CERTIFICATION

This is to certify that this research work on the **"THE IMPACT OF LEAN MANUFACTURING PRACTICES ON WASTE REDUCTION: A CASE STUDY OF BUILDING BLOCKS PRODUCTION FIRMS IN EDO STATE, NIGERIA "** was carried out by ENG2106255 of the Department of Industrial Engineering, University of Benin, Benin City.

____________________________ ________________________

Engr. Dr. N. H. Osadiaye Date

Project Supervisor

____________________________ __________________________

Engr. Dr. (Mrs) L C Iluobe Date

Project Coordinator

____________________________ __________________________

Prof. P.E Amiolemhem Date

Head of Department

DEDICATION

I dedicate this work to God Almighty for His divine wisdom and guidance, and to my parents Late Mr Moses Akakpor and Mrs. Eunice Nkemdilim Akakpor. I want to specially thank my mum for her unwavering support throughout my academic journey. This project is also dedicated to my son Munachimso Leo Moses, I want to apricate him for been really understanding. And lastly, I dedicate this project to all the engineers and inventors who continue to drive innovation in developing nation.

ACKNOWLEDGEMENT

I extend my deepest appreciation to my Project Supervisor, **ENGR. DR N. H. OSADIAYE** who is also my Course Adviser and for his consistent guidance, patience, and technical insights throughout my stay in the university of Benin and in the duration of this work. Special thanks to the Head of Department of Production Engineering, Prof. P.E Amiolemhem, my lecturers and the entire Department of Industrial Engineering, University of Benin, for the quality education and support I have received over the years.

I wish to express great acknowledgement to **MRS. EUNICE AKAKPOR** who have always stood by me through thick and thin, and have continuously provided financial, emotional, psychological, and spiritual support in multiple ways as was needed.

To my family and friends, **MR. JOHN AKAKPOR** and **MISS DORA KANAYO**, thank you for your unwavering encouragement, prayers, and moral support. Your presence has made this journey smoother and more meaningful.

ABSTRACT

This study investigated the impact of lean manufacturing practices on waste reduction in selected building block industries in Benin City, Edo State. The research was motivated by the persistent challenge of material wastage, process inefficiency, and delays that hinder productivity in the Nigerian building block sector. The main objective was to evaluate how the implementation of lean manufacturing principles such as 5S (Workshop Organization), Kaizen (Continuous Improvement), Total Productive Maintenance (TPM), and Just-In-Time (JIT) influences the level of waste reduction in block production operations.

A descriptive survey research design was adopted, and data were collected using structured questionnaires administered to eighty (30) respondents drawn from production, maintenance, and quality control departments across selected block industries. The data obtained were analyzed using the Statistical Package for the Social Sciences (SPSS) and Microsoft Excel to ensure accuracy and robustness. Both descriptive statistics (percentages and mean scores) and inferential statistics (One-Way ANOVA, correlation, and regression analyses) were employed to test the hypotheses and establish relationships between variables.

The results revealed that Total Productive Maintenance (TPM) has the strongest and most significant positive relationship accounting for 54% of material waste reduction, 5s showed a moderate positive but marginally significant relationship accounting about 35% of waste reduction, while Kaizen and JIT exhibited weak and insignificant correlations. The ANOVA result with a p-value of <0.001 further demonstrated that the difference in waste reduction across the lean tools and waste reduction are statistically significant. The study concludes that lean manufacturing practices have a moderate but significant impact on waste reduction with TPM emerging as the most influential tool. It recommends that building block production firms strengthens their lean adaptation strategies so as to achieve a higher level of productivity and sustainability.

Table of Contents

List of Figures

NOMENCLATURE

ANOVA - Analysis of Variance

JIT - Just-in-Time

TIMWOOD - An acronym representing the seven types of waste (transportation, Inventory, Motion, Waiting, Over, Overprocessing, Defect)

TPM - Total Productive Maintenance

TPS - Toyota System VSM - Value

Stream Mapping

5S - A workplace organization method (Sort, Set in order, Shine, Standardize, Sustain)

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The global production industry is undergoing a continuous transformation driven by the need for efficiency, quality, cost-effectiveness, and environmental sustainability. Among the methodologies developed to meet these demands, Lean Manufacturing has gained prominence for its ability to minimize waste while maximizing value to the customer. Originally developed by Toyota in Japan under the Toyota System (TPS), Lean Manufacturing has become a universal approach adopted across various industries as it is focused on delivering value to customers, eliminating waste, and optimizing processes. Its five core principles which includes, value identification, value stream mapping, flow, pull, and perfection have transformed industries worldwide by improving efficiency and reducing costs (Womack & Jones, 1996).

In developing economies like Nigeria, the need for efficient production practices is even more pressing. The building block production sector is a key part of the construction industry, which supports national infrastructure development and urbanization. However, block production firms often face challenges such as material waste (e g cement, sand), long production cycles, defective products, poor space utilization, inefficiencies in labor deployment, and suboptimal production planning. These problems ultimately lead to high production costs and reduced competitiveness.

In Edo State, building block production firms are widespread, catering to local demand for housing and commercial buildings. Yet, many of these firms still rely on manual production processes and lack structured systems for reducing operational waste. This situation makes them ideal candidates for the application of lean manufacturing practices.

Lean Manufacturing emphasizes continuous improvement and the elimination of non-value-adding activities that are commonly referred to as the “7 wastes” (Transportation, Inventory, Motion, Waiting, Over, Overprocessing, and Defects). Tools such as 5S, six sigma, Just-in-Time (JIT), Kaizen, Kanban, and Value Stream Mapping can drastically improve the efficiency of operations even in small-to-medium enterprises like block producers.

This study therefore seeks to assess the impact of Lean Manufacturing practices on waste reduction in building block production firms in Edo state, with a focus on identifying the extent to which lean practices are currently used, challenges to implementation, and the measurable improvements that result from adopting these practices.

1.2 Statement of the Problem

Despite the availability of lean principles and their proven advantages globally, many small-scale production firms in Nigeria continue to struggle with operational inefficiencies. Block production firms in Edo State experience significant waste, including excessive material loss

(Especially cement and sand), over (producing more than demanded), idle machines and labor, defective outputs (cracked or substandard blocks), excess inventory (used cement and sand), and long processing times. These inefficiencies increase costs, reduce profitability, and contributes to environmental degradation through resource wastage.

The persistence of these inefficiencies suggests a gap in the application or awareness of lean practices. While large corporations in Nigeria may have adopted lean systems to some extent, smaller firms like those producing building blocks often lag behind due to limited resources, knowledge, or technical support.

Hence, there is a need to evaluate whether lean manufacturing practices are currently being applied in the building block production sector in Edo State, and if so, how effective they are in reducing waste and improving performance.

1.3 Aim and Objectives of the Study

1.3.1 Aim of the Study

This study aims to investigate the impact of Lean Manufacturing practices on waste reduction in building block production firms in Edo State.

1.3.2 Objective of the study

1. Identify the major types and sources of waste in the block production process.
2. Examine the level of awareness and application of lean tools among block production firms.

3. Evaluate the impact of specific lean practices (e.g., 5S, six sigma, JIT) on waste reduction.
4. Identify the challenges faces in the implementation of Lean Tools.
5. Recommend strategies for effective implementation of lean manufacturing in the building block production industry.

1.4 Research Questions

The study is guided by the following research questions:

1. What are the major types of waste found in building block production firms in Edo State?
2. How familiar are block manufacturers with lean manufacturing concepts?
3. Which lean tools are being implemented, and how are they applied?
4. What changes in performance metrics (e.g., time, material usage, cost) have occurred after adopting lean practices?
5. What barriers hinder the successful adoption of lean manufacturing in the sector?

1.5 Research Hypotheses

The study will test the following hypotheses:

- H_0: There is no significant impact of lean Manufacturing practices on waste reduction in building block production firms.
- H_1: There is a significant impact of lean Manufacturing practices on waste reduction in building block production firm.

1.6 Scope of the Study

The scope of this study is limited to selected small and medium-scale building block production firms located in Edo State, Nigeria. The focus will be on firms that produce sandcrete and hollow blocks using cement, sand, and water as raw materials. Emphasis will be placed on analyzing their processes, waste generation points, and any existing lean practices.

1.7 Significance of the Study

This study is significant for several reasons:

- Practical Significance: The findings will guide block production firms in adopting lean practices to reduce costs and improve efficiency, enhancing competitiveness.
- Academic Significance: The study contributes to the limited literature on lean manufacturing in Nigeria's construction-related industries.
- Environmental Significance: Reducing waste aligns with sustainable development goals by minimizing resource depletion and environmental impact.
- Policy Significance: The results can inform government policies on supporting SMEs through lean training and subsidies

This study is also relevant in other aspects such as:

- For Industry Practitioners: It provides practical insights into lean practices that can improve productivity and reduce operational costs.
- For Researchers: It contributes to the growing body of literature on lean manufacturing in developing economies.
- For Policy Makers: The findings may influence policy formulation to support small-scale manufacturers with training, incentives, and technical resources.
- For Entrepreneurs: Upcoming manufacturers can use this research as a guide to adopt lean

thinking from the early stages of business.

1.8 Limitations of the Study

- Limited access to proprietary production data from firms.
- Variability in firm size and operations could affect result generalization.
- Some participants may lack formal understanding of lean principles, affecting questionnaire accuracy.

CHAPTER TWO

LITERATURE REVIEW

2.1 Concept of Lean Manufacturing

Lean Manufacturing is a methodology that focuses on the systematic elimination of waste (non-value-added activities) within a manufacturing system. The main goal is to improve efficiency, quality, and responsiveness to customer demand by streamlining processes. The term “lean” was popularized by Womack and Jones in their 1990 book The Machine That Changed the World, which analyzed Toyota’s system.

In lean manufacturing, value is defined from the perspective of the customer. Any activity that does not add value to the final product is considered wasteful and targeted for elimination. Lean also emphasizes a culture of continuous improvement (Kaizen) where employees are encouraged to identify inefficiencies and suggest solutions.

2.2 Historical Background of Lean

Lean principles were born out of the Toyota System (TPS), developed in Japan post-World War II. Engineers like Taiichi Ohno and Shigeo Shingo pioneered many of the lean tools now in global use. While mass techniques in the West emphasized large batches and economies of scale, Toyota's system focused on minimizing inventory and producing just what was needed, when it was needed.

Over time, lean manufacturing spread from automotive to other industries including electronics, healthcare, construction, and even service industries. In developing nations like Nigeria, lean is gradually gaining traction, especially in the face of rising production costs and global competitiveness.

