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Assessment of Compressive Strength Variations in Sandcrete Blocks from Ikole-Ekiti and Across Nigeria

Oluwapelumi Oluwaseyi Adejumo[1*], Oluwafemi Moses Ogunmisi[2], Kazeem Aderemi Bello[2], Daniel Oluwadamilare Olasupo[2], Gbenga Daniel Ilori[3]
[1]Department of Mechanical Engineering, Missouri University of Science and Technology, Missouri, USA
[2]Department of Mechanical Engineering, Federal University Oye Ekiti, Ekiti State, Nigeria
[3]Department of Mechatronics Engineering, Federal University Oye Ekiti, Ekiti State, Nigeria
*Corresponding Author: adebaice@gmail.com

***Abstract*— *Sandcrete blocks are one of the most widely used building materials in Nigeria, yet their quality has continued to raise safety concerns due to frequent cases of structural failure. This study investigated sandcrete block production in Ikole-Ekiti and compared the results with findings from other regions in Nigeria. The research included process mapping, SIPOC (Suppliers, Inputs, Process, Outputs, Customers) analysis, and compressive strength testing in line with Nigerian Industrial Standards (NIS 587:2007). Results showed that none of the blocks produced met the NIS requirements for both load bearing (3.45 MPa) and non-load bearing (2.5 MPa) applications. A fishbone analysis was implemented to identify four main categories of contributing factors: men, machines, materials, and management. The study concludes that the problem is common across the block industries and recommends improved production practices, effective quality control systems, regular training workshops, and strict enforcement of NIS guidelines by government authorities.*

***Keywords*— *Compressive Strength: Fishbone: Nigeria Industrial Standards: Sandcrete blocks: SIPOC: Quality Control.*

I. Introduction

Sandcrete blocks typically consist of a mix of sand, cement, and water, with varying proportions affecting their strength and durability [1] and are widely used in Nigeria. The compressive strength of standard sandcrete blocks is essential for structural integrity, with minimum requirements set by standards such as Nigerian Industrial Standards (NIS); however, deficiencies in production practices and inadequate quality control have contributed to the increase of substandard products, often linked to structural failures and building collapses [2].

A study in Akure, Ado-Ekiti, and Ile-Ife examined commercially produced blocks with respect to bulk density, water absorption, and compressive strength. Bulk density values generally conformed to British Standards, but compressive strength results were reported as extremely below the accepted standards of the NIS. The study further established that soil samples with silt/clay-to-sand ratios greater than 6.56% negatively affected block quality [3]. In Owerri municipality, 90% of respondents identified the use of inferior raw materials as a major cause of low-quality blocks, while 85% pointed to the use of substandard production machinery [4].

The major factors undermining sandcrete block quality include poor material selection, insufficient curing, and non-compliance with prescribed standards. Although the recommended mix ratio is 1:6, manufacturers often employ ratios ranging from 1:12 to 1:14, which significantly reduces block strength [5]. Inadequate curing practices are also prevalent, further diminishing block durability[6, 7]. Compressive strength, the most critical parameter for assessing block quality, is strongly influenced by cement type, mix proportion, sand quality, and curing method. Reported compressive strength values often fall below the NIS minimum requirement of 2.5 N/mm² for six-inch blocks and 3.45 N/mm² for nine-inch blocks, with values as low as 0.66 N/mm² and 0.432 N/mm², respectively [5, 7]. Excessive water absorption further compromises the block integrity. Although the NIS specifies a maximum of 12%, recorded values have reached 18.10% [5]. Elevated absorption increases porosity, thereby weakening the structural performance of the blocks.

Raheem observed that many Nigerian blockmakers cure blocks for only a few days; as a result, even at 28 days, strengths remained around 1 N/mm² or lower in some cases [8]. Okeke et al. compared machine-molded against hand-molded blocks in Anambra and found machine-compacted blocks to have significantly higher densities (up to ~2120 kg/m³) than hand-made ones. This higher density translated to better compliance with standards: four out of six machine-made samples met the NIS 87 minimum density of 1920 kg/m³, whereas most hand-molded samples did not [9]. Okonkwo et al. varied the compaction pressure applied during block forming and found that higher pressures significantly increased the block's density and compressive strength while also reducing its water absorption [10].

This study investigates sandcrete block production at a facility in Ikole-Ekiti, located near the Federal University Oye-Ekiti, while drawing comparisons with findings from other regions in Nigeria. Structural testing was conducted in line with NIS standards, and the observed deviations were analyzed using quality improvement tools. The aim is to identify the underlying causes of poor block performance and propose practical interventions that can improve consistency, ensure compliance with standards, and ultimately strengthen the safety and reliability of sandcrete blocks in the Nigerian construction industry.

