature, presence of admixture, water (salty or portable), compaction method, time difference between mixing and compaction greatly affect the property of sandcrete blocks (Oyekan and Kamiyo 2008). The proportions of the constituents, the production and the curing methods used are critical to achieving adequate compressive strength, durability, and dimensional stability (Falade&Ikponmwosa, 2011).

There has being a proliferation of block moulding industries in many parts of Nigeria as a result of the rapid urbanization and development in the housing sector (Afolabi & Akinyemi, 2022).Figure 5 shows a cross-section of some block moulding industries in the study area.

Figure 5: Cross section of sandcrete blocks at different block moulding industries.

These factories or individuals operate on both small and large scales without necessarily adhering to standard production practices. The quality of blocks produced however, differs from each industry (Abdullahi, 2005). Thereby posing serious structural risks and contributes to the rising number of building failures (Oyenuga&Fadamiro, 2021; Ettu et al., 2013; Ezeh&Ibearugbulem,2009). To maximize profit lots of producers cut corners by using insufficient cement content, improper curing methods, or substandard sand, resulting in blocks with lowcompressive strength and durability. In recent years, Nigeria has witnessed a troubling increase in the incidence of building failures and partial collapses, many of which have been linked to the use of substandard construction materials, particularly sandcrete blocks. Despite their widespread use in residential and public infrastructure, the quality of sandcrete blocks remains inconsistent, with many producers failing to comply with established standards such as the Nigerian Industrial Standard (NIS 87:2007). The use of sandcrete blocks with substandard strength results in structural instability and safety hazards, excessive cracking and deflection, increased maintenance cost and premature building failure. For safer buildings, Engineers should ensure blocks are tested and meet the NIS minimum requirements.

**1.6 Previous studies on sandcrete blocks evaluation**

Over the past two decades, several studies in Nigeria and across Sub-Saharan Africa have evaluated the physical and mechanical properties of sandcrete blocks, with particular emphasis on compressive strength, mix proportions, and compliance with standards. These investigations are crucial in understanding the performance of blocks produced by both formal and informal manufacturers and provide context for the current study.

Oyekan and Kamiyo (2011), compared the compressive strength of blocks subjected to different curing methods. It concluded that water immersion curing for 7 to 28 days significantly improved strength, whereas sun-dried blocks exhibited poor performance. The findings underscored the impact of curing techniques on the final strength of blocks.Ayubaet al., (2014), in a survey carried out in Makurdi Metropolis, the researchers assessed local block manufacturing practices and found that over 60% of sampled blocks failed to meet the standard compressive strength. The authors attributed this failure to non-compliance with standard mix proportions and poor-quality control procedures.Joshua et al., (2018)investigated how raw material properties influence the compressive strength of sandcrete blocks. It revealed that fine aggregates with high silt content and low-grade cement significantly reduce strength. The study recommended routine testing and material screening prior to production. Ede and Amadi (2014), in their study titled “Strength Characteristics of Sandcrete Blocks in Ibadan”, sampled blocks from 20 different manufacturers and discovered that most blocks had compressive strengths ranging between 1.1 N/mm² to 2.5 N/mm², which is far below the minimum recommended by NIS 87:2007. They emphasized the need for better regulation of the industry.Ejeh and Jibrin (2012)evaluated the performance of commercially produced blocks in Minna, Niger State. It concluded that factory-produced blocks showed more consistency in strength than those produced on-site. However, even factory blocks frequently fell below standard due to poor curing.Falade and Ikponmwosa (2007), studied the effects of various curing durations and concluded that a curing period of at least 14 days was essential to achieving acceptable strength values. Their findings promoted public awareness of the dangers of premature loading and selling of freshly molded blocks.Bamisaye (2004), examined both mechanical properties and production techniques across Lagos State. He found that informal producers dominated the industry and recommended formal training and licensing as a prerequisite for operation.Onoh and Okonkwo (2019), in their research conducted in Enugu State, examined 50 sandcrete blocks from local producers and revealed that 72% of the blocks tested failed to meet the 3.45 N/mm² standard. The study emphasized the growing issue of profit-driven compromise in materials selection and recommended random on-site testing as part of quality control strategies.Okonet al., (2021), evaluation of blocks in Akwa Ibom State revealed significant inconsistencies in compressive strength between factory and roadside producers. The study highlighted the role of operator skill level and equipment quality, stressing the importance of training and regulatory inspections.Afolabi and Akinyemi (2022), investigated block production in Lagos and Ogun states, this study adopted non-destructive ultrasonic testing alongside traditional crush testing. They found that non-destructive tests could reliably predict compressive strength, recommending its adoption for quicker quality control in block factories.Ozoani et al., (2023), in a nationwide study assessed compliance with NIS standards across six geopolitical zones. It concluded that while major cities have shown improved compliance due to increased enforcement, semi-urban and rural areas still lag significantly, with over 65% of sampled blocks failing to meet minimum strength standards.