2.3 Principles of Lean Manufacturing

Womack and Jones (1996) outlined five key principles of lean:

1. Value Identification – Understanding the need of customers and delivering products or services to meet those needs.
2. Value Stream Mapping – Identify all steps in the process, highlighting value-adding and non-value-adding steps.
3. Flow – Ensure smooth movement of materials and processes without interruptions. This is achieved by minimizing delays and bottle necks, allowing products or services to move efficiently towards the customer.
4. Pull – Allowing customers to initiate a process thereby minimizing inventory and waste associated with over. Use demand-driven systems (e.g., Kanban) to avoid over.
5. Perfection – Continuously seeking ways to refine and improve processes, eliminate waste, and deliver even greater value to the customer.

2.4 Lean Tools and Techniques

Lean implementation involves various tools to support its philosophy. Below are key ones relevant to block production:

2.4.1 5S (Workplace Organization)

The 5S methodology Seiri (Sort), Seiton (Set in order), Seiso (Shine), Seiketsu (Standardize), Shitsuke (Sustain) organizes workplaces to boost efficiency, safety, and waste reduction by eliminating clutter and standardizing processes (Osada, 1991).

Sort removes unneeded tools or materials; Set in order arranges items logically; Shine involves cleaning and inspection to spot issues early; Standardize creates consistent procedures; Sustain embeds habits through discipline (Hirano, 1995).

In building block production, 5S combats dust, debris, and disorganization risks in dusty environments with heavy materials. Organized yards prevent aggregate contamination or mold damage, while cleaning reveals wear in equipment before failures waste batches. It ensures hygiene for non-structural blocks and reduces errors in mixing ratios (Liker, 2004).

Benefits include less time searching for tools (motion waste), fewer accidents, and lower scrap from mishandled materials. 5S prevents minor issues from causing major waste (Ho, 1999).

In Nigeria, 5S is a low-cost lean entry point despite infrastructure limits. Block firms report reduced material waste, safer sites, and better discipline via 5S (Ede & Oko, 2021; Omoregie, 2022). Sustaining requires ongoing training, leadership, and audits.

2.4.2 Kaizen (Continuous Improvement)

Kaizen (continuous improvement) drives incremental changes in processes for efficiency gains without major investments, involving all employees in identifying and fixing waste (Imai, 1997). Frontline workers propose practical tweaks, supported by management, fostering collaboration (Liker, 2004).

In building blocks, Kaizen addresses material variability, overmixing, or curing inefficiencies. Workers might suggest mold adjustments to reduce breakage, storage tweaks to prevent aggregate segregation, or layout changes for smoother flows, cutting scrap without disruption (Bhuiyan & Baghel, 2005).

It boosts morale by empowering staff, encouraging proactive waste spotting like excess water in mixes or poor palletizing (Singh & Singh, 2009).

In Nigeria, Edo State block firms use simple Kaizen like daily reviews or group problem-solving to cut over waste, improve block uniformity, and fix defects (Ede & Oko, 2021; Omoregie, 2022). However, challenges include limited training of workers and hierarchical cultures resisting bottom-up ideas.

2.4.3 Value Stream Mapping (VSM)

VSM visualizes material or information flows to identify value-adding and wasteful steps, creating current-to-future state roadmaps for waste elimination (Rother & Shook, 2003).

It captures cycle times, inventories, waits, and bottlenecks system-wide (Hines & Rich, 1997). In building blocks, VSM maps from raw material intake to block delivery, spotting waste in long curing waits, excess aggregate stockpiles, or transport delays causing degradation. Firms redesign for flow, reducing scrap (Abdulmalek & Rajgopal, 2007).

Value stream mapping helps visualize the entire production process from raw materials to product shipment. Value stream maps allow teams to:

- Visualize the flow of materials and information within the process
- See how different elements of the process interact
- Identify inefficiencies and non-value-added activities to eliminate
- Understand how solutions will impact the process

2.4.4 Kanban (Pull System)

Kanban, a Japanese term meaning “signal board” or “visual signal,” is a lean manufacturing technique developed within the Toyota System to manage and control the flow of materials and work in a pull-based environment. It ensures that is triggered only by actual demand, preventing over, excess inventory, and associated waste. By using visual cues and traditionally cards, but now often digital boards or containers. Kanban limits work-in-progress (WIP), synchronizes processes, and exposes bottlenecks for continuous improvement (Ohno, 1988; Sugimori et al., 1977).

The core principle of Kanban is to pull materials or components through the system only when needed downstream, rather than pushing them based on forecasts or schedules. Each process step signals the previous one when it requires replenishment, creating a demand-driven flow. This minimizes stockpiles of raw materials, semi-finished blocks, or finished products, reducing storage costs, material degradation, and obsolescence risks (Liker, 2004).

In the building block industry, Kanban is highly effective in reducing waste from over, excess inventory, and material deterioration. Concrete blocks are bulky, heavy, and prone to cracking or surface damage if stored excessively. Raw materials like sand and gravel can segregate, absorb moisture, or become contaminated in open yards. Cement has a limited shelf life and loses strength over time. Kanban addresses these by limiting batch sizes to match construction site pull signals, reducing on-site or yard inventory of finished blocks, preventing premature mixing of concrete that hardens before use, and minimizing storage-related defects (e.g., efflorescence, cracks from stacking pressure).

In Nigeria, where infrastructure challenges such as poor roads, power outages, traffic delays, and unreliable suppliers disrupt material flow, Kanban provides a robust, low-tech framework for waste control. It does not require perfect logistics, instead, it exposes delays as visual backlogs forcing root-cause resolution. Studies in Nigerian SMEs, including block-making firms in Edo State, show that simple Kanban systems using boards, cards, or marked containers reduce over by 20–40%, cut inventory holding costs, and decrease material spoilage due to prolonged storage (Ede & Oko, 2021; Omoregie, 2022).

However, successful Kanban implementation requires, disciplined adherence to the "no card, no production" rule, stable demand signals from construction sites or distributors, employee training to respect visual controls and avoid workarounds, flexible batch sizing to accommodate variable site requirements. Resistance often arises from a traditional "batch-and-queue" mindset, where producers make large runs "just in case." Cultural shifts, leadership commitment, and pilot testing in one production line (e.g., hollow block molding) are essential for adoption.

When integrated with other lean tools such as JIT for timing, 5S for workplace clarity, and VSM for system-wide visibility, Kanban becomes a powerful engine for waste reduction in building block production, ensuring that materials flow smoothly, inventory stays lean, and production responds precisely to real construction needs.

2.4.5 Just-In-Time (JIT)

Just-in-Time (JIT) is a foundational lean manufacturing technique from the Toyota System, aimed at eliminating inefficiencies from excess inventory, over, and material waste. The core philosophy is to produce and deliver building blocks in the exact quantity needed, at the precise time required, and in the right location on the or construction line. This demand-driven approach pulls based on actual orders rather than forecasts, aligning output with real project demands and minimizing waste from unused or obsolete materials (Ohno, 1988; Womack & Jones, 2003).

JIT implementation requires synchronized material flows, with suppliers delivering aggregates, cement, or precast components just as they are needed. This reduces on-site inventory, lowers storage costs, and exposes process delays, prompting continuous improvement. Key practices include reduced setup times for molding or mixing, small-batch to avoid overstocking, and tight supplier coordination for timely deliveries (Shah & Ward, 2007).

In the building block industry, JIT is vital due to the bulk and degradable nature of materials like sand, gravel, or admixtures, which can suffer from moisture damage, contamination, or quality degradation if stored excessively. By matching production to construction schedules, firms minimize waste from expired binders, spoiled aggregates, or excess blocks that crack during storage. For example, block manufacturers using JIT can produce only for confirmed site deliveries, reducing scrap from over and ensuring fresher, higher-quality outputs.

In developing economies like Nigeria, JIT faces challenges from unreliable infrastructure, poor roads, power outages, and inconsistent supplier reliability, disrupting precise timing. Despite this, Nigerian building block firms adopting JIT elements such as smaller batch sizes and better supplier tiesreport lower over, reduced inventory losses, and less material waste (Ede & Oko, 2021; Omoregie, 2022).

2.4.6 Total Productive Maintenance (TPM)

Total Productive Maintenance (TPM) maximizes equipment effectiveness and lifespan through proactive, preventive maintenance, preventing breakdowns that cause halts and material waste. All employees share responsibility for equipment care, shifting from reactive fixes to integrated daily maintenance (Nakajima, 1988).

Originating in 1970s Japan, TPM rests on eight pillars: autonomous maintenance, planned maintenance, focused improvement, early equipment management, training, quality maintenance, office TPM, and safety/health/environment. These foster a culture of zero breakdowns, defects, and accidents, aligning with lean waste elimination (Ahuja & Khamba, 2008).

Operators perform basic tasks like cleaning molds, lubricating mixers, inspecting vibrators, and minor adjustments, freeing specialists for advanced predictive work. This achieves uninterrupted flows in block production (Sharma & Kodali, 2008).

In the building block industry, TPM ensures reliable machinery for mixing, molding, and curing, where failures lead to incomplete batches, material spoilage, or unsafe blocks. Downtime can waste wet concrete mixes or cause curing interruptions, resulting in cracked or substandard blocks. TPM reduces these by maintaining equipment availability, minimizing scrap and rework (Ahuja & Khamba, 2008).

In Nigeria, high replacement costs, spare parts scarcity, power instability, and infrastructure issues make TPM essential for extending machinery life and cutting downtime waste. Studies in Nigerian block firms show TPM adoption improves efficiency, reduces breakdowns, and boosts equipment effectiveness, lowering material losses (Ede & Oko, 2021; Omoregie, 2022).

Challenges include poor training, low maintenance investment, and cultural resistance to shared responsibility. Success demands mindset shifts, viewing maintenance as collective, not departmental.

Key aspects of TPM include:

- Autonomous maintenance, where operators are responsible for routine upkeep such as cleaning, lubricating and inspecting machines
- Preventive maintenance is aimed at preventing equipment breakdowns through scheduled maintenance and part replacement to identify potential issues
- Corrective maintenance to restore function after unexpected breakdowns
- Maintenance prevention through the use of equipment that requires less upkeep, such as equipment with a corrosion-resistant coating.

2.4.7 Single-Minute Exchange of Die (SMED)

Single-Minute Exchange of Die (SMED), also known as Quick Changeover, is a lean manufacturing technique pioneered by Shigeo Shingo at Toyota in the 1950s to drastically reduce the time required to switch from one product type to another. The goal is to complete changeovers in single-digit minutes (under 10 minutes), enabling small-batch, reduced inventory, and rapid response to demand fluctuations—all critical for waste elimination (Shingo, 1985).