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II. METHODOLOGY

This research involved a detailed investigation of a sandcrete block manufacturing facility located in the Ikole-Ekiti axis of Nigeria, near Federal University Oye-Ekiti, Ikole Campus. The selected industry reports using a cement-to-sand mix ratio of 1:6, with a production capacity of approximately 35 units per cycle for 9-inch blocks and 50 units per cycle for 6-inch blocks. The mixing process is performed manually using shovels, and block molding is carried out using a vibrating machine that produces one block per vibration. The facility employs seven workers, obtains its water from an open well, and carries out curing for a maximum of five days.

To provide comparative insight, findings from other researchers were reviewed. Mohammed and Anwar [11] conducted strength assessments of sandcrete blocks across various production facilities in Kano State. Industry A, located in Ungogo LGA near Bayero University's new campus, produces approximately 40 blocks of 225 mm thickness per bag of cement, which deviates from the recommended 1:6 mix or the acceptable maximum of 25 blocks per bag. Production in this facility employs an automatic block-making machine that compacts and vibrates the mix in a steel mold, producing four blocks of 460 mm × 225 mm simultaneously. Water is sourced from a tap, and curing is carried out by spraying twice daily for a period of 3–7 days, with a workforce of 10 men engaged in operations. Industry B, situated in Gezawa LGA, records a production range of 35–39 blocks per bag of cement, adopting a curing method like that of Industry A. In Wada LGA, Industry C utilizes Ashaka brand Ordinary Portland Cement, with a curing process identical to those of the previous industries, though the exact mix ratio was not disclosed. Similarly, Industry D in Gwarzo LGA produces about 40 blocks per bag of Ashaka brand cement, while Industry E in Wudil LGA reports an equivalent production rate, with both facilities maintaining curing practices consistent with the other sites. Wasiu et al. [12] investigated four commercial block industries in Idah Local Government Area. Ten samples each of 450 × 225 × 225 mm and 450 × 225 × 150 mm blocks from each manufacturer were purchased, monitored during production, and tested for quality in accordance with Nigerian Industrial Standards (NIS 587:2007).

A. Flow Process and SIPOC Analysis

Sandcrete blocks are primarily composed of cement, water, and fine aggregates. Cement serves as the binding agent, with the typical mix ratio being 1:6 (cement to fine aggregate), although variations such as 1:8 or mixes incorporating fine sand or quarry dust have also been reported [13, 14]. Water plays a critical role in cement hydration, directly influencing both workability and strength, as adequate water content is necessary to achieve the desired compressive strength [15]. The aggregate component is usually sharp sand; however, alternatives such as fine sandcrete block waste and quarry dust are increasingly being investigated [16, 17].

The production of sandcrete blocks follows a process flow, as illustrated in Figure 1. The process begins with the selection of raw materials, primarily cement and aggregate, which are proportioned during the batching stage. Subsequently, water is introduced, and all components are subjected to mixing to form a homogeneous paste. In cases where hand mixing is employed, the materials shall be mixed until an even color and consistency throughout is achieved [18].

