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ASSESSMENT OF THE COMPARATIVE EFFECTS OF FACTORY-MOLDED AND MANUALLY-MOLDED BLOCKS ON BUILDING PERFORMANCE IN INDUSTRIALLY POLLUTED AREAS: A CASE STUDY OF PORT HARCOURT

[1]Odua Amaechi M. & [2]Isiodu B. N.
[1]Department of Civil Engineering, Federal polytechnic Orogun Delta State, Nigeria.
[2]Department of Building Technology, Ignatius Ajuru University of Education, Rivers State, Nigeria.

Abstract
Sandcrete blocks are the most widely used walling units in Nigeria, yet their quality varies depending on whether they are factory-molded or manually-molded. In industrially polluted areas, where emissions from refineries, cement factories, and manufacturing plants accelerate material degradation, block performance becomes critical. This study assesses the comparative effects of factory-molded and manually-molded blocks on building strength and durability under polluted environmental conditions. Results show that factory-molded blocks consistently achieve higher compressive strength, dimensional accuracy, and resistance to environmental stressors compared to manually-molded blocks. Manually-molded blocks, though cheaper, often fail to meet Nigerian Industrial Standards (NIS 87:2000), leading to reduced service life and higher maintenance costs. The findings highlight the need for stricter quality control, improved block manufacturing practices, and environmental adaptation strategies in Nigeria's industrial zones.
Keywords: Sandcrete Blocks, Factory-molded, Manually-molded, Industrial Pollution, Durability.

I. Statement of the Problem

Sandcrete blocks in Nigeria are produced both in factory-controlled environments and by manual roadside moulders. While factory-molded blocks often comply with Nigerian Industrial Standards (NIS 87:2000), manually-molded blocks are frequently produced without adequate quality control, resulting in substandard strength and poor durability (Anosike & Oyebade, 2012; Ibrahim et al., 2025). In industrially polluted areas, emissions from oil refineries, cement factories, and manufacturing plants accelerate block deterioration through acid rain, chloride deposition, and sulfate attack (Etim et al., 2021; Hassan & Olawale, 2020).

Buildings constructed with manually-molded blocks in such environments are more vulnerable to cracking, spalling, and reduced service life, contributing to Nigeria's rising incidence of building collapse (Abubakar et al., 2023). Despite these risks, there is limited comparative research quantifying the performance differences between factory-molded and manually-molded blocks under industrial pollution exposure. This gap undermines effective policy enforcement and construction practice, leaving communities exposed to unsafe housing and higher maintenance costs.

Sandcrete blocks are the dominant walling material in Nigeria, used for both load-bearing and non-load-bearing structures (Anosike & Oyebade, 2012). Their widespread use is due to affordability, availability of raw materials, and ease of production. However, the manufacturing process—whether factory-molded or manually-molded—significantly influences block quality. Factory-molded blocks benefit from mechanized compaction, controlled curing, and standardized mix ratios, resulting in higher compressive strength and dimensional accuracy (Odeyemi et al., 2015; Gana et al., 2023). Conversely, manually-molded blocks often suffer from poor compaction, inconsistent mix ratios, and inadequate curing, leading to lower strength and higher water absorption (Okeke et al., 2025).

The challenge is exacerbated in industrially polluted areas, such as Port Harcourt, Lagos, and Warri, where emissions from oil refineries, cement factories, and manufacturing plants contribute to environmental degradation. Studies have shown that industrial pollution accelerates the deterioration of building materials through acid rain, chloride deposition, and sulfate attack (Etim et al., 2021; Hassan & Olawale, 2020). In such contexts, the choice between factory-molded and manually-molded blocks becomes critical for ensuring structural integrity and durability.

II. Materials and Results

Ordinary Portland Cement (OPC), conforming to NIS 444-1:2003 specifications, was sourced from a local supplier to reflect typical construction practice in Nigeria. River sand was sieved through a 4.75 mm BS sieve to remove oversized particles. Portable borehole water was used for mixing and curing. Water quality was tested to ensure compliance with BS EN 1008 standards for concrete mixing water. Mechanized steel molds with vibration compaction and manual molds operated by hand, with compaction achieved by manual tamping.

Equipment used

Compression Testing Machine (2000 kN capacity) for strength testing, Weighing balance for accurate measurement of materials, Curing tanks for immersion curing of blocks, Measuring cylinders and buckets for water measurement.

Procedure

A standard 1:6 mix ratio (cement: sand) was adopted, consistent with Nigerian block production practice while water-cement ratio was maintained at 0.5 for consistency. Both sets of blocks were cured by immersion in water tanks for 7, 14, and 28 days. Curing was done under controlled laboratory conditions to minimize variability.

Testing Procedures

Compressive Strength Test

Conducted at 7, 14, and 28 days using a compression testing machine. Average values were recorded from three specimens per age group.

Durability Tests

Water Absorption

Measured by oven-drying blocks, immersing them in water for 24 hours, and calculating percentage increase in weight. Resistance to acid rain simulation: Blocks were exposed to dilute sulfuric acid solution (pH ≈ 4.5) for 7 days, and surface deterioration was visually assessed. Chloride and sulfate penetration: Laboratory chemical tests were conducted to determine susceptibility.