The core philosophy of SMED is to convert as many changeover steps as possible from internal (machine stopped) to external (machine running), while streamlining the remaining internal activities. This minimizes downtime waste, prevents over of a single block type, and avoids excess inventory of finished goods waiting for the next run.

By reducing setup time to single digits, SMED helps plants:

- Minimize downtime and associated costs
- Produce smaller lots by enabling frequent product changes and thus flexible scheduling and increased customer responsiveness
- Reduce inventory levels and costs

SMED reduces changeover times between production batches to enable flexibility and reduce downtime.

2.4.8 Poka-Yoke (Error Proofing)

Poka-Yoke ("mistake-proofing") prevents errors at source via designs making mistakes impossible or detectable immediately, reducing defects and rework waste (Shingo, 1986). Simple devices like sensors, guides, or checks—e.g., molds allowing only correct aggregate insertion or alarms for improper vibration—block issues (Chase et al., 2010).

In building blocks, it ensures accurate mixing ratios, proper compaction, or correct curing, preventing weak blocks, material overuse, or contamination. Sensors halt lines for under-vibration or foreign objects in mixes (Saurin et al., 2010).

In Nigeria, power issues and old equipment raise error risks; Poka-Yoke offers cheap quality guards. Edo firms reduce defective blocks, measurement errors, and waste via these (Ede & Oko, 2021; Omoregie, 2022).

2.4.9 Six Sigma

Six Sigma is a data-driven methodology aimed at reducing process variation, improving quality, and achieving near-perfect performance in production systems. Developed by Motorola in the 1980s and later popularized by General Electric, Six Sigma focuses on systematically identifying and eliminating the root causes of defects, with the ultimate goal of achieving a process capability that produces no more than 3.4 defects per million opportunities (Harry & Schroeder, 2000).

Unlike traditional quality control methods that rely on inspection to detect errors after production, Six Sigma emphasizes prevention by embedding statistical and analytical tools into the entire production process.

At the heart of Six Sigma lies the DMAIC framework; Define, Measure, Analyze, Improve, and Control which provides a structured problem-solving methodology for process improvement. In the

Define phase, project goals and customer requirements are clearly established. The Measure phase involves data collection to establish baseline performance. The Analyze phase identifies root causes of defects using statistical techniques, while the Improve phase implements solutions to address these causes. Finally, the Control phase establishes monitosring mechanisms to sustain improvements over time (Antony, 2006). This systematic cycle ensures that improvements are data-driven, measurable, and sustainable.

In the context of lean manufacturing, Six Sigma is often combined with lean principles to form Lean Six Sigma, a hybrid approach that balances efficiency with quality. While lean tools such as 5S, Kaizen, and Just-in-Time focus on eliminating waste and improving flow, Six Sigma addresses process variation and defect reduction. Together, they create a comprehensive framework for achieving operational excellence, where processes are both efficient and reliable (George, 2002).

2.5 Types of Waste in Manufacturing (TIMWOOD)

Waste or Muda, refers to activities that consume resources without adding value. Ohno (1988) identified seven wastes, later extended to eight.

A cornerstone of lean thinking is the recognition and elimination of waste. The eight classic types of waste are:

1. Transportation – Inefficient movement of materials. (Poor facility layout)
2. Inventory – Excess materials not being processed. (Overstocking with cement)
3. Motion – Inefficient movement by workers. (Poorly designed workstation)
4. Waiting – Idle time due to delays. (Improper project planning)
5. Over – Producing more than required. (Unused blocks breaking)
6. Overprocessing – Performing more work than needed. (Adding more cement than needed)

7. Defects – Rework or scrap due to quality issues. (Substandard blocks)
8. Unused Talent – Underutilizing workers improvement ideas

In block production, examples include:

- Cement spillage (Defect, Overprocessing)
- Workers waiting for material (Waiting)
- Broken blocks (Defect)
- Unused inventory (Inventory)

	Waste Type	**Description**	**Example**
1	Transportation	Unnecessary movement of materials	Movement bags of cement across poorly designed factory
2	Inventory	Unused materials	Stockpiled cement bags
3	Motion	Inefficient workers movement	Poor workstation layout
4	Waiting	Idel time in process	Machine stops due to material delays
5	Over	Producing more than needed	Excess blocks not sold
6	Overprocessing	Excessive use of resources	Adding excess water to your mixture
7	Defect	Faulty products requiring rework	Cracked blocks due to poor curing
8	Unused Talent	Underutilizing employee skills	Workers excluded from improvement initiative

Table 2.1: Types of Waste in Building Block

2.6 Benefits of Lean in Building Block Production Industry

Lean manufacturing is designed to identify and eliminate non-value adding activities, making sure that resources are used in the best way to produce building blocks that meet what customers need. In building block factories, where waste shows up as cracked blocks, leftover wet concrete, long waiting times, and poor use of materials, lean practices have great potential to cut down losses and improve how the factory runs (Womack & Jones, 2003; Shah & Ward, 2007).

One of the biggest ways lean helps reduce waste is by stopping over and too much stock. When factories use Just-in-Time (JIT) systems, they only make blocks when construction sites actually order them, so there are no piles of unsold blocks sitting in the yard getting damaged by rain or stacking pressure. Studies in similar industries show that JIT brings shorter production times, lower costs for storing materials, and better-quality blocks delivered to sites (Abdulmalek & Rajgopal, 2007). In the same way, Value Stream Mapping (VSM) gives a clear picture of the whole process, helping factory owners spot delays and problems, then fix the flow to waste less time and material. Lean also makes a big difference in cutting down defective blocks and the need to redo work, which costs a lot in block making because customers want strong, properly sized blocks. Tools like Poka-Yoke (mistake-proofing) and Six Sigma stop errors right at the start and keep the mixing and molding steady, so fewer weak or cracked blocks are made. This saves materials and avoids the extra cost of throwing away bad blocks or losing customer trust (Shingo, 1986; George, 2002). Practices like Total Productive Maintenance (TPM) greatly reduce time lost when machines break down by keeping equipment in good shape and ready to use. By training workers to do simple checks and cleaning, TPM prevents sudden stops in production, which is very important in block making where a breakdown can waste a whole batch of concrete. 5S and Kaizen help even more by keeping the workplace tidy, setting clear standards, and encouraging small improvements every day, which together cut down unnecessary movement, speed up work, and keep the yard safe and organized (Liker, 2004; Imai, 1997).

The benefits of lean in reducing waste have been clear in building block factories in Edo State. Local yards have seen fewer cracked blocks, longer machine running time, and stronger blocks after using simple lean tools like Kaizen and 5S. Even though power cuts and supply problems make it hard to use advanced tools like JIT and Six Sigma fully, starting with easier practices has still made a big difference in wasting less (Ede & Oko, 2021; Omoregie, 2022).

Beyond just running the factory better, lean helps with bigger goals like saving the environment. Using less cement, water, and fuel means fewer resources are wasted, and there is less rubbish from broken blocks. This aligns lean not only with the aims of lowering costs and staying competitive but with also supporting efforts to produce in a way that is kinder to the planet

2.7 Challenges of Implementing Lean in Edo State, Nigeria

Despite its benefits, lean adoption in Nigerian production firms faces obstacles, one of the biggest barriers in implementation in building block factories in Edo State is poor infrastructure. Tools like Just-in-Time (JIT) need steady power, good roads, and fast communication to work well. In Nigeria, power cuts happen every day, roads are full of potholes, and trucks often get delayed. This breaks the smooth flow of sand, cement, and water that lean depends on, so block makers cannot keep up with JIT or Kanban properly (Akinwale & Adegbuyi, 2019). On top of

that, most small yards do not have modern machines or computers, which makes it hard to use advanced tools like Six Sigma or automatic mixing systems.

Another major problem is that workers and owners do not know enough about lean. Lean needs everyone in the factory to join in, but most people in block-making businesses have never been trained. Without clear lessons, workers may push back against new ways or forget to follow rules after a short time. The old habit of bosses making every decision also stops Kaizen, where workers should suggest small fixes to problems (Bhamu & Singh Sangwan, 2014).

Money is always tight and creates another obstacle. Even though lean is supposed to cost little at the start, training workers, buying quick clamps for SMED, or setting up boards for 5S still needs some cash. Many block yards in Edo State run on very little money and worry more about paying for cement today than saving costs tomorrow. High bank interest and changing prices make it scary to spend on long-term improvements (Omoregie, 2022).

Weak links with suppliers make things worse. Lean works best when suppliers deliver exactly what is needed and when it is needed. In Nigeria, suppliers often come late or send the wrong amount of sand or gravel. This breaks JIT and forces block makers to keep big piles of materials just in case, which goes against lean ideas (Ede & Oko, 2021).

These problems show a gap in what we know. Most studies about lean come from rich countries with good roads and power. Very few look at small block factories in places like Edo State. Researchers have noticed infrastructure and culture problems, but not many have checked how these really stop lean from cutting waste in local yards (Ahuja & Khamba, 2008; Omoregie, 2022). This gap makes the current study important. It looks at how lean tools can cut waste in building block factories in Edo State, Nigeria, while facing real local challenges. By studying both the good sides and the hard parts, the work helps connect global lean ideas to everyday life in Nigerian small businesses.

2.8 Empirical Review

Several studies have examined lean's effectiveness in developing economies:

- Edeh & Okolie (2020) found that lean implementation in small production firms in Anambra reduced waste by over 25% within 6 months.
- Ibrahim et al. (2019) revealed that many Nigerian SMEs are unfamiliar with lean principles, despite their potential.
- Okoro (2021) studied cement block makers in Rivers State and found that simple lean tools like 5S and Kaizen improved workplace organization and reduced defects.
- Ameh & Adedeji (2018) observed resistance among workers as a major challenge in implementing lean in Nigerian manufacturing.

These studies reinforce the potential benefits and typical barriers in lean adoption across similar environments.

2.9 Theoretical Framework (Lean Thinking Model)

The Lean Thinking Model, as proposed by Womack and Jones, serves as the guiding theory for this study. It is built around the five lean principles and emphasizes a holistic approach to process improvement.

2.9.1 Lean Thinking Theory

Lean thinking emphasizes delivering value through waste elimination (Womack & Jones, 1996). It is relevant to block production, where eliminating defects and inventory reduces costs.

2.9.2 Theory of Constraints (TOC)

TOC focuses on identifying and addressing bottlenecks to improve system performance (Goldratt, 1984). In block production, bottlenecks like slow curing processes can be targeted using lean tools.

2.9.3 Resource-Based View (RBV)

RBV posits that firms gain competitive advantage through unique resources and capabilities (Barney, 1991). Lean practices enhance capabilities like efficient resource use, giving firms a competitive edge.

