CHAPTER THREE

3.0 MATERIAL AND METHOD

3.1 Material selection

Sandcrete blocks, a common building material, require careful material selection to ensure strength, durability, and cost-effectiveness. Key criteria include the quality of cement, sand, and water, as well as the mix proportions. Adhering to standards like the Nigerian Industrial Standard (NIS) is crucial for achieving the desired compressive strength and other properties.

Here's a breakdown of the material selection criteria:

1. Cement:

3.1.1 Type

Portland cement is typically used, but other binders like pozzolanas or rice husk ash can be added to reduce cement content according to Wikipedia.

3.1.2 Quality

The cement should be fresh and free from lumps, ensuring it is properly hydrated and contributes to the block's strength.

3.1.3 Quantity

The cement-to-sand ratio is a critical factor. Common ratios are 1:6 or 1:8 (cement:sand), but some studies suggest that leaner mixes (1:9) can still produce blocks meeting minimum strength requirements.

3.2 Sand

Type: Sharp, clean, and well-graded sand is essential. It should be free from clay, silt, and organic matter, as these impurities can weaken the block.

Grading: The sand particles should be properly sized to provide a dense and strong matrix when combined with cement.

Quantity: The sand content is determined by the desired mix ratio with cement.

3.3 Water

Quality: Clean, potable water is necessary.

Quantity: The water-cement ratio is crucial for proper hydration of the cement. A ratio of 0.5 (water-binder ratio) is commonly adopted.

3.4 Supplementary Materials

Micronized laterite: Some studies explore replacing cement with micronized laterite to reduce costs.

Pozzolanas and Rice Husk Ash: These can be added to reduce cement content and improve block properties.

3.5 Mix Proportions

Cement-to-sand ratio:

The ratio affects the block's strength and workability. Common ratios are 1:6 and 1:8, but some research suggests leaner mixes are adequate.

Water-cement ratio:

Adequate water is needed for hydration and workability, but excessive water can weaken the block.

3.6 Other Considerations

Compressive Strength:

Sandcrete blocks should meet minimum compressive strength standards, which can vary by region and application (load-bearing vs. non-load-bearing).

3.7 Density

The density of the block affects its strength, thermal insulation, and durability.

Water Absorption:

Excessive water absorption can weaken the block and affect its performance in wet conditions.

3.8 Dimensions

Standard dimensions for sandcrete blocks are 450mm x 225mm x 225mm and 450mm x 150mm x 225mm. (Dieter, G.E., & Schmidt, L.C., 2016)

1. Mild steel plate
2. angle iron
3. channel iron
4. Hollow metal pipe
6. springs
7. bearing
8. Welding electrodes
9. fasteners (nuts, bolts, washers)

3.9 MATERIAL SELECTION FOR THE MACHINE

3.9.1 MATERIAL

Component(s)

Justification for Selection

3.9.1.1 Mild Steel Plate

Frame, mold box, lever arms, compression plate

High tensile strength, excellent weldability, cost-effective, widely available dimension

2440 x 1220 x 1.5 (2440 x 1220 x 3mm)

3.9.1.2 Angle Iron

Frame structure, vertical and horizontal supports

Provides rigidity, ease of assembly, suitable for structural framing dimension

(50.4 x 50.4 x 5mm)

3.9.1.3 Channel Iron

Base frame, mold track guides

High bending resistance, suitable for load-bearing applications dimension

(100 x 50 x 6mm)

3.9.1.4 Hollow Steel Pipe

Handles, guide shafts

Lightweight and strong, ideal for moving or rotating parts

3.9.1.5 High Carbon Steel

Compression springs

High elasticity and fatigue resistance, returns mold to original position

3.10 SANDCRETE BLOCK TESTING PROCEDURE

Primarily involves determining its compressive strength and water absorption capacity. Compressive strength is measured using a compression machine, while water absorption is determined by immersing the block in water for a specified time and then calculating the percentage increase in weight.

3.10.1 Compressive Strength Test

3.10.1.1 Apparatus

Compression machine, steel plates, weighing balance, and the sandcrete block samples.

Procedure:

- Weigh the block and record its weight.

- Place the block on the compression machine with steel plates on top and bottom to distribute the load evenly.
- Apply load gradually and continuously until the block fails.
- Record the maximum load the block can withstand before failure.