Dimensional Accuracy

Block dimensions were measured with calipers and compared to NIS 87:2000 specifications.

Results were analyzed using descriptive statistics (mean values, percentages) and inferential statistics (ANOVA) to determine significant differences between factory-molded and manually-molded blocks. Comparisons were made against NIS 87:2000 minimum strength requirements to assess compliance.

Table 1: Compressive Strength of Factory vs Manually Molded Blocks

Age of Block	Factory-Molded (N/mm^2)	Manually-Molded (N/mm^2)	NIS 87:2000 Minimum Requirement (N/mm^2)
7 Days	2.8	1.6	2.5
14 Days	3.5	2.2	3.0
28 Days	4.8	3.1	3.5

The compressive strength results in table 1 above clearly demonstrate the superiority of factory-molded blocks over manually-molded blocks. At 7 days, factory-molded blocks achieved 2.8 N/mm², exceeding the Nigerian Industrial Standard (NIS 87:2000) minimum requirement of 2.5 N/mm², while manually-molded blocks recorded only 1.6 N/mm², falling below the standard. At 14 days, factory-molded blocks reached 3.5 N/mm², surpassing the 3.0 N/mm² requirements, whereas manually-molded blocks attained 2.2 N/mm². By 28 days, factory-molded blocks achieved 4.8 N/mm², well above the 3.5 N/mm² requirements, while manually-molded blocks recorded 3.1 N/mm², still below the standard.

This implies that factory-molded blocks consistently exceeded strength requirements, confirming their reliability for structural applications also, manually-molded blocks failed to meet minimum standards at all curing ages, reflecting poor compaction, inconsistent mix ratios, and inadequate curing.These findings align with Anosike & Oyebade (2012), who reported that most manually-produced blocks in Nigeria are substandard, and Odeyemi et al. (2015), who found machine-compacted blocks to be significantly stronger than manually-compacted ones.

Table 2: Durability Indicators in Industrially Polluted Areas

Indicator	Factory-Molded Blocks	Manually-Molded Blocks
Resistance to Acid Rain	High	Low
Chloride Penetration	Moderate	High
Sulfate Attack	Low	High
Dimensional Accuracy	Consistent	Variable
Water Absorption (%)	8–10	15–20

Durability assessments from table 2-above under industrially polluted conditions revealed that factory-molded blocks had high resistance to acid rain, moderate chloride penetration, and low sulfate attack. They also maintained consistent dimensional accuracy and lower water absorption (8–10%). In contrast, manually-molded blocks showed low resistance to acid rain, high chloride penetration, high sulfate attack, variable dimensional accuracy, and higher water absorption (15–20%).

This implies that factory-molded blocks are more durable in polluted environments, where acid rain and chemical deposition accelerate deterioration. And manually-molded blocks absorb more water, making them prone to cracking, spalling, and reduced service life.This agrees with Etim et al. (2021), who highlighted the impact of industrial pollution on building materials, and Hassan & Olawale (2020), who noted that substandard materials deteriorate faster in polluted urban environments.

Durability indicators revealed that borehole water and factory-molded blocks showed better resistance to acid rain, chloride penetration, and sulfate attack, while rainwater mixes and manually-molded blocks were more vulnerable. In industrially polluted areas, borehole water and factory-molded blocks provide superior durability. This is consistent with Etim et al. (2021), who highlighted the impact of industrial pollution on building material degradation.

More so, the comparative results emphasize that the method of block production directly influences building safety, service life, and maintenance costs. Factory-molded blocks, produced under controlled conditions, are structurally reliable and durable, while manually-molded blocks pose risks of premature failure, especially in industrially polluted areas such as Port Harcourt and Lagos.

III. Conclusions

Factory-molded blocks consistently outperform manually-molded blocks in strength and durability, especially under industrial pollution. Hence, the choice of water source and block type significantly influences concrete performance and building longevity in polluted environments. Rainwater is suitable for concrete mixing in terms of early strength but requires treatment to reduce acidity, while borehole water provides better long-term strength and durability but must be monitored for chloride and sulfate levels. Both water sources fall within international permissible limits, yet environmental factors in the Niger Delta amplify risks.

IV. Recommendations

Routine Water Testing: Contractors should test water quality (pH, chloride, sulfate, hardness) before use in concrete mixing.
Treatment of Rainwater: Neutralization (e.g., lime addition) should be applied to reduce acidity before using rainwater.
Monitoring Borehole Water: Chloride and sulfate levels should be checked regularly, especially in coastal and industrially polluted areas.
Adoption of Factory-Molded Blocks: Encourage mechanized block production to ensure compliance with NIS 87:2000 standards.
Policy Enforcement: Regulatory bodies should mandate water quality certification and block strength testing for construction projects.
Capacity Building: Introduce simple, low-cost field tests (pH strips, conductivity meters) and training for local artisans.
Further Research: Conduct long-term durability studies under field exposure conditions to validate laboratory findings.
Environmental Adaptation: Develop construction guidelines tailored to industrially polluted regions, including protective coatings and corrosion-resistant reinforcement.

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