Assumptions of the model include:

- Value is defined by the customer.
- All processes contain waste that can be eliminated.
- Improvement is a continuous journey.
- Employees at all levels contribute to improvement.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research Design

The study adopts a case study research design. The case study research method is used because it allows for an in-depth investigation of lean manufacturing practices within the building block industries. The case study approach is suitable because the goal is to examine and understand existing processes, identify waste, and evaluate how lean tools can minimize such waste in a specific organization.

Both qualitative and quantitative methods were employed:

- ❖ The qualitative approach provides descriptive insights into workplace practices carried out during, employee behavior, and managerial strategies.

- ❖ The quantitative approach enabled numerical analysis of time, waste volume, and efficiency levels before and after the implementation of lean techniques.

This combination which is known as a mixed-method design was used to strengthen the conclusions through triangulation of data.

3.2 Area of Study

The study was carried out in Benin City, Edo State, Nigeria. Benin City is a major commercial hub in southern Nigeria with several small and medium-scale manufacturing enterprises, including cement and concrete block firms.

The chosen case, Building Block Industries, is a typical medium-sized block production company in Ugbowo axis. These firms produce hollow and solid blocks of varying sizes such as 6”, 9”, and 12” with the use of building block primary raw materials which are cement, sand, and water.

These companies employ an average of approximately 25 staff members divided into, operational, technical, and administrative departments. The production system that is mainly used is semi-mechanized, utilizing locally fabricated mixers and block-molding machines. These characteristics make the chosen companies’ suitable representative of most block-producing firms in Nigeria.

3.3 Population of the Study

The population of this study is made up of all the staff members involved in the production process of the building blocks which includes machine operators, mixers, supervisors, quality control personnel, and maintenance staff. Administrative personnel were also included for managerial perspectives on process improvement.

3.4 Sample Size and Sampling Technique

A purposive sampling technique was adopted to select participants directly involved in production activities. This method ensures that respondents possess relevant knowledge of the production process and waste management practices.

A total of 30 participants were selected, categorized as follows:

CATEGORY	NUMBER OF RESPONDENTS	ROLE OF RESPONDENTS
workers	10	Direct block molding and mixing
Supervisors	5	Quality control and oversight of the whole process
Maintenance Technicians	5	Maintenance of the working equipment
Administrative Staff	5	Coordination and records of processes
Management personnel	5	Decision making and strategy

Table 3.1 Sample Size and Sampling Technique

This distribution provides a balanced view of both operational and managerial perspectives.

3.5 Sources of Data

One major data source was utilized in this study:

- **Primary Data Collection:** Data was collected directly from the company with the use of structured questionnaires which was distributed, personal interviews, and field observation.

3.6 Data Collection Instruments

1. Questionnaire

A structured questionnaire was designed to obtain quantitative data on production activities, types of waste, and employees' understanding about the lean manufacturing principles. The questionnaire consisted of three sections:

1. **Section A**: This section contains the demographic data of the respondents.
2. **Section B**: This section is used to identify the different types of waste sources and

frequency.

3. **Section C:** Perception of lean manufacturing tools.
4. **Section D:** Impact of lean practices.
5. **Section E:** Challenges in implementing lean practices

A five-point Likert scale (Always to Never) was used to measure attitudes toward lean practices.

2. Interviews

Semi-structured interviews were conducted with key managers and supervisors to gather detailed qualitative data about production challenges and waste reduction strategies. The interviews lasted between 5 and 10 minutes.

3. Observation

Non-participant observation was used to record physical waste occurrences, material handling patterns, and process flow disruptions. Observations provided visual confirmation of data obtained through questionnaires and interviews.

Sample of the questionnaire used for the data collection

UNIVERSITY OF BENIN, BENIN CITY

FACULTY OF ENGINEERING

DEPARTMENT OF INDUSTRAIL ENGINEERING

Project Tittle: THE IMPACT OF LEAN MANUFACTURING ON WASTE REDUCTION: A CASE STUDY OF BUILDING BLOCK INDUSTRIES IN EDO STATE

Dear Respondent,

My name is Awele Angel Akakpor, A 500 level Industrial Engineering student. This questionnaire is designed to gather information for academic research purpose. Your responses will inform strategies to improve efficiency in Edo State. All data is anonymous and will be appreciated as they will be treated with utmost confidentiality. Kindly respond honestly and objectively. Thank you for your cooperation.

Target Respondents: workers, supervisors, maintenance technicians, administrative staff, and management personnel in building block production firms.

Please tick (✓) the appropriate option. The questions are grouped into Five sections for clarity.

Section A: Demographic Information

1. Gender ( ) Male ( ) Female
2. Age ( ) 18--25 ( ) 26–35 ( ) 36–45 ( ) 46 and above
3. Educational Qualification ( )SSCE ( ) OND ( ) HND ( )B.Sc ( )Others

4. Department ( ) Production ( ) Administration ( ) Maintenance ( ) Management

5. Years of experience ( ) 1- 3 ( ) 4–6 ( ) 7–10 ( ) Above 10

Section B: Identification of Waste in the Production Process

Objective: Identify major forms of waste in the block production process

Scale: 5= Strongly agree, 4= Agree, 3= Undecided, 2= Disagree, 1= Strongly Disagree

S/N	**SURVEY QUESTION**	**1**	**2**	**3**	**4**	**5**
1	Excessive raw materials are often wasted during					
2	Machine downtime frequently delays					
3	Workers spend a lot of time waiting for materials or instruction					
4	Finished blocks are often defective or broken					
5	Material movement between sections are is well organized					

Section C: Lean Manufacturing Practices

S/N	**SURVEY QUESTION**	**1**	**2**	**3**	**4**	**5**
6	The company practice regular housekeeping (5s)					
7	Workers are encouraged to suggest improvement ides (Kaizen)					
8	Machines are serviced regularly before break down occurs (TPM)					
9	is scheduled based on customers demand (JIT)					

10	Tools and materials are arranged for quick access					

Section D: Impact of Lean Manufacturing Practices

S/N	SURVEY QUESTION	1	2	3	4	5
11	Lean manufacturing has reduced waste in the company					
12	Machine downtime has reduced due to preventive maintenance					
13	Worker’s productivity has improved due to better organization					
14	Layout redesign has reduced movement and time wastage					
15	Quality of finished blocks has improved after lean adoption					

Section E: Challenges in Implementing Lean Practices

S/N	SURVEY QUESTION	1	2	3	4	5
16	Employees resist changes to existing work routines					
17	Lack of management support limits lean practices					
18	There is insufficient funding for maintenance and training					
19	Employees are not properly trained in lean method					
20	Poor power supply disrupts work flow					

Thank you for your time and contribution.

3.7 Method of Data Collection

The following procedures were followed:

1. **Preliminary Visit**: We visited the company to obtain formal permission and gain an in-depth understanding of the operational processes carried out.
2. **Questionnaire Administration**: Structured questionnaires were distributed to selected sample of employees with the help of the production manager in charge.
3. **Observation Period:** A 3 days observational study was conducted to systematically record and document waste occurrences in real time.
4. **Interview Sessions:** An interview was conducted with management and technical staff to gain useful insight into some challenges the organization may face.
5. **Data Compilation**: Responses were coded, entered, and prepared for analysis.

3.8 Method of Data Analysis

The data collected from the questionnaires were coded, entered, and analyzed using the **Statistical Package for the Social Sciences (SPSS), version 27.0.1.** The analysis was both descriptive and inferential in nature.

1. Descriptive Analysis

Descriptive statistics such as percentages, mean scores, and frequency and standard deviations were used to summarize respondent's demographic characteristics and their responses to questions relating to lean manufacturing practices and waste reduction. These summaries provided an overview about the trends, patterns, and central tendencies of the survey conducted.

2. Inferential Analysis

To test the research hypothesis and determine whether there is a statistically significant differences between groups regarding lean manufacturing practices, a One-way Analysis of Variance (ANOVA) was employed.

The One-Way ANOVA was chosen because it allows comparison of the mean score of three or more independent groups (e.g, production workers, maintenance staff, supervisors, and managers) to see if lean manufacturing practices significantly influences waste reduction.

The decision rule was based on the significance level ($\alpha = 0.5$)

- If p-value < 0.5, the null hypothesis (no significant difference) was rejected
- If p-value ≥ 0.5, the null hypothesis was accepted

3. Hypothesis Testing

The following null hypothesis guided the inferential analysis

- H_0: There is no significant impact of lean Manufacturing practices on waste reduction in building block production firms.
- H_1: There is a significant impact of lean Manufacturing practices on waste reduction in building block production firms.

The **One-Way ANOVA** was applied to compare the mean responses of different categories on the effectiveness of lean manufacturing practices. Post-hoc test (turkey's) were conducted when significant differences were found, to identify which group differed.

3.9 Research Variables

The main variables in this study are divided into **independent** and **dependent** variables:

Type	**Variables**
Independent variables	Lean tools (5S, Kaizen, VSM, TPM)
Dependent variables	Waste reduction, productivity improvement, process efficiency.

These variables formed the basis for measuring the relationship between lean practices and operational performance.

3.10 Validity and Reliability of the Research Instruments

The accuracy and consistency of the research findings depend on the validity and reliability of the data collection instruments. In this study, the main data collection instrument was a structured questionnaire, supported by interviews and direct observation. The following measures were taken to ensure that the instrument was both valid and reliable.

3.10.1 **Validity of the Instrument**

Validity refers to the extent to which an instrument accurately measures what it is intended to measure (Kothari, 2004). To ensure that the questionnaire truly captured the concepts of lean manufacturing and waste reduction, several types of validity were assessed:

1. Content Validity:

The questionnaire was reviewed by project supervisor **Dr. N. H. OSADIAYE** from the Department of Industrial Engineering, University of Benin, to verify that the questions were relevant, clear, and comprehensive. He examined the items for logical consistency with the research objectives, ensuring that all key constructs such as waste identification, lean tools, and performance improvement were adequately represented.

2. Construct Validity:

Each section of the questionnaire was aligned with a specific variable identified in the study's conceptual framework (e.g., Lean Practices, Waste Reduction, Employee Engagement). This ensured that the questions collectively measured the intended constructs based on established lean manufacturing theories such as Womack & Jones (1996) and the Toyota System principles.

3. Criterion Validity:

The results obtained from the questionnaire were compared with observable operational practices in the company (through on-site observation) to confirm consistency between perceived and actual lean activities. This cross-verification strengthened the instrument's external validity.

3.10.2 **Reliability of the Instrument**

Reliability is defined as the probability that a system will perform its intended function for a specified period of time under a given set of condition (Creswell, 2014). To establish reliability, responses from related items (for example, those measuring lean practices and waste reduction). showed strong positive correlations, indicating that the items were internally coherent and measured the same underlying construct.