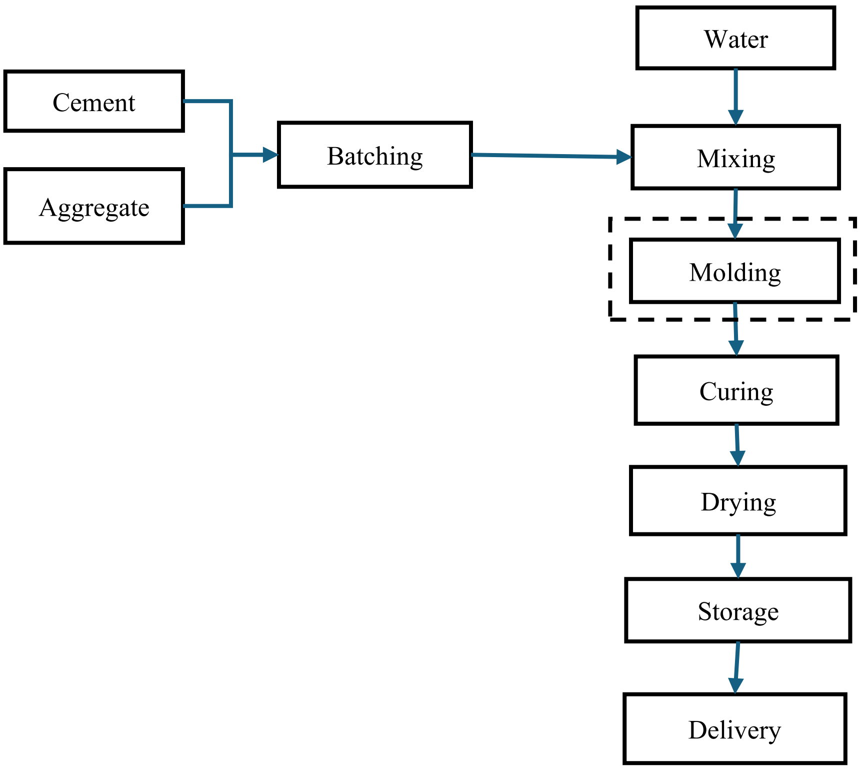

Figure 1: Sandcrete block production process

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TABLE 1: SIPOC chart

Suppliers	Inputs	Processes	Outputs	Customers
Merchant	Purchase request	Procurement of raw materials	Delivery of raw materials	Store/Warehouse manager
Workforce	Raw materials (cement, sand, water)	Batching of cement and aggregates	Homogeneous mixture	Production team
Workforce	Homogeneous mixture	Molding into block shapes	Compacted blocks placed on pallets	Production team
Workforce	Pallets of freshly molded blocks	Curing under controlled conditions	Blocks gaining required strength	Quality control team
Workforce	Cured blocks arranged on edge for airflow	Stacking for storage	Blocks ready for sale	Purchasers/End users

The fresh mixture is then transferred into block molds during the molding stage, where it is compacted to achieve the desired shape and dimensional accuracy. Once molded, they are typically cured in a water tank or yard for at least 14 days, with curing water replaced every 4 days, before being dried for about 4 weeks. Drying helps reduce excess moisture content. The dried blocks are then removed from block pallets and moved to storage areas to prevent damage and allow for quality inspection. They are typically stored in a controlled environment to maintain their condition. Finally, the blocks are prepared for delivery to end users or construction sites.

Following the definition of the activities carried out in a block industry, a SIPOC chart was developed (TABLE 1). This tool provided a structured overview of the production chain, from the supply of raw materials to the delivery of finished products, grouping critical elements into suppliers, inputs, processes, outputs, and customers.

B. Structural Testing

The compressive strength of the blocks molded at Ikole-Ekiti were determined using a compression testing machine in accordance with Nigerian Industrial Standards (NIS 587:2007). The testing setup can be seen in Figure 2. Strength values were calculated using Equation (1):

$$F_c = \frac{P}{A} \quad (1)$$

Where F_c is the compressive strength (MPa), P is the crushing load (N), and A is the cross-sectional area of the specimen (mm²). During testing, each block was placed between the plates of the machine, and load was applied gradually until failure occurred.

Figure 3 presents the compressive strengths obtained from different production locations, including the Ikole-Ekiti facility assessed in this study and other sites reported in earlier works. The results show significant deviation from the NIS requirements, with blocks manufactured at the Ikole-Ekiti facility recording the highest compressive strength (1.10 MPa) and those from Gwarzo the lowest (0.37 MPa).

III. Results and Discussion

A. Compressive Strength

The compressive strength results obtained from the surveyed block industries show substantial deviations from the NIS requirements for both load-bearing and non-load bearing sandcrete blocks. The consistent failure across all the locations suggests that the problem is systemic, not limited to sites.

For non-load-bearing blocks, NIS 87:2000 requires a minimum strength of 2.5 MPa. As shown in Figure 4, none of the blocks met this standard. The lowest strength deviation recorded was 1.40 MPa in Ikole-Ekiti, and the highest deviation was 2.13 MPa in Gwarzo. For load-bearing blocks, NIS 87:2000 requires at least 3.45 MPa. Figure 5 shows that all locations fell below this standard.