Over the years, numerous studies have been conducted on the quality assessment of sandcrete blocks in Nigeria, especially in urban centers such as Lagos, Abuja, and Port Harcourt (Oyetola& Abdullahi, 2006;Ozoani et al., 2023). These studies have provided valuable insights into the compressive strength, production techniques, and regulatory compliance of sandcrete blocks produced by various industries. However, a number of important gaps still exist in the body of knowledge, particularly in the context of localized and semi-urban production environments. While some research has focused on strength variability and substandard production practices in general (Mohammed & Olusola, 2014; Okonet al., 2021), there remains limited empirical data specifically addressing sandcrete block production across different moulding industries within Delta State, a region witnessing rapid urban expansion and rising housing demand. The unique geotechnical conditions, availability of local materials, and varying adherence to regulatory standards in the state create conditions that are not entirely captured in existing national-level studies. Most prior investigations often fail to draw distinctions between large-scale industrial block manufacturers and informal roadside producers, despite growing concerns that this disparity significantly affects the overall structural integrity of buildings in semi-urban and rural communities (Onoh& Okonkwo, 2019; Nduka &Ekeh, 2024). As a result, current literature does not adequately capture how production scale, material proportions, or curing practices influence compressive strength outcomes in these settings. While emerging technologies such as non-destructive testing and AI-based evaluation have been suggested (Afolabi & Akinyemi, 2022; Nduka &Ekeh, 2024), there is a lack of field-based data comparing actual compressive strengths with those predicted by simplified industry assumptions, particularly in states like Delta where regulatory enforcement may be minimal.Finally, despite increased emphasis on quality control mechanisms and standardization, there remains a scarcity of localized studies that examine the effectiveness of these mechanisms in practice, especially in moulding industries that operate with limited oversight.

This study therefore, seeks to evaluate the compressive strength of sandcrete hollow blocks of 150 mm and 225 mm produced by different block moulding industries and compare their strength to what is stipulated the Nigerian Industrial Standard (NIS 87:2007).

## II. Materials and Method

### 2.1 Study Area

This study was carried out across five Local Government Areas in Delta South and Delta Central Senatorial District of Delta State of Nigeria. The industries are located in Warri (Warri South LGA), Effurun (Uvwie LGA), Okuokoko (Okpe LGA), Ughelli (Ughelli North LGA) Oleh (Isoko South LGA), all within the Niger Delta region of the Nigeria, Figure 6. A total of eighty (80)different block moulding locations in all. Thesecities are experiencing rapid urbanization and infrastructural development, which has increased the demand for sandcrete blocks as a primary building material for residential and commercial structures. The local government areas are characterized by dense urban development and significant housing.