3.10.1.2 Water Absorption Test

Procedure:

Weigh the dry block.

Immerse the block in clean water at room temperature for 24 hours.

Remove the block from the water and allow it to drain for a minute.

Weigh the wet block.

Calculate the water absorption percentage using the formula: (Wet weight - Dry weight) / Dry weight * 100.

3.10.1.3 Other Tests

Dimension Measurement: Measure the length, width, and height of the block.

Density: Determine the mass and volume of the block to calculate its density.

Important Considerations:

3.10.1.4 Curing

Sandcrete blocks should be properly cured (typically by spraying with water for a specific duration) to ensure adequate strength development.

3.10.1.5 Mix Ratio

The mix ratio of cement, sand, and water significantly impacts the compressive strength of the block.

3.10.1.6 Standard Compliance

Sandcrete blocks should meet the standards set by relevant authorities (e.g., NIS 87:2007 in Nigeria).

3.10.1.7 Quality Control

Regular testing and quality control measures are crucial to ensure that sandcrete blocks meet the required specifications and prevent building failures.

3.11 SANDCRETE BLOCK TESTING CRITERIA

Sandcrete block testing criteria primarily focus on compressive strength, water absorption, and dimensional accuracy. These tests help ensure the blocks meet minimum quality standards for construction, as specified in standards like the Nigerian Industrial Standard (NIS) 87:2000.

Here's a breakdown of the key testing criteria:

3.11.1 Compressive Strength:

This test measures the block's ability to withstand compressive forces, a crucial factor for load-bearing walls.

The Nigerian Industrial Standard (NIS) 87:2000 specifies a minimum compressive strength of 2.5 N/mm^2 for non-load-bearing walls and 3.45 N/mm^2 for load-bearing walls.

Blocks are typically tested at 28 days after production.

A compressive testing machine (CTM) is used to apply pressure until the block fails, and the maximum load is recorded.

The compressive strength is then calculated based on the block's cross-sectional area.

3.11.2 Water Absorption

This test evaluates the block's ability to resist water penetration, which is important for durability and preventing structural damage.

The test involves measuring the amount of water absorbed by the block after a specific immersion period.

The ASTM C140 standard recommends a maximum water absorption capacity of 240 kg/m^3.

3.11.3 Dimensional Accuracy

This involves verifying that the block's dimensions (length, width, and height) conform to specified standards.

Sandcrete blocks are produced in standard sizes, such as 450mm x 225mm x 225mm and 450mm x 225mm x 150mm.

Deviations from these dimensions can affect the overall structural integrity and aesthetic appearance of the building.

3.11.4 Other Tests (Optional)

Density: This test measures the mass of the block per unit volume.

Visual Inspection: A visual check for cracks, defects, and proper shape.

Sound Test (Ring Test): Acoustic assessment by knocking two blocks together.

Weight Test: Feeling the weight of the block to assess its density and material composition.

Drop Test: Assessing the block's resistance to impact by dropping it from a certain height.

3.11.5 Importance of Testing

Ensuring Structural Integrity:

Meeting minimum strength and water absorption requirements is crucial for the stability and longevity of structures.

3.11.6 Compliance with Standards

Adhering to standards ensures that buildings are safe and meet regulatory requirements.

3.11.7 Preventing Failures

Testing helps identify and prevent the use of substandard blocks, reducing the risk of construction defects and failures.

3.11.8 Quality Control

Testing provides a means of quality control throughout the production process, ensuring consistent and reliable block production.

By adhering to these testing criteria, sandcrete block manufacturers can ensure the production of high-quality blocks that meet the demands of the construction industry.

3.12 METHOD

3.12.1 DESIGN CONSIDERATION

Design Considerations for Sandcrete Block Moulding Machines

The design of sandcrete block moulding machines requires careful consideration of several factors to ensure efficient, reliable, and high-quality block production. These considerations span material selection, structural integrity, compaction mechanisms, and operational ergonomics.

3.12.2 Material Selection and Durability:

The choice of materials significantly impacts the machine's lifespan and performance. High-stress components like the mould box and compaction table should be constructed from hardened steel (e.g., AISI 1045 or equivalent) to resist wear and deformation. The frame should be made from structural steel (e.g., ASTM A36) to provide adequate support and rigidity (DeGarmo, E.P., & Black J.T., 2003).