Figure 2: Concrete block under compression testing

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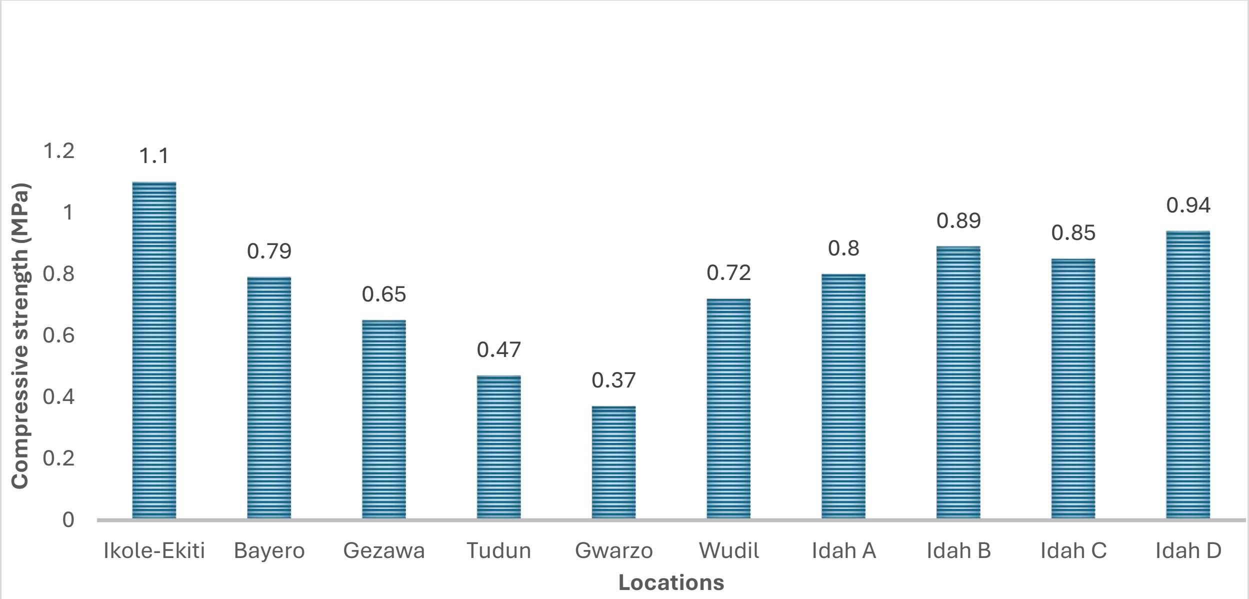

Figure 3: Compressive strengths across different locations

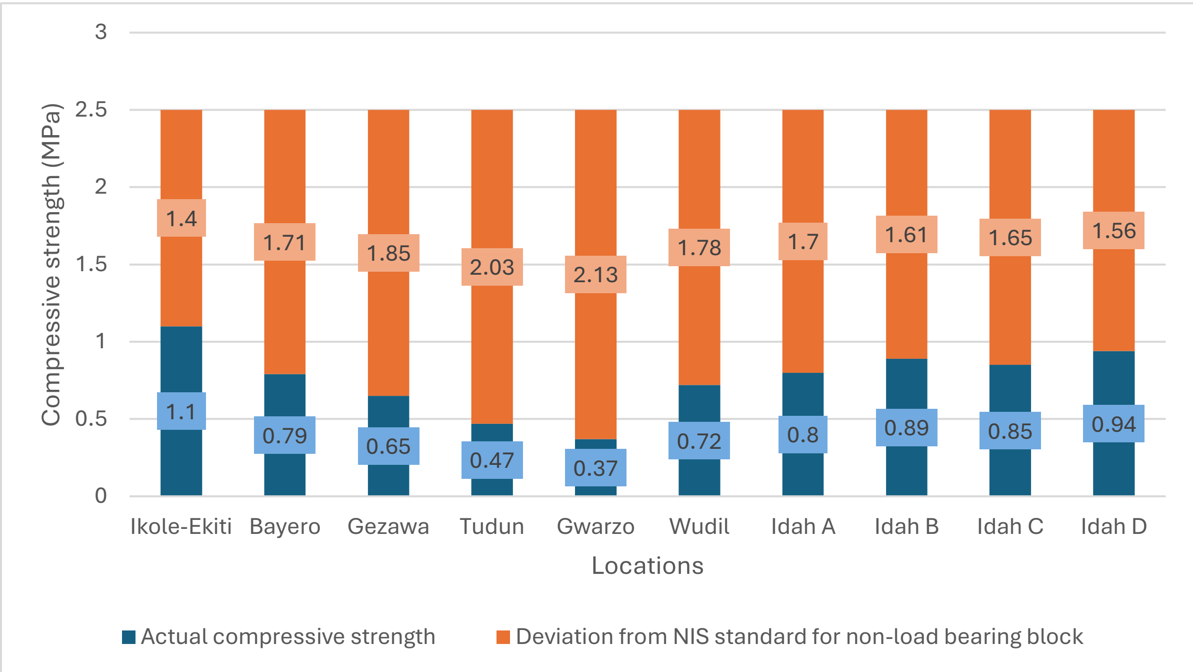

Figure 4: Difference between actual comprehensive strength and comprehensive strength for non-load bearing block

B. Fishbone Diagram

To better understand the factors behind the low compressive strengths and inconsistent quality of the hollow sandcrete blocks, a fishbone diagram (Figure 6) was used. This cause-and-effect tool systematically organizes potential sources of variation into four main categories: men, machines, materials, and management.