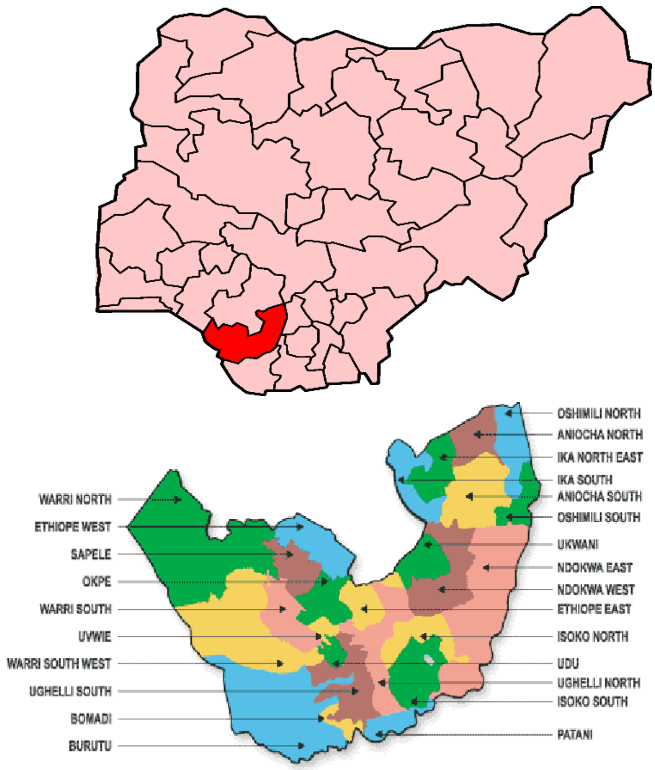


Figure 6: Map of Delta State, Nigeria.

The geographic coordinates for the study locations are shown in Table 5.

**Table 5:** Coordinates of study area.

| Location | Local Government Area (LGA) | Latitude | Longitude |
|---|---|---|---|
| Warri | Warri South LGA | 5° 31' 2" N | 5° 45' 0" E |
| Effurun | Uvwie LGA | 5° 31' 0" N | 5° 45' 0" E |
| Okuokoko | Okpe LGA | 5°34' 49" N | 5° 49' 26" E |
| Ughelli | Ughelli North LGA | 5° 30' 0" N | 6° 02' 0" E |
| Oleh | Isoko South LGA | 5° 27' 42" N | 6° 12' 22" E |

The citiesare home to numerous block moulding industries that produce sandcrete blocks for both load-bearing and non-load-bearing walls. Its selection as a study area is based on its economic importance and high rate of construction activities, which makes quality assurance of sandcrete blocks critical. They experience a tropical monsoon climate, with an average annual rainfall of about 2,000 – 3,000 mm and temperatures ranging between 25°C and 32°C. The soil composition in this area predominantly consists of sandy loam and silty clay, which influence the availability and characteristics of fine aggregates used in sandcrete block production.The choice of the study area is based on the high construction demand, presence of numerous block-moulding industries, and it is representation of both semi-urban and urban environments within Delta State. Evaluation will provide a comprehensive understanding of the compressive strength and quality variations of sandcrete blocks produced in this part of the state.

## 2.2 Materials and Methods

### 2.2.1 Samples Collection

Eighty 225mm × 225mm × 450mm (9'')sandcrete hollow blocks ofapproximately 28 days old were procured from twenty randomly selected block moulding industries across five Local Government Areas in Delta South and Delta Central Senatorial District of Delta State. The industries are located in Warri (Warri South LGA), Effurun (Uvwie LGA), Okuokoko (Okpe LGA), Ughelli (Ughelli North LGA) Oleh (Isoko South LGA).At each factory, observations were made to gather information about batching, mix ratios, curing methods and duration, mixing process, method of compaction and quality of water for producing the blocks, Table 6. Oral Interviews of owners and workers on site were also carried out.