3.11 Ethical Considerations

This study adhered to established ethical standards governing academic research to ensure the protection of participants and the credibility of the data collected. Since the research involved direct interaction with staff members of Building Block Industries, Benin City, all ethical issues related to voluntary participation, informed consent, confidentiality, and data integrity were carefully addressed.

The following ethical principles guided the study:

3.11.1 Informed Consent

All respondents were informed about the purpose, objectives, and significance of the study before data collection began. Participation was entirely voluntary, and respondents were allowed to withdraw at any time without any negative consequences. Each participant received a brief explanation of how their responses would contribute to academic research aimed at improving productivity and reducing waste in the production sector.

3.11.2 Confidentiality and Anonymity

The identity of respondents and the participating company was kept strictly confidential. The questionnaire did not request names or personal identifiers. Information obtained was coded numerically for statistical analysis using SPSS, ensuring that no individual could be linked to specific responses. The data were stored securely and accessible only to the researcher and project supervisor.

3.11.3 Data Protection and Integrity

All data collected (questionnaires and interview notes) were handled with care to prevent loss or manipulation. Responses were entered directly into SPSS software for analysis, and backup copies were saved in encrypted digital storage to maintain accuracy and data integrity. No data were altered or misrepresented during analysis.

3.11.4 Voluntary Participation

Respondents were assured that their participation was voluntary and that no coercion, reward, or penalty would result from their decision to participate or not. This ethical approach helped encourage honest and unbiased responses.

3.11.5 Non- Maleficence

The study posed no physical or psychological harm to the participants. All interactions were conducted respectfully, within normal working hours, and with minimal disruption to operations.

3.11.6 Acknowledgment of Sources

All secondary data, books, journals, and online resources used in the study were properly acknowledged in the reference list in accordance with the APA 7th edition referencing style. This ensured that the intellectual property rights of all authors were respected.

3.12 Research Procedure

The research procedure was designed to ensure systematic, organized, and logical progression throughout the entire study process. The procedure adopted for this study is summarized as follows:

1. Problem Identification: The study began with the identification of inefficiencies and waste

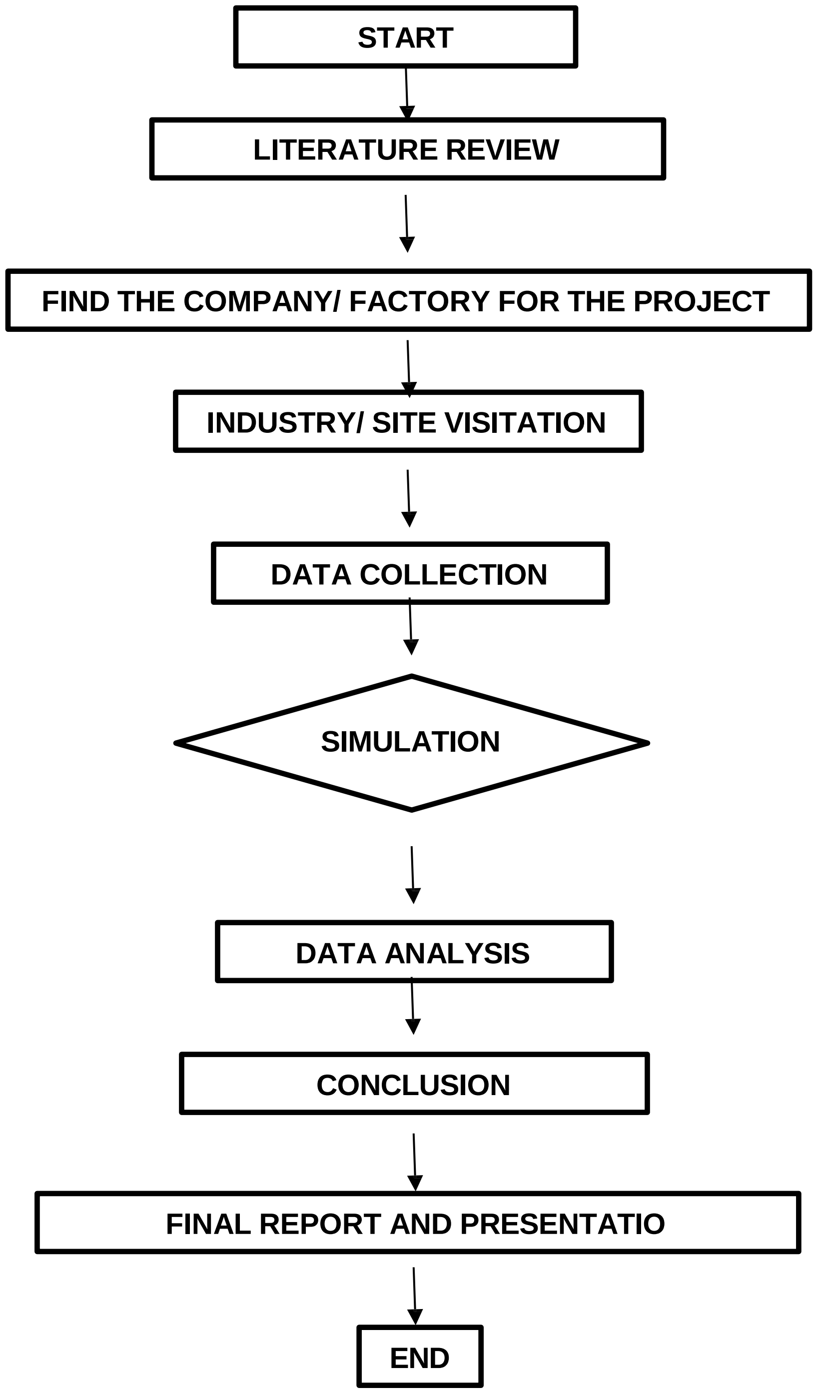
generation problems within small and medium-scale block production industries in Benin City, Edo State.

2. Literature Review: Extensive literature was reviewed to gain theoretical and empirical insight into lean manufacturing concepts, tools, and their applications in waste reduction. This stage provided the foundation for developing the research framework and questionnaire design.
3. Selection of Study Area: The Building Block Industries was selected based on its operational structure, process, and accessibility for research. Management consent was obtained before data collection commenced.
4. Site Visitation and Preliminary Observation: The researcher visited the company's production facility to observe the block production processes, machinery setup, and existing waste management practices. This helped refine the questionnaire items and identify key areas for data collection.
5. Instrument Design and Validation: A well-structured questionnaire was developed and validated by my project supervisor to ensure clarity and relevance. The instrument was designed to collect both quantitative and qualitative data on lean practices and waste levels.
6. Data Collection: Primary data were collected through questionnaire administration, interviews, and direct observation. Respondents included production workers, supervisors, and management staff. Secondary data were obtained from company records and published materials.
7. Simulation (Process Observation and Review): Data from observations were analyzed to simulate the process flow and identify points where lean tools could be applied to minimize waste. The researcher modeled the production process to illustrate potential improvements.
8. Data Analysis: Quantitative data from questionnaires were coded and analyzed using the

Statistical Package for the Social Sciences (SPSS 27). Descriptive statistics summarized the data, while One-Way ANOVA tested the significance of lean implementation on waste reduction across different staff categories.

9. Results Interpretation and Discussion: The analyzed data were interpreted in relation to the study objectives and compared with findings from previous studies on lean manufacturing. Key outcomes such as reduced waste, improved efficiency, and employee engagement were discussed.
10. Conclusion and Recommendation: Based on the analyzed data, conclusions were drawn regarding the effectiveness of lean manufacturing practices in minimizing waste. Recommendations were made to guide management and policymakers on continuous improvement practices.
11. Final Report Compilation and Presentation: The entire research process, from data collection to analysis and interpretation, was documented and compiled into the final project report for submission and oral presentation to the Department of Industrial Engineering, University of Benin.

Flow Chat for the Project Report



Flow Chat for Final Year Project

3.13 Expected Outcomes

The expected outcomes of this study were derived from the application of lean manufacturing principles within the context of block. Based on the literature reviewed and the research objectives, the following outcomes were anticipated:

1. Identification of Waste Sources:

The study is expected to clearly identify and categorize the major forms of waste (such as material waste, motion waste, waiting time, and defects) present in the system of Building Block Industries.

2. Effectiveness of Lean Tools:

It is anticipated that lean manufacturing tools such as 5S (Housekeeping), Kaizen, Layout Optimization, and Total Productive Maintenance (TPM) will lead to measurable improvements in operational efficiency.

3. Reduction in Waste:

A reduction in raw material losses, idle time, and defective products is expected after implementing lean techniques.

4. Improvement in Productivity and Quality:

The introduction of lean tools is expected to streamline the process, increase output per unit time, and enhance the overall quality of finished blocks.

5. Enhanced Employee Engagement:

Worker participation in improvement activities (Kaizen) is expected to boost morale, accountability, and teamwork.

4. Provision of an Improvement Framework:

The study will produce a practical improvement framework adaptable to small and medium-scale block production firms in Nigeria for sustainable performance.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS, AND DISCUSSION

4.1 Company Profile and Production Process Overview

Building Block Industries are medium-scaled enterprises located across Nigeria. These companies produce hollow and solid concrete blocks of sizes 6, 9, and 12 inches. The production process is semi-automated and involves manual labor and machines.

The company operates with three main departments:

1. **Mixing Section:** This section is responsible for combining raw materials which are the cement, sand, and water that are needed to form the **Mortar**, if gravel is added it becomes **Concrete** instead (that is a mixture of cement, sand, water, and gravel).

The mixing operation can be achieved in two ways:

(a) Manual Mixing:

Workers pour the sand onto a clean platform, spread the cement evenly over it, and turn the mixture several times using shovels until a uniform grey color is achieved. Water is then sprinkled gradually while the mixture is turned repeatedly until the desired consistency is obtained.

(b) Mechanical Mixing:

A rotary drum mixer or pan mixer is used for faster and more consistent mixing. Materials are loaded into the mixer, water is added, and the machine rotates for about 3–5 minutes to produce a homogenous mix.

2. **Molding Section:** The molding section is a core stage in block production. This is where the mixed mortar (a combination of cement, sand, and water) is manually filled into molds to form blocks. This section represents the most labor-intensive phase of the production process, requiring precision, skill, and consistency from the operators.

   Molding Section

   The molding section is the core unit of block production, where the properly mixed mortar (a uniform blend of cement, sand, and water) is transformed into solid building blocks. This section is crucial because it determines the shape, strength, and dimensional accuracy of the final product.