1) Men

Poor curing practices, incorrect mix ratios, fatigue, and inconsistent aggregate mixing were observed across the visited sites. The manual method of mixing aggregates before molding was inconsistent, producing uneven cement distribution. Fatigue from manual labor also contributed to inconsistencies, leading to defective products even before curing began.

2) Machines

Machine-related issues were another factor. Power failures often interrupted production, causing the vibration process to stop too early and leaving the blocks poorly compacted. Proper and continuous vibration is needed for good compaction, and without it, blocks become porous and weak. This shows that unreliable equipment and power supply make it difficult to achieve consistent quality.

3) Materials

In many cases, resources were insufficient, wrong types of materials were used, and poor storage practices were common.

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High clay content in some aggregates reduced bonding strength, while improper storage exposed materials to moisture and contamination, weakening the block's compressive strength. Since the strength of a block depends directly on the quality of its raw materials, these problems played a big role in the poor test results obtained.

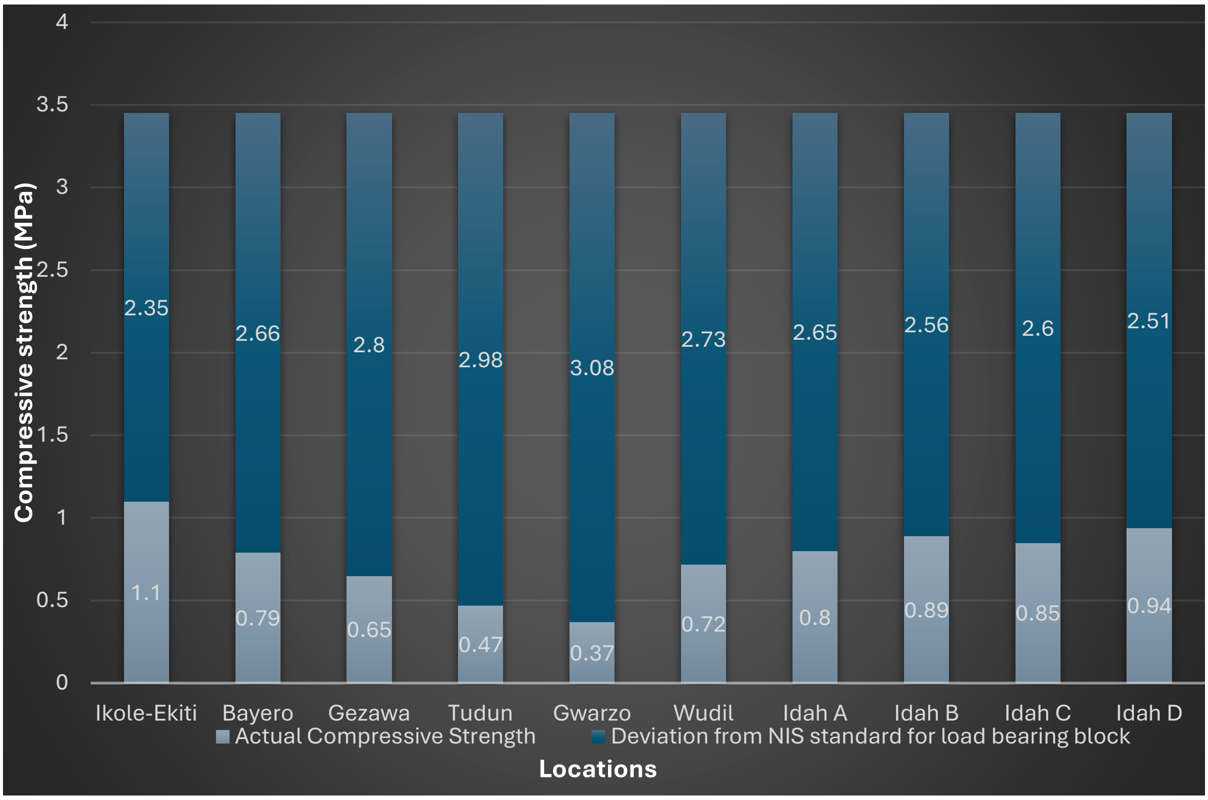

Figure 5: Difference between actual comprehensive strength and comprehensive strength gotten for load bearing block