Table 6: Production methods of blocks at each location

| LGA | Factories | No. of block | Batching method | Method of mixing | Method of compaction | Method of curing | Type of cement |
|---|---|---|---|---|---|---|---|
| **Warri South** | W1 | 4 | Volume | Mechanical | Mechanical | Water hose | Dangote OPC |
| | W2 | 4 | Volume | Mechanical | Mechanical | Water hose | Dangote OPC |
| | W3 | 4 | Volume | Mechanical | Mechanical | Water hose | Dangote OPC |
| | W4 | 4 | Volume | Manual | Mechanical | Water hose | Dangote OPC |
| **Uvwie** | E1 | 4 | Volume | Mechanical | Mechanical | Water hose | Dangote OPC |
| | E2 | 4 | Volume | Mechanical | Mechanical | Water hose | Dangote OPC |
| | E3 | 4 | Volume | Mechanical | Mechanical | Water hose | Dangote OPC |
| | E4 | 4 | Volume | Manual | Manual | Water hose | Dangote OPC |
| **Okpe** | O1 | 4 | Volume | Mechanical | Mechanical | Water hose | Dangote OPC |
| | O2 | 4 | Volume | Mechanical | Manual | Water hose | Dangote OPC |
| | O3 | 4 | Volume | Mechanical | Mechanical | Water hose | Dangote OPC |
| | O4 | 4 | Volume | Manual | Manual | Water hose | Dangote OPC |
| **Ughelli North** | U1 | 4 | Volume | Mechanical | Mechanical | Water hose | Dangote OPC |
| | U2 | 4 | Volume | Mechanical | Manual | Water hose | Dangote OPC |
| | U3 | 4 | Volume | Mechanical | Manual | Water hose | Dangote OPC |
| | U4 | 4 | Volume | Manual | Mechanical | Water hose | Dangote OPC |
| **Isoko South** | S1 | 4 | Volume | Mechanical | Mechanical | Water hose | Dangote OPC |
| | S2 | 4 | Volume | Mechanical | Mechanical | Water hose | Dangote OPC |
| | S3 | 4 | Volume | Mechanical | Manual | Water hose | Dangote OPC |
| | S4 | 4 | Volume | Manual | Manual | Water hose | Dangote OPC |

The hardened blocks were transported to site on pallets in dump trucks astransportation and storage of blocks can adversely affect the quality of the blocks. The blocks were handled with care to avoid the chipping of the edges and corners.

**2.3 Laboratory Tests**

The sandcrete blocks were taken to the structures laboratory of the Civil Engineering Department of Delta State University, Abraka, Oleh Campus. The blocks were cleaned and the following tests were conducted in accordance to Standard Codes of Practice (BS 8500-2:2015+A2:2019;ASTM, 2011).

**2.3.1 Density Determination**

Density is defined as the measure of how many particles of an element or material are squeezed into a given space. The more closely packed the particles, the higher the density of the material. Higher levels, therefore, indicate a corresponding degree of compaction. This is the mass of the masonry unit divided by the dimensional volume, mathematically expressed as mass of block (kg) divided by the dimensional volume of block (m$^3$). Nigerian Industrial Standard (NIS) stipulates a minimum bulk density of 1920 kg/m³ for load-bearing applications, and above 1500 kg/m³ for general grade blocks. The Density of the blocks were calculated as the mass of the block unit divided by the dimensional volume according to (BS EN 206-1, 2006; BS EN 771-3:2011+A1:2015; ASTM C90, 2014), Equation 7.

$$\text{Density} = \frac{\text{Mass of the block (Kg)}}{\text{Dimensional volume of block } (m^3)} \quad (7)$$

**2.3.2 Water Absorption**

The water absorption values of the concrete paving blocks were investigated at the age of 28 days according to ASTM C140, (2011). The dry blocks were heated to 110 ± 5 °C for 48 in an oven for 24 hours till theyattained constant mass. and then allowed to cool at room temperature and the weight of the bricks were recorded as ($W_1$). They were then immersed in awater tank at a temperature of 27° ± 2°C and later taken out of water and wiped with a damp cloth. Three minutes, thereafter were weighed again and recorded as $W_2$. The water absorption was calculated by comparing the saturated and oven-dry weights of the blocks and determining the amount of water that had been absorbed.Block's absorption was calculated according to Equation 8.

$$w = \frac{m_2 - m_1}{m_1} \times 100\% \quad (8)$$

Where,

$w$ = water absorption(%);
$m_2$ = block saturated mass (kg);
$m_1$ = block dried mass (kg).