3.12.3 Structural Design and Vibration Resistance

The machine's structural design must withstand continuous vibrations and dynamic loads. Finite Element Analysis (FEA) can be employed to optimize the frame design, ensuring stress distribution is within acceptable limits. Welding joints should be designed and executed according to AWS standards to prevent fatigue failures. (Budynas, R.G., & Nisbett, J.K, 2014)

3.12.4 Compaction Mechanism

Efficient compaction is crucial for producing dense, strong blocks. Vibration frequency, amplitude, and distribution must be optimized. Eccentric vibrators are commonly used, and their placement should ensure uniform compaction across the mould box. Pneumatic or hydraulic systems may be integrated for applying additional pressure (Handa, V.K, 2008)

3.12.5 Mould Design

The mould design should facilitate easy block removal and maintain dimensional accuracy. Tapered mould walls and a smooth internal finish can reduce friction. Quick-release mechanisms should be incorporated to minimize cycle time (Dieter, G.E., 2016)

3.12.6 Ergonomics and Safety

The machine should be designed for ease of operation and maintenance. Control panels should be intuitive, and safety features such as emergency stop buttons and guards should be integrated to protect operators. Noise levels should be minimized to comply with occupational health and safety standards. (Sanders, M.S., 1999).

3.13 DESIGN SPECIFICATION

Design Specification of Sandcrete Block Moulding Machine.

The design specification for a sandcrete block moulding machine encompasses various critical parameters that ensure the machine's efficiency, effectiveness, and safety in producing quality sandcrete blocks. The specifications can be categorized into mechanical, electrical, and operational requirements.

3.13.1 Mechanical Specifications

- Frame Material: Structural steel (e.g., ASTM A36) with a minimum thickness of 5 mm to ensure rigidity and durability.
- Mould Dimensions: Adjustable mould sizes to produce blocks of standard dimensions (e.g., 400 mm x 200 mm x 200 mm) and custom sizes as required.
- Compaction Mechanism: Eccentric vibration system with a frequency range of 50-60 Hz and adjustable amplitude for optimal compaction.
- Production Capacity: Capable of producing 200-300 blocks per hour, depending on the block size and mix design.
- Weight: Total machine weight should not exceed 500 kg for portability while ensuring stability during operation.

3.13.2 Electrical Specifications

- Power Supply: Three-phase electric motor with a power rating of 5-7.5 kW for the vibration mechanism.
- Control System: PLC (Programmable Logic Controller) for automated operation, including start/stop controls and safety interlocks.
- Safety Features: Emergency stop button, overload protection, and safety guards around moving parts to ensure operator safety.

3.13.3 Operational Specifications

- User Interface: Intuitive control panel with digital displays for monitoring operational parameters such as vibration frequency and production count.

- Maintenance Requirements: Designed for easy access to all components for routine maintenance, including lubrication points and electrical connections.

- Noise Level: Operating noise should not exceed 85 dB(A) to comply with occupational health standards.

3.14 DESIGN CALCULATION

Ramming force = Mg

Mram = mass of vibrator (mv)+ mass of Rammer + mass of Ram Bass plate + Rammer stepper rods (Falade, F. 1999).

$M = \rho \times v$ ……………………………………………………....(3.14.1)

$\rho steel = 1875kg/m^3$
V = L x b x t

508 x 508 x 10 = 0.01

$= 0.00258064m^3$

For the Mass of Ram Base Plate

MBp = (L x b+t)(p) ……………………………………………(3.14.2)

= Vp

= 0.00258064(1875)

= 4.8387kg

Wbp=MBp x g ………………………………………………… (3.14.3)

= 4.8387 x 9.81

= 47.4676N

For Ram Sleeper Rod

11^{11} x 25.4 =279.4mm

= 0.2794m

$WRss = (pv)g$ ………………………………………………...(3.14.4)

$P = 1875kg/m^3$

$V = \pi rh$ ………………………………………………………. (3.14.5)

Where; r = rod radius

= 10mm

= 0.01m

h = length of rod = 0.2794m

g = acceleration due to gravity = $9.81m/s^2$

$WRss = p(\pi r^2h)(g)$ …………………………………………..(3.14.6)

$= 1875(3.142(0.01)^2(0.279) \times 9.81$

WRss = 1.61N

Power Requirement

T = Torque

F = Ramming load

$T = 60/2\pi N$

$T = P/w$ ……………………………………………………….. (3.14.7)

$FR = P/w$ ……………………………………………………… (3.14.8)

F = Total Ramming load.