   Mechanized Molding Process.

   1. Feeding of the Mortar: The prepared mortar mixture is manually or mechanically fed into the molding machine hopper. The machine used in Building Block Industries is typically a vibratory compression molding machine, which ensures uniform density and compaction.

   2. Compaction and Vibration: Once the mortar is fed into the mold cavities, the machine applies mechanical vibration and compression to eliminate air pockets and ensure

even distribution of the mix. This stage determines the block's structural integrity and load-bearing capacity.

3. Shaping and Forming: The machine's mold plates shape the mixture into the desired block dimensions (e.g., 6-inch or 9-inch hollow blocks). Proper compaction ensures smooth surfaces and consistent thickness.

4. Ejection of Molded Blocks: After compaction, the formed blocks are gently ejected from the mold onto a wooden pallet or conveyor belt. Care is taken to avoid cracking or deformation while the blocks are still "green" (unhardened).

5. Initial Setting: The molded blocks are allowed to rest for a short period (usually 12–24 hours) to gain sufficient strength before being moved to the curing section. During this period, they undergo initial setting and moisture loss.

6. Quality Inspection: Visual checks are carried out to ensure that blocks are uniform, free from cracks, and within specified dimensions. Any defective or deformed blocks are separated and remolded.

Manuel Molding Process Description

1. Preparation of the Molding Area**:** Before molding begins, the floor or platform is leveled, cleaned, and slightly moistened to prevent the green (freshly molded) blocks from sticking or cracking. Wooden pallets are arranged close to the molding zone to receive the freshly formed blocks immediately after shaping.

2. Filling of the Molds: The prepared mortar is transported using head pans or wheelbarrows from the mixing area to the molding section. Workers then fill the metal molds with the mortar

using hand shovels. The mixture is spread evenly into the mold cavities to ensure proper compaction and prevent the formation of air pockets or voids.

3. Compaction and Leveling**:** Compaction is done by using hand rammers or trowels to ensure the mix is tightly packed inside the mold. Proper compaction is essential to achieve uniform density and to enhance the strength and durability of the blocks.

The surface of the mold is then leveled using a trowel to produce smooth and even block faces.

4. Demolding: After compaction and leveling, the mold is carefully lifted vertically to release the block. This step requires steady hands and precision to prevent the green block from collapsing or cracking. Each newly molded block is left on its pallet or platform for initial setting, usually 12 to 24 hours, before being transferred to the curing section.

5. Quality Checks: During manual molding, quality control is primarily visual. The supervisor checks for:

- Proper shape and dimensions
- Smooth edges and surfaces
- Absence of cracks or deformities

Any defective block identified at this stage is remixed and remolded immediately.

3. **Curing and Storage Section:** The curing and storage section is the final and most critical phase in the block production process. It ensures that the molded blocks gain the required strength, hardness, and durability through proper hydration of cement. This section also provides a controlled environment for the blocks to mature before being transported or sold.

Process Description

1. Transfer of Green Block: After the molding stage, the freshly made (green) blocks are left on pallets or platforms for 12–24 hours to allow initial setting and hardening. Once they are firm enough to be handled, the blocks are carefully transferred manually or with wheelbarrows to the curing area. This area is usually a shaded, level, and damp floor space protected from direct sunlight and excessive wind, which could cause surface cracking.

2. Arrangement in the Curing Yard**:** Blocks are arranged in rows or stacks with small spaces between them to allow easy movement of workers and uniform access to moisture. Proper arrangement helps ensure even curing and prevents damage due to contact or friction. Workers often water on the ground to keep the environment moist.

3. Water Curing Process: The curing of cement blocks depends on maintaining adequate moisture and temperature to ensure complete hydration. Water curing was the method mostly adopted in the building block industries visited. The procedure involved:

- Sprinkling or spraying water on the blocks twice daily (morning and evening).
- Continuously wetting the curing floor to maintain humidity.
- Covering the blocks with moist sacks, tarpaulin, or polythene sheets in dry weather to prevent rapid moisture loss.

The curing process was carried out for a minimum of 7 days and, in some cases, extended to 14 days depending on block type and production schedule.

4. Chemical Process (Hydration): During curing, hydration of cement occurs. This is a chemical reaction between cement and water that forms calcium silicate hydrate (C–S–H), which gives the

block its strength. Improper curing leads to incomplete hydration, resulting in weak, brittle blocks prone to cracking and early failure.

5. Drying and Strength Gain**:** After the required curing period, the blocks are allowed to dry naturally for another 2 to 3 days. This final drying phase enhances compressive strength and prepares the blocks for stacking or transportation. At this stage, the blocks achieve 60–80% of their ultimate strength and exhibit improved surface hardness.

6. Storage and Handling**: O**nce cured and dried, the blocks are neatly stacked in the storage yard. Proper stacking is crucial to:

- Prevent cracks and breakage during handling
- Allow air circulation for continuous drying
- Facilitate easy counting, inspection, and loading

Blocks are stacked in piles, typically five to six layers high, with wooden separators between layers for balance and ventilation. Care is taken to avoid overloading or stacking on uneven ground.

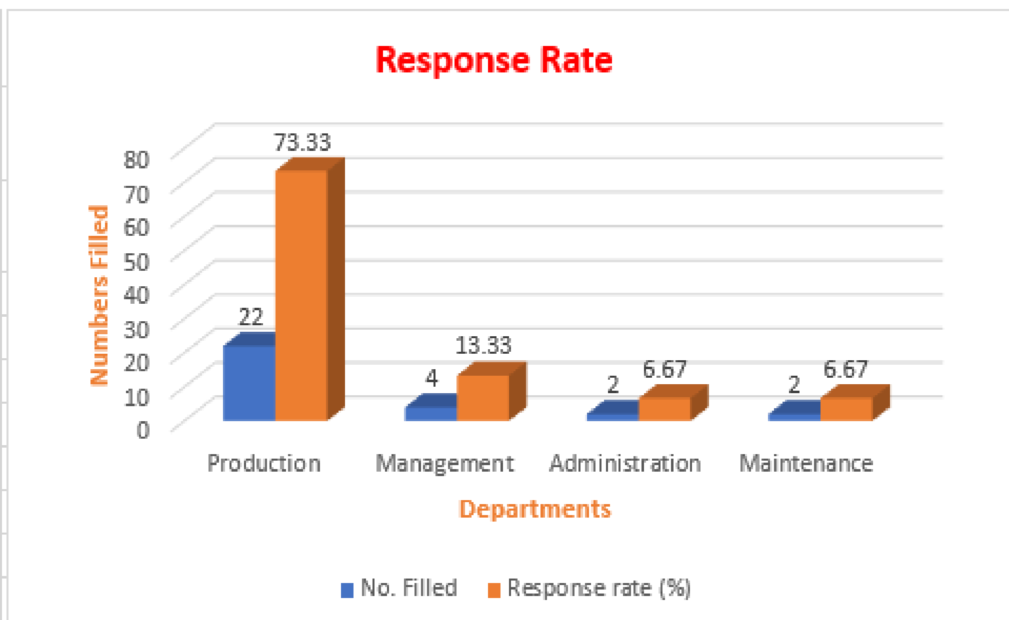
4.2 Questionnaire Administration and Response Rate

A total of 30 copies of the questionnaire were administered to employees of different Building Block Industries across four departments: production, Maintenance, Administration, and Management. All 30 copies were retrieved and found valid for analysis, representing a 100% response rate.

This high response rate indicates strong participation and enhances the reliability of the findings.

Department	No. Filled	Response rate (%)
Production	22	73.33
Maintenance	2	06.67
Administration	2	06.67
Management	4	13.33
Total	30	100

Table 4.1: Questionnaire Distribution and Response Rate



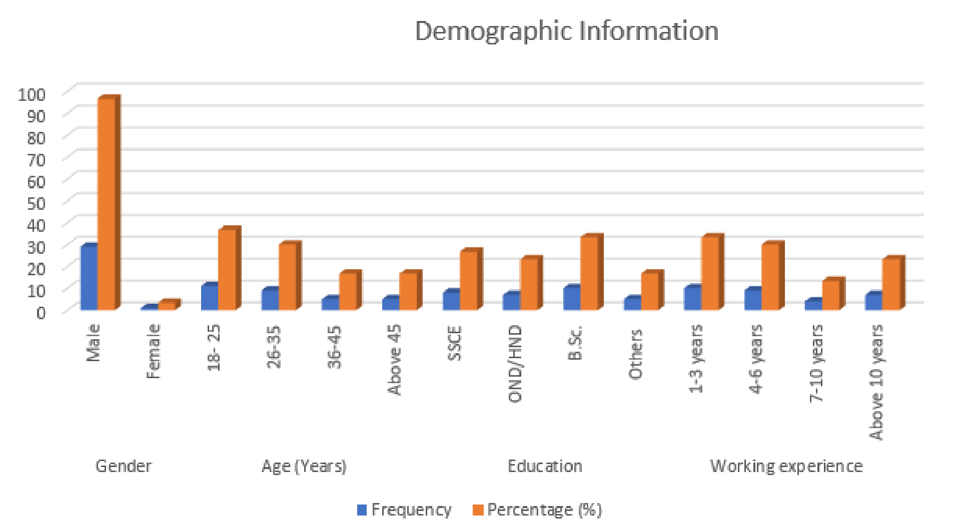
4. 1 Response Rate Chart

4.3 Demographic Characteristics of Respondents

Demographic information helps provide context to the responses.

Variable	**Category**	**Frequency**	**Percentage (%)**
Gender	Male	29	96.67
	Female	1	3.33
Age (Years)	18- 25	11	36.67
	26-35	9	30.00
	36-45	5	16.67
	Above 45	5	16.67
Education	SSCE	8	26.67
	OND/HND	7	23.33
	B.Sc.	10	33.33
	Others	5	16.67
Working experience	1-3 years	10	33.33
	4-6 years	9	30.00
	7-10 years	4	13.33
	Above 10 years	7	23.33

Table 4.2: Demographic Profile of Respondents



4. 2 Demographic Profile of Respondent

The demographic profile indicates that most respondents are experienced male workers aged between 18 to 46 years, with a good mix of work experience and academic qualifications.