**2.3.3 Compressive Strength**

The procedure involved placing the hollow sandcrete block a universal testing machine and subjecting it to a compressive force until it fails, as shown in Figure 7. The test was conducted in a universal testing machine model DL30000, with device displacement of 2 mm/min. The results of the compressive strength (MPa) were obtained by dividing the maximum load (N) by the area of section ($mm^2$), The maximum load sustained by the block during the test is recorded, and the compressive strength was calculated based on the cross-sectional area of the block, according to (BS EN 12390-3:2009; BS EN 772-1:2011; ASTM C140/C140M, 2018) using Equation 9.

$$\text{Compressive strength } (Fc) = \frac{\text{Maximum load (kN)} \times 1000\ \text{(P)}}{\text{Cross} - \text{sectional Area (A)}(mm^2)} \tag{9}$$

Where:

$fc$ = Compressive strength ($N/mm^2$)

$P$ = Maximum load at failure (N)

$A$= Cross-sectional area of the block ($mm^2$)

**2.3.4 Data Tables**

Table7 shows data gotten from verbal interview with representatives of the block molding industries from which the sandcrete blocks were procured. Table 8 also depicts the concrete block production parameters and output across the selected factories.

Table7: Production information from block molding industries under review.

| LGA | Factories | Blocks Produced Per Bag | | Mix ratio |
|---|---|---|---|---|
| | | 150mm | 225mm | |
| Warri South | W1 | 45 | 38 | 1:13 |
| | W2 | 41 | 35 | 1:12 |
| | W3 | 42 | 40 | 1:12 |
| | W4 | 43 | 40 | 1:12 |
| Uvwie | E1 | 40 | 34 | 1:12 |
| | E2 | 46 | 37 | 1:13 |
| | E3 | 47 | 35 | 1:13 |
| | E4 | 42 | 41 | 1:12 |
| Okpe | O1 | 44 | 48 | 1:13 |
| | O2 | - | - | 1:12 |
| | O3 | 48 | 46 | 1:13 |
| | O4 | 48 | 39 | 1:12 |
| Ughelli North | U1 | 49 | 38 | 1:12 |
| | U2 | 45 | 33 | 1:12 |
| | U3 | 44 | 38 | - |
| | U4 | 47 | 37 | 1:13 |
| Isoko South | S1 | 46 | 37 | 1:12 |
| | S2 | 45 | 34 | 1:12 |
| | S3 | - | - | 1:13 |
| | S4 | 42 | 35 | 1:12 |

## III. Results and Discussion

Table 8 shows results of the tested physical properties of the 9 inches sandcrete blocks from the various block moulding industries.The production survey across five Local Government Areas (LGAs) in Delta State highlights varied manufacturing indices among commercial block industries. From Table 8, the number of blocks produced per bag of cement varied based on size and factory requirements. For the 150mm blocks, the yield ranged from 40 blocks per bag at factory E1 in Uvwie LGA to 49 blocks per bag at factory U1 in Ughelli North LGA, establishing a study mean of 45 blocks per bag. Conversely, the 225mm blocks recorded a lower yield range between 33 blocks per bag at factory U2 in Ughelli North and 48 blocks per bag at factory O1 in Okpe, maintaining a regional mean of 38 blocks per bag. These yield figures heavily dictate the material mix ratios chosen by the operators. Factories favouring a richer 1:12 mix proportion generally limited their block yields to maximize quality, whereas factories utilizing a leaner 1:13 mix layout expanded their block yields per bag of cement. Leaner mixes like 1:13 reduce production costs but significantly thin out the cement matrix bonding the sharp river sand particles together.