R = Dept of Ramming (max)

$= 2^{11} \times 25.4=50.8mm$

=0.0508m

Since $T=60p/2\pi N$ ……………………………………………... (3.14.9)

Also; $T = FR$ ………………………………………………….. (3.14.10)

$FR = 60p/2\pi N$

$P = (FR)(2\pi N)/60$

F = Total load=90.79N

R = Max Ramming Dept = 0.0508m

$\pi = 3.142$

N = rpm of Vibrator

= 800rpm

$P = (90.79)(0.0508)(2)(3.142)800/60$

= 386.43w

Since 1hp = 74.5w

- Approximately ½Hp selected.

3.15 FABRICATION PROCESS

Sandcrete blocks are building materials made from a mixture of sand, cement, and water, molded into block shapes and then cured. They are a widely used, cost-effective option for both load-bearing and non-load-bearing walls in construction.

Fabrication Process:

3.15.1 Mixing

Sand and cement are combined in a specific ratio, typically 1:6 or 1:8 (cement to sand), along with water.

3.15.2 Molding

The mixture is placed into molds, often using a hydraulic press machine, to achieve the desired block shape and size.

3.15.3 Compaction

The mixture is compacted within the mold, either manually or through vibration, to eliminate air pockets and increase density.

3.15.4 Curing

The molded blocks are cured, typically by sprinkling with water, to allow the cement to hydrate and the blocks to gain strength.

3.15.5 Mix Ratio

The cement-to-sand ratio is crucial for the block's strength. A common ratio is 1:6, but this can vary.

Water-Cement Ratio

The appropriate amount of water is also important for proper hydration of the cement.

3.15.6 Compaction

Proper compaction ensures a dense and strong block.

3.15.7 Curing

Adequate curing is essential for the blocks to achieve their full strength.

3.15.8 Standard Sizes

Common sizes for hollow sandcrete blocks include 450mm x 225mm x 225mm, 450mm x 150mm x 225mm, and 450mm x 125mm x 225mm.

3.15.9 Strength

Sandcrete blocks have relatively low compressive strength compared to concrete and are susceptible to seismic activity.

3.15.10 Environmental Concerns

The use of dredged sand for sandcrete production can have negative environmental impacts.

3.16 BILL OF ENGINEERING MEASUREMENT AND EVALUATION (BEME)

A Bill of Engineering Measurement and Evaluation (BEME) for sandcrete block making or moulding outlines the quantities and costs of materials, labor, and other resources needed for the production of sandcrete blocks. It serves as a detailed breakdown for estimating costs, tendering, and evaluating work progress. The BEME includes specifications for site preparation, material proportions (sand, cement, water), mixing, moulding, curing, and quality control, as well as labor and equipment requirements.

Key Components of a BEME for Sandcrete Block Production:

Site Preparation:

Clearing the site of vegetation, debris, and topsoil.

Excavation and leveling of the ground.

Compacting the base for block production.

Materials:

Sand: Specify the type (river sand, pit sand), quantity, and quality (e.g., particle size distribution).

Cement: Specify the type (OPC, PPC), quantity, and grade.

Water: Specify the quantity and quality (potable water).

Admixtures: If used, specify the type and quantity.

Mixing:

Proportions of sand, cement, water, and admixtures (e.g., 1:6 cement-sand ratio).

Method of mixing (manual or machine).

Moulding:

Specify the type and dimensions of the sandcrete blocks.

Number of blocks to be produced.

Method of moulding (manual or machine).

Curing:

Specify the method of curing (wet curing, etc.).

Duration of curing.

Quality Control:

Specify the testing procedures (e.g., compressive strength testing).

Acceptance criteria for blocks.

Labor:

Number and types of workers required (e.g., mixer, moulder, carrier, etc.).

Labor rates.

Equipment:

Specify the type and quantity of equipment needed (e.g., mixers, wheelbarrows, moulds, etc.).

Equipment rental rates or ownership costs.

Transportation:

Cost of transporting materials to the site.

Cost of transporting blocks.