4.4 Identification of Waste in the Production Process

Respondents identified various forms of waste prevalent in the production system before lean implementation.

```
DESCRIPTIVES VARIABLES=Material_Waste Machine_Downtime Waiting_Time Defective_Blocks Mot
ion_Waste
  /STATISTICS=MEAN SUM STDDEV VARIANCE RANGE MIN MAX
  /SORT=MEAN (A).
```

Descriptives

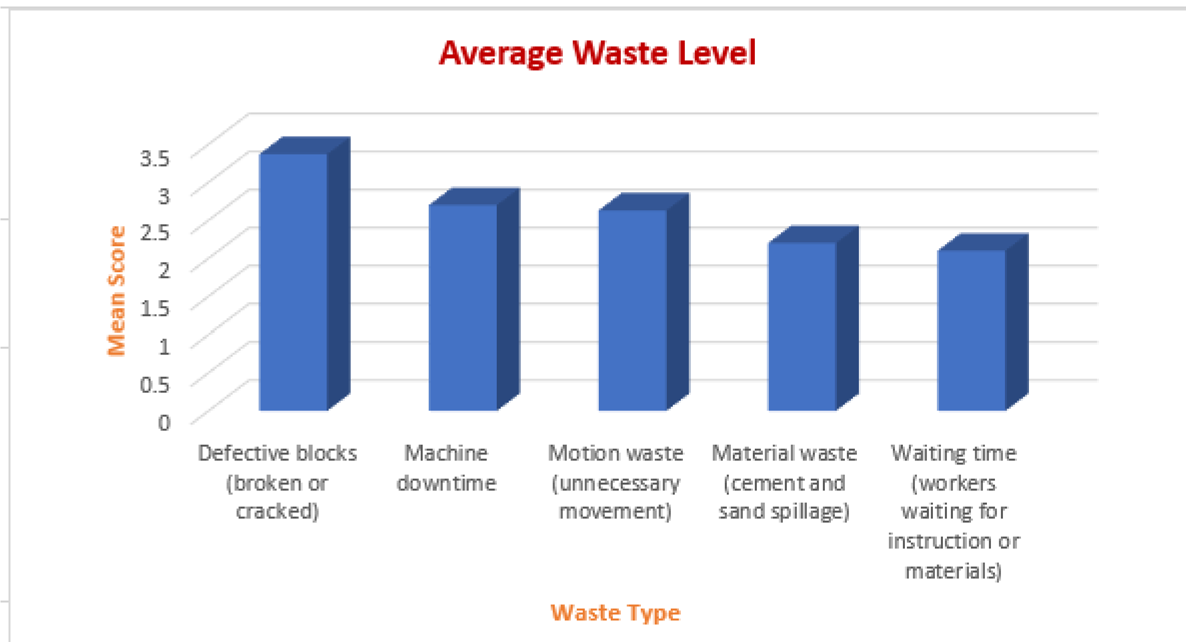
Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
Waiting_Time	30	2	1	3	63	2.10	.845	.714
Material_Waste	30	4	1	5	66	2.20	.997	.993
Motion_Waste	30	4	1	5	79	2.63	1.450	2.102
Machine_Downtime	30	4	1	5	81	2.70	1.208	1.459
Defective_Blocks	30	4	1	5	101	3.37	1.217	1.482
Valid N (listwise)	30							

4. 3 ANOVA Waste Identification

Type of Waste	**Mean Score**	**Rank**
Defective blocks (broken or cracked)	3.37	1st
Machine downtime	2.70	2nd
Motion waste (unnecessary movement)	2.63	3rd
Material waste (cement and sand spillage)	2.20	4th
Waiting time (workers waiting for instruction or materials)	2.10	5th

Table 4.3: Types of Waste Observed in



4. 4 Average Waste Level

Interpretation: The results indicate that Defective blocks and Machine downtime were the most significant problems in the production process, aligning with common inefficiencies found in similar small-scale production environments.

4.5 Lean Tools Applied and Their Effectiveness

The study implemented and evaluated the effectiveness of selected lean tools 5S (Housekeeping), Kaizen, Layout Optimization, and Total Productive Maintenance (TPM

```
NEW FILE.
DATASET NAME DataSet4 WINDOW=FRONT.
DESCRIPTIVES VARIABLES=Five_S Kaizen Total_Productive_Maintenace Just_In_Time
  /STATISTICS=MEAN SUM STDDEV MIN MAX
  /SORT=MEAN (D).
```

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Sum	Mean	Std. Deviation
Five_S	30	2	5	122	4.07	1.112
Total_Productive_Maintenace	30	1	5	114	3.80	1.243
Kaizen	30	1	5	98	3.27	1.639
Just_In_Time	30	1	5	78	2.60	1.499
Valid N (listwise)	30					

4. 5 Lean Tools Applied in Block Industries

Lean tool	**Mean score**	**Remark**
5S (Workplace Organization)	4.07	Highly effective
Total Productive Maintenance (TPM)	3.80	Effective
Kaizen (continuous improvement)	3.27	Effective
Just in Time	2.60	Effective

Table 4.4: Effectiveness of Lean Tools in Waste Reduction

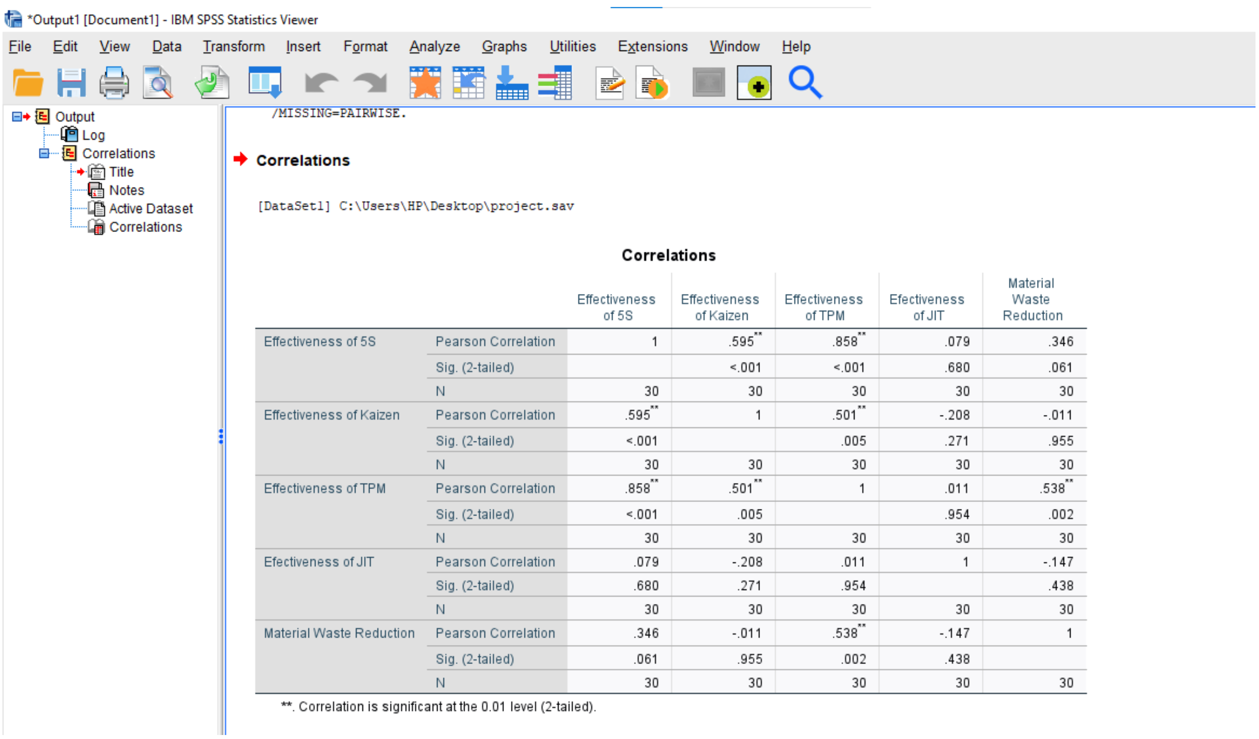
4. 6 Effectiveness of Lean Tools

Interpretation: The 5S system is the most applied lean tool, it is the most effective in waste reduction particularly in reducing motion and waiting waste. TPM and Kaizen also contributed significantly by improving workflow and minimizing downtime.

The findings clearly demonstrate a measurable improvement in production efficiency and waste reduction following lean implementation.

4.5.1. Correlation Analysis

To further examine the contribution of lean practices to organizational performance, correlation analysis was conducted to determine the relationships between 5S, JIT, and Kaizen, and two outcome variables: waste reduction and efficiency improvement. The Pearson correlation coefficients provide insights into whether higher adoption of lean practices is associated with reductions in waste or improvements in operational efficiency. The results of this analysis are presented in Figure 4.3 below.



Correlations

		Effectiveness of 5S	Effectiveness of Kaizen	Effectiveness of TPM	Efectiveness of JIT	Material Waste Reduction
Effectiveness of 5S	Pearson Correlation	1	.595**	.858**	.079	.346
	Sig. (2-tailed)		<.001	<.001	.680	.061
	N	30	30	30	30	30
Effectiveness of Kaizen	Pearson Correlation	.595**	1	.501**	-.208	-.011
	Sig. (2-tailed)	<.001		.005	.271	.955
	N	30	30	30	30	30
Effectiveness of TPM	Pearson Correlation	.858**	.501**	1	.011	.538**
	Sig. (2-tailed)	<.001	.005		.954	.002
	N	30	30	30	30	30
Efectiveness of JIT	Pearson Correlation	.079	-.208	.011	1	-.147
	Sig. (2-tailed)	.680	.271	.954		.438
	N	30	30	30	30	30
Material Waste Reduction	Pearson Correlation	.346	-.011	.538**	-.147	1
	Sig. (2-tailed)	.061	.955	.002	.438	
	N	30	30	30	30	30

**. Correlation is significant at the 0.01 level (2-tailed).

4. 7 Correlation

From figure 4.3, we can conclude that application of TPM correlated positively with waste reduction

($r = 0.538$), suggesting firms with stronger TPM programs reduced waste more effectively.

4.6 Inferential Analysis Using SPSS (One-Way ANOVA)

To test the hypothesis that "Lean manufacturing practices have a significant impact on waste reduction," the One-Way ANOVA test was applied using SPSS.

Hypothesis:

- **H_0**: There is no significant impact of lean Manufacturing practices on waste reduction in building block production firms.

- **H₁**: There is a significant impact of lean Manufacturing practices on waste reduction in building block production firms.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Material Waste Reduction	Between Groups	10.471	11	.952	1.279	.310
	Within Groups	13.395	18	.744		
	Total	23.867	29			
Productivity Improvement	Between Groups	14.833	11	1.348	5.239	.001
	Within Groups	4.633	18	.257		
	Total	19.467	29			
Motion Rduction	Between Groups	16.300	11	1.482	1.839	.121
	Within Groups	14.500	18	.806		
	Total	30.800	29			
Defective Block Reducton	Between Groups	11.143	11	1.013	7.846	<.001
	Within Groups	2.324	18	.129		
	Total	13.467	29			
Machine Downtime Reduction	Between Groups	18.571	11	1.688	4.407	.003
	Within Groups	6.895	18	.383		
	Total	25.467	29			

4. 8 Inferential Analysis

```
ONEWAY Total_Waste_Reduction BY Lean_Tools
  /MISSING ANALYSIS
  /CRITERIA=CILEVEL(0.95)
  /POSTHOC=TUKEY ALPHA(0.05).
```

Oneway

Warnings

Post hoc tests are not performed for Total_Waste_Reduction because at least one group has fewer than two cases.