Table 8: Summary table of the sandcrete block mechanical properties at Day 28.

| LGA | Factories | Blocks Produced per Bag | | Mix ratio | Density | Water absorption | Compressive strength 9'' hollow blocks($N/mm^2$) | Mean strength ($N/mm^2$) |
|---|---|---|---|---|---|---|---|---|
| | | 150mm | 225mm | | | | | |
| Warri South | W1 | 45 | 38 | 1:13 | 1595 | 10.82 | 1.476 | 1.588 |
| | W2 | 41 | 35 | 1:12 | 1674 | 9.78 | 1.621 | |
| | W3 | 42 | 40 | 1:12 | 1658 | 9.94 | 1.591 | |
| | W4 | 43 | 40 | 1:12 | 1698 | 9.42 | 1.664 | |
| | E1 | 40 | 34 | 1:12 | 1649 | 10.11 | 1.574 | 1.578 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Uvwie | E2 | 46 | 37 | 1:13 | 1646 | 10.15 | 1.570 | |
| | E3 | 47 | 35 | 1:13 | 1647 | 10.13 | 1.571 | |
| | E4 | 42 | 41 | 1:12 | 1661 | 9.89 | 1.597 | |
| | O1 | 44 | 48 | 1:13 | 1685 | 9.58 | 1.641 | |
| Okpe | O2 | - | - | 1:12 | 1715 | 9.11 | 1.695 | 1.651 |
| | O3 | 48 | 46 | 1:13 | 1650 | 10.08 | 1.575 | |
| | O4 | 48 | 39 | 1:12 | 1714 | 9.13 | 1.694 | |
| | U1 | 49 | 38 | 1:12 | 1679 | 9.69 | 1.630 | |
| Ughelli | U2 | 45 | 33 | 1:12 | 1709 | 9.24 | 1.685 | 1.639 |
| North | U3 | 44 | 38 | - | 1702 | 9.35 | 1.672 | |
| | U4 | 47 | 37 | 1:13 | 1645 | 10.19 | 1.567 | |
| Isoko | S1 | 46 | 37 | 1:12 | 1658 | 9.94 | 1.591 | |
| South | S2 | 45 | 34 | 1:12 | 1698 | 9.42 | 1.664 | 1.600 |
| | S3 | - | - | 1:13 | 1649 | 10.11 | 1.574 | |
| | S4 | 42 | 35 | 1:12 | 1646 | 10.15 | 1.570 | |
| Mean | | 45 | 38 | | 1671 | 9.81 | 1.611 | |

The bulk density of sandcrete blocks is a vital metric that reflects their level of compaction, aggregate packing, and internal void structures. Looking closely at the experimental dataset, the bulk density values range between a minimum of 1,595 kg/m³ at factory W1 in Warri South and a maximum of 1,715 kg/m³ at factory O2 in Okpe. The overall calculated mean density across all twenty sampled factories stands at 1,671 kg/m³. When evaluated against standard regulatory provisions, such as the Nigerian Industrial Standard NIS 87:2014 or the British Standard BS 2028, which suggest a minimum bulk density threshold of 1,800 kg/m³ for optimal quality, the commercial hollow blocks produced in these zones fall short. This lower density profile is attributed to manual machine compaction methods and lean sand-to-cement ratios common among local manufacturers. The highest density values were consistently observed in factories adopting 1:12 mix layouts, such as factories O2, O4, and U2, which underscores how richer cement content improves aggregate coating and filling of microscopic voids.

Water absorption capacity directly mirrors the permeable pore spaces within a block matrix. Based on the experimental outcomes, water absorption values span from a low of 9.11% at factory O2 in Okpe to a high of 10.82% at factory W1 in Warri South, culminating in a regional mean of 9.81%. According to NIS 87:2014, the maximum permissible water absorption for sandcrete blocks is capped at 12.0%. An analysis of the data reveals that 100% of the sampled factories across Warri South, Uvwie, Okpe, Ughelli North, and Isoko South strictly comply with this durability requirement. A clear inverse relationship is evident between bulk density and moisture absorption, as factories with higher density marks, like O2 with 1,715 kg/m³ and O4 with 1,714 kg/m³, naturally display lower absorption percentages of 9.11% and 9.13%, respectively. This occurs because denser block packing restricts interconnected capillary paths, preventing excess water entry.