Other Costs:

Contingency for unforeseen issues.

Profit margin.

3.17 IMPORTANCE OF A BEME

Cost Estimation: Provides a detailed breakdown for accurate cost estimation for the project.

Tendering: Used by contractors to prepare bids and tenders.

Progress Measurement: Used to measure and value work done for payment purposes.

Contractual Agreement: Provides a clear basis for the contractual agreement between the client and the contractor.

Variation and Extra Work: Helps in negotiating and valuing variations and extra work.

Dispute Resolution: Provides a documented basis for resolving disputes.

3.18 LAB TEST

3.18.1 PHYSICAL PROPERTIES OF SANDCRETE BLOCKS

Jackson & Dhir (1980) asserted that 'The physical properties of sandcrete hollow block depend to a varying degree on the type and proportion of the continent material, the manufacturing process , and the mode duration of curing employed, as well as on the form and size of the sandcrete block: All of these can vary greatly and subsequently affect the properties of sandcrete blocks.

3.18.2 COMPRESSIVE STRENGTH

Compressive strength is the most common measure for judging the overall picture of the quality of sandcrete hollow blocks as a waling and load bearing in building structure, Frank (1982). The Portland (PCA) (1980) said that the compressive strength of sandcrete hollow block is influenced principally by the type and amount of cement, the type and grading of aggregate degree of compaction, age of the specimen curing procedure and moisture content at the time of test.

The PCA (1980) stated that different types of cement have different strength producing characteristics and that the strength of sandcrete block increase with the cement content. It usually depend on the strength of cement paste and the bond between the cement and the aggregate. This bond is affected greatly by the texture and cleanliness of aggregated. The strength also decrease as the amount of sand in a mix aggregate because of increased water requirement and then effect on the water-cement ratio.

3.18.3 DENSITY

Orchard (1996) said the maximum density is obtained when the mix used is of adequate work ability. Nasa (1980), said there is a close correlation between the strength at a given age (for a particular aggregate/ cement ratio) and the density.

He said they both increase as the proportion of fine aggregate is increased. Jackson & Dhir (1996) stated that the typical range for dry density sandcrete block is usually given as 500-2100kg/m2 , but BS EN 771-3:2006, specifies that the block density of type A block whether solid, hollow or cellular shall not be less than 1500kg.m3 when determined according to the standard, and similarly the density of type B and C block shall be less than 1500kg/m3 .

3.18.4 DRY SHRINKAGE AND MOISTURE MOVEMENT

This is another important property of sandcrete hollow block, it is dimensional change occurring sandcrete block owing to variation in the ambient moisture and temperature condition, according to Jackson & Dhir(1996).

The drying shrinkage is the reduction in length obtain when a saturated sample is dried under certain condition, while the moisture movement is the increase in length of the sample when again saturated.

According to NEVILLE (2012) said that cement deficient in gypsum can exhibit high shrinkage. He also said entrainment of air has virtually no effect on shrinkage. Dry shrinkage and moisture movement can be controlled by through or proper production and handling of the blocks. When produced, the block should be properly cured to avoid dimensional change that may cause crack on wall.

3.18.5 FIRE RESISTANCE

Sandcrete blocks are generally good for resistance properties. However, shettima (2006), mention in his write up that, the actual fire-endurance is controlled by numerous factor, which include: the type and grading of aggregate cement content in the mix, weight and thickness of the block and its moisture content.

Jackson and Dhir (1996) stated that as a general rule, most sandcrete block of 100mm thickness can provide an adequate resistance to fire for up to two hours if load – bearing or up to four hours if non-load bearing

3.18.6 THERMAL CONDUCTIVITY

The thermal conductivity of a concrete block is largely dependent on its density. It is observed that aerated concrete and light weight concrete block have relatively low thermal conductivities. The lighter and more porous the blocks, the better will be its insulating value obende (1990).

3.18.7 EFFLORESCENCE

Efflorescence usually occur at the time the wall are drying out after construction. It is the formation of salt deposit on the surface of the block wall because of a reaction between the free calcium hydroxide (Ca (oH)2) brought to the surface and atmospheric carbon dioxide to form a white deposit of calcium carbonate. Neville (2012) stated that efflorescence Is the salt coating on the surface of sandcrete hollow block which may appear in due course as a white deposit on the surface of the block hollow.