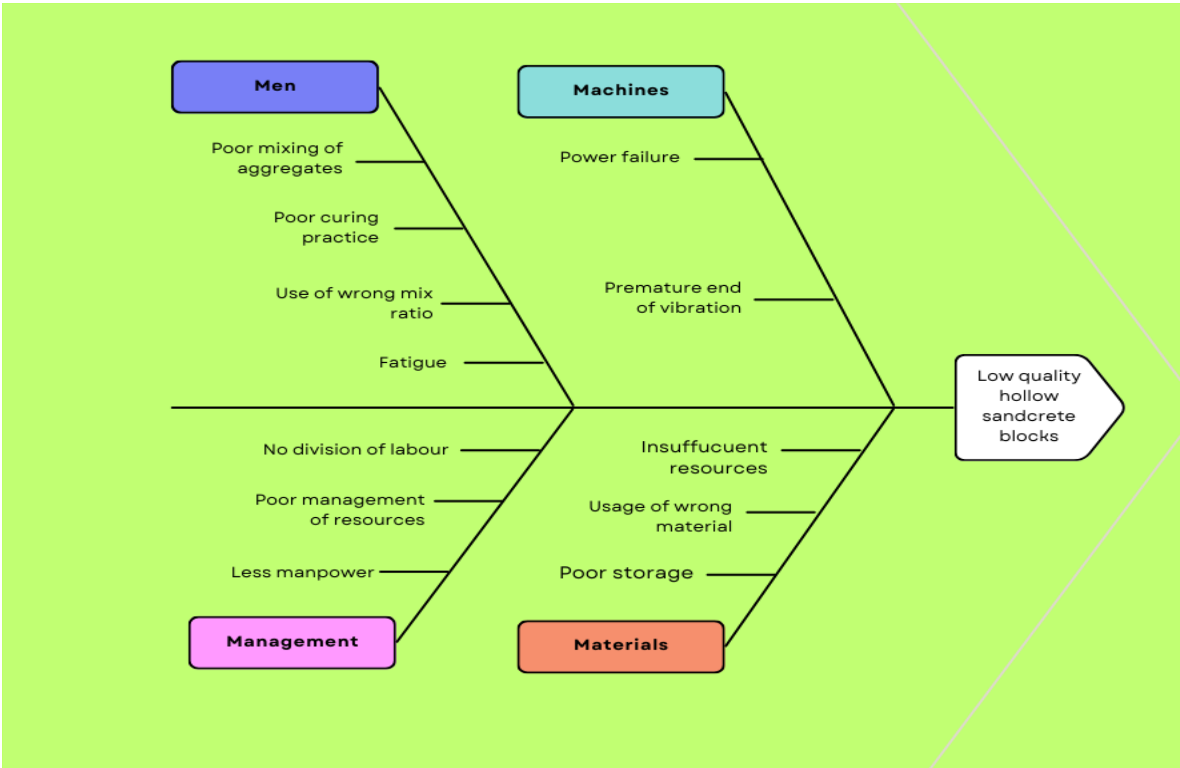

Figure 6: Fishbone diagram

4) Management

Management weaknesses tied many of the other problems together. There was little division of labor, which led to workers becoming overworked. Resources were not well managed, and in some cases, there were not enough workers to meet production demands. These gaps in planning and supervision meant that even when good materials or machines were available, they were not used effectively.

IV. Conclusion

This study focused on sandcrete block production in Ikole-Ekiti and compared it with results from other parts of Nigeria. According to the NIS, sandcrete blocks should be produced with a 1:6 cement-to-sand ratio, cured for at least 14 days, achieve a minimum compressive strength of 2.5 N/mm² for non-load-bearing blocks and 3.45 N/mm² for load-bearing blocks, and have a maximum water absorption of 12%. However, the findings revealed that none of the blocks tested met the requirements for compressive strength. The main reasons for poor quality were traced to four areas: men, machines, materials, and management. To address the identified issues, workshops and seminars should be organized regularly to educate block producers on the importance of following standards. Manufacturers also need to set up proper quality control systems, including random testing of samples to ensure they meet the required strength. Furthermore, government authorities should strictly enforce compliance with NIS guidelines across all block factories.

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