The compressive strength parameter serves as the primary structural yardstick for block safety and performance. The individual crushing strengths across the fields fluctuated from 1.476 N/mm² at factory W1 up to a peak of 1.695 N/mm² at factory O2. On a zonal basis, Warri South recorded a mean strength of 1.588 N/mm², Uvwie recorded 1.578 N/mm², Okpe achieved 1.651 N/mm², Ughelli North reached 1.639 N/mm², and Isoko South maintained an average of 1.600 N/mm². The grand mean compressive strength for the entire study area sits at 1.611 N/mm². When evaluated against the standard requirements of BS 2028 (1970) for precast building items, which prescribes a minimum compressive strength of 2.80 N/mm² for Type B lightweight/general blocks and 3.50 N/mm² for Type A structural load-bearing blocks, all sampled products fail to meet the standard. Similarly, the blocks fail to meet the local NIS 87:2014 standard, which demands a minimum strength limit of 2.50 N/mm² for non-load-bearing units. This widespread strength deficiency is directly caused by the lean mix designs of 1:12 and 1:13 and excessive block yield configurations up to 49 blocks per bag utilized by local commercial producers. These practices are driven by profit-driven field optimization rather than compliance with formal building codes, making these blocks unsuitable for critical load-bearing applications unless the mix designs are enriched.

## IV. Conclusion and Recommendations

### 4.1 Conclusion

The structural evaluation of commercial sandcrete blocks across the sampled local government areas in Delta State reveals critical gaps between market production choices and established regulatory standards. Although 100% of the manufacturing factories met the durability criteria for water absorption by staying safely beneath the 12.0% maximum threshold dictated by NIS 87:2014, their structural capacities tell a different story. The grand mean compressive strength of 1.611 N/mm² across the study zones falls severely short of the 2.50 N/mm² minimum requirement set by the Nigerian Industrial Standard for non-load-bearing masonry, and it fails to approach the 2.80 N/mm² Type B limit specified in BS EN 773-1:2011. This widespread strength deficiency directly correlates with low bulk density profiles, which averaged just 1,671 kg/m³ instead of the standard 1,800 kg/m³ benchmark. Ultimately, these laboratory outcomes prove that commercial block operators in Warri South, Uvwie, Okpe, Ughelli North, and Isoko South are maximizing financial profits by producing excessive block yieldsstretching up to 49 blocks per bag of cement using lean 1:12 and 1:13 mix ratiosat the absolute expense of the structural safety and structural integrity of local building developments.

**4.2 Recommendations**

To rectify these dangerous structural deficiencies and ensure building safety across Delta State, immediate technical updates and regulatory enforcement must be implemented.

i. Commercial manufacturers must immediately abandon lean 1:12 and 1:13 mix designs and transition to a richer, code-compliant mix ratio no leaner than 1:6 or 1:8, which will naturally reduce block yields to a safer 30 to 35 blocks per bag of cement.
ii. Production yards must replace manual mixing and low-energy compaction methods with automated mechanical vibrators to properly compress the concrete matrix, reduce microscopic air voids, and raise bulk densities above the mandatory 1,800 kg/m³ threshold.
iii. Regulatory bodies such as the Standards Organization of Nigeria (SON) and local town planning authorities must launch strict field monitoring routines, penalizing factories that distribute substandard masonry units.
iv. Public awareness campaigns should be introduced across the construction sector to educate site engineers and block buyers on identifying code-compliant materials, ensuring that blocks below the 2.50 N/mm² threshold are restricted from load-bearing construction applications.

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