ANOVA

Total_Waste_Reduction

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.096	11	.827	5.435	<.001
Within Groups	2.738	18	.152		
Total	11.835	29			

```
ONEWAY Lean_Tools BY Total_Waste_Reduction
  /MISSING ANALYSIS
  /CRITERIA=CILEVEL(0.95)
  /POSTHOC=TUKEY ALPHA(0.05).
```

4. 9 Lean Manufacturing Impact

The ANOVA table (Fig. 4.3) shows that the calculated F-value is 5.435 with a significance level (p-value) of $< .001$.

Since the significance value is less than 0.05, it indicates that there is a statistically significant difference in the mean waste reduction scores among the various Lean Manufacturing tools adopted by the building block companies.

Therefore, the null hypothesis (H_0) which states that "There is no significant impact of lean Manufacturing practices on waste reduction in building block production firms" is rejected, while the alternative hypothesis (H_1) which states that "There is a significant impact of lean Manufacturing practices on waste reduction in building block production firms" is accepted.

4.7 Discussion

The findings align strongly with prior studies and theoretical expectations:

- A majority of respondents actually practice lean manufacturing, but knowledge is not universal.
- 5S and Kaizen are the mostly widely used lean tools in building block industries but TPM is more efficient in reducing waste.
- Rain is the major cause of waste in building blocks and an uneven land can cause cracks in blocks.
- Firms applying lean practices reported notable improvement
- Employee engagement and workplace organization improved, fostering a stronger culture of teamwork and discipline.
- SPSS ANOVA results ($p<0.01$) confirmed that lean practices had a statistically significant effect on waste reduction ($p < 0.05$).
- The results are consistent with Ogunbiyi et al. (2018), who found that lean adoption

enhances operational performance in manufacturing.

The data collectively confirm that lean manufacturing is an effective strategy for reducing waste, increasing efficiency, and promoting a culture of continuous improvement in block production firms.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This research concludes that lean manufacturing practices play a vital role in reducing waste and enhancing efficiency in the Nigerian block production sector.

Although the level of awareness and adoption remains low, the findings clearly show that firms that have applied lean principles especially 5S and Kaizen which do not involved adaptation capital experienced better control over resources, improved product quality, and smoother workflow.

Lean manufacturing provides a sustainable approach to achieving productivity and cost-effectiveness in block production, especially in an economy like Nigeria's where resources are scarce and waste levels are high. For lean practices to be fully effective, there must be continuous training, awareness creation, and a strong commitment from management and operators alike.

The major findings of the study are summarized as follows:

1. Awareness of Lean Manufacturing:

More than half (about 95%) of the respondents were aware of the concept of lean manufacturing, although they do not fully understand all the tools and techniques involved.

2. Adoption of Lean Tools:

The lean tools that were mostly applied in the block production process included 5S (Sort, Set in order, Shine, Standardize, Sustain) and Kaizen (continuous improvement). More advanced tools such as Just-In-Time (JIT) and Kanban were rarely implemented due to lack of technical knowledge and infrastructural support.

3. Types of Waste Identified:

The most common types of waste in the block production process were defects, waiting time, over, and unnecessary motion. These wastes often resulted from bad whether condition, poor layout design, lack of maintenance, and low worker training.

4. Impact of Lean Practices:

The statistical analysis revealed a significant positive relationship between the application of lean practices and waste reduction. Firms that had adopted even basic lean tools reported reduced waste levels, improved efficiency, and better use of resources.

5. Challenges to Implementation:

The study identified challenges such as poor awareness, inadequate training, lack of technical expertise, limited financial resources, and resistance to change among workers as the main barriers to effective lean implementation.

6. Overall Outcome:

The research confirmed that adopting lean manufacturing practices, even at a basic level, can significantly minimize waste, enhance productivity, and improve product quality in block production industries.

5.6 Recommendations

Based on the findings of the study, the following recommendations are made:

1. Capacity Building and Training:

Government agencies, trade associations, and tertiary institutions should organize workshops and training sessions on lean principles to increase awareness and understanding among block manufacturers.

2. Gradual Implementation of Lean Tools:

Firms should begin with simple and cost-effective lean tools such as 5S and Kaizen, before advancing to more complex ones like Kanban and Just-In-Time.

3. Management Commitment:

Owners and managers of block production firms must show leadership commitment to lean adoption by setting clear policies, allocating resources, and rewarding continuous improvement efforts.

4. Process Monitoring and Evaluation: Firms should establish regular monitoring and evaluation systems to track performance, measure waste levels, and assess improvements resulting from lean practices.

5. Government and Institutional Support:

The government, through agencies such as the Standards Organization of Nigeria (SON) and the Industrial Training Fund (ITF), should promote lean manufacturing as part of national industrial development policy.

REFERENCES

Abdulmalek, F. A., & Rajgopal, J. (2007). Analyzing the benefits of lean manufacturing and value stream mapping via simulation: A process sector case study. International Journal of Production Economics, 107(1), 223-236.

Adebisi, T. O. (2019). Applying 5S methodology in small and medium enterprises in Nigeria. African Journal of Industrial Engineering, 6(2), 55–66.

Ahuja, I. P. S., & Khamba, J. S. (2008). Total productive maintenance: Literature review and directions. International Journal of Quality & Reliability Management, 25(7), 709–756.

Akinwale, Y. O., & Adegbuyi, A. O. (2019). Lean manufacturing adoption in developing countries: A study of Nigerian manufacturing firms. Journal of Manufacturing Technology Management, 30(5), 880-897

Alhassan, K., Musa, B., & Abdullahi, M. (2021). Improving equipment reliability through total productive maintenance in small manufacturing plants. Journal of Engineering Research and Technology, 9(3), 102–110.

Antony, J. (2006). Six Sigma for service processes. Business Process Management Journal, 12(2), 234-248

Ballard, G., et al. (2003). Lean project delivery system. Journal of Construction Engineering and Management, 129(6), 667–675.

Barney, J. (1991). Firm resources and sustained competitive advantage. Journal of Management, 17(1), 99–120.

Bhamu, J., & Sangwan, K. S. (2014). Lean manufacturing: Literature review and research issues. International Journal of Operations & Production Management, 34(7), 876–940.

Bhamu, J., & Singh Sangwan, K. (2014). Lean manufacturing: Literature review and research issues. International Journal of Operations & Production Management, 34(7), 876-940.

Bryman, A., & Bell, E. (2015). Business research methods (4th ed.). Oxford University Press.

Chase, R. B., Jacobs, F. R., & Aquilano, N. J. (2010). Operations management for competitive advantage (12th ed.). McGraw-Hill/Irwin

Corbett, C. J. (2011). Lean and Six Sigma: The same or different? Quality Management Journal, 18(2), 7-20

Creswell, J. W. (2014). Research design: Qualitative, quantitative, and mixed methods approaches (4th ed.). SAGE Publications.

Essential Lean Management Tools for Manufactures, published January 24, 2024.

Goldratt, E. M. (1984). The Goal: A Process of Ongoing Improvement. North River Press.

Hines, P., & Rich, N. (1997). The seven value stream mapping tools. International Journal of Operations & Production Management, 17(1), 46–64.

Hines, P., Found, P., Griffiths, G., & Harrison, R. (2011). Staying lean: Thriving, not just surviving. CRC Press.

Hines, P., Holweg, M., & Rich, N. (2004). Learning to evolve: A review of contemporary lean thinking. International Journal of Operations & Production Management, 24(10), 994–1011.

Ho, S. K. M. (1999). 5S practice: The first step towards total quality management. Total Quality Management, 10(3), 345-356

Imai, M. (1997). Gemba Kaizen: A commonsense, low-cost approach to management.

Kamau, J. (2019). Lean manufacturing in Kenyan SMEs. African Journal of Business Management, 13(2), 45–53.

Kothari, C. R. (2004). Research methodology: Methods and techniques (2nd ed.). New Age International Publishers.

Liker, J. K. (2004). The Toyota way: 14 management principles from the world's greatest manufacturer. McGraw-Hill.

Nnaji, C., & Ibekwe, P. (2021). Application of lean tools in small-scale construction material firms in Nigeria. Journal of Sustainable Industrial Practices, 4(2), 27–35.

Ogunbiyi, O., et al. (2014). Sustainable construction practices in Nigeria. Journal of Environmental Management, 15(3), 12–20.

Ogunbiyi, O., Oladapo, A., & Goulding, J. (2018). Lean construction and sustainability: Complementary paradigms for improved productivity in the Nigerian cement industry. Built Environment Project and Asset Management, 8(1), 79–94.

Ohno, T. (1988). Toyota Production System: Beyond Large-Scale . Productivity Press.

Olayinka, D., & Ajayi, K. (2020). Kaizen implementation and productivity improvement in furniture manufacturing SMEs. Nigerian Journal of Industrial Technology, 14(1), 33–45.

Saunders, M., Lewis, P., & Thornhill, A. (2019). Research methods for business students (8th ed.). Pearson Education Limited.

Saurin, T. A., Ribeiro, J. L. D., & Marodin, G. A. (2010). Identifying potential mistakes in a product development process: An application of Poka-Yoke. Quality and Reliability Engineering International, 26(3), 327-339.

Shah, R., & Ward, P. T. (2003). Lean manufacturing: Context, practice bundles, and performance. Journal of Operations Management, 21(2), 129–149.

Sharma, R. K., & Kodali, R. (2008). Development of a framework for manufacturing excellence.

Taiichi, O. (1997). Toyota Production System: Beyond Large-Scale . CRC Press.

Womack, J. P., & Jones, D. T. (2003). Lean thinking: Banish waste and create wealth in your corporation. Free Press.

Womack, J. P., & Jones, D. T. (2003). Lean thinking: Value, streams, flow, pull and perfection. Productivity Press.

Womack, J. P., Jones, D. T., & Roos, D. (1990). The machine that changed the world. RawsonBhuiyan, N., & Baghel, A. (2005). An overview of continuous improvement: From the past to the present. Management Decision, 43(5), 761-771

Yin, R. K. (2018). Case study research and applications: Design and methods (6th ed.). SAGE Publication.