

FABRICATAION OF A SINGLE STANDARD METAL DOOR

BY

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**A PROJECT REPORT SUBMITTED TO THE
DEPARTMENT OF MECHANICAL ENGINEERING TECHNOLOGY,
FEDERAL POLYTECHNIC, MUBI
ADAMAWA STATE**

AUGUST, 2025

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REQUIREMENTS FOR THE AWARD OF NATIONAL DIPLOMA/HIGHIER
NATIONAL DIPLOMA IN MECHANICAL ENGINEERING TECHNOLOGY**

AUGUST, 2025

DECLARATION

We hereby declare that this project report was written by us and it is a record of our own research work. It has not been submitted to or accepted in any institution of higher learning for the award of any certificate. All sources of information have been duly acknowledged by means of references.

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CERTIFICATION

This is to certify that We MONKOM ANTHONY (ET/ME/ND/012) and VINCENT NATHAN (ET/ME/ND/013) Carried out the project work presented in this report during 2024/2025 academic session.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Project

The fabrication of metal doors has become an essential component of modern construction and building security. With increasing urbanization and the rising demand for affordable yet durable building materials, metal doors are gradually replacing traditional wooden alternatives in both residential and commercial structures. Unlike wooden doors, which are vulnerable to termite infestation, warping, and fire hazards, metal doors especially those made from mild steel offer greater resistance to environmental factors, mechanical stress, and forced entry (Afolabi *et al.*, 2022). Their long service life, low maintenance requirements, and ease of customization make them a preferred choice in Nigeria's construction sector.

In developing countries like Nigeria, the transition from traditional carpentry to metal fabrication has also been influenced by the declining availability of timber and rising environmental concerns about deforestation. Consequently, there is an increasing interest in utilizing recyclable and locally sourced metallic materials for structural and architectural components (Nwachukwu & Eze, 2023). As a result, vocational and tertiary institutions have placed greater emphasis on practical training in metalwork, including the design and fabrication of doors, gates, and window frames, which are crucial in promoting self-reliance and technical innovation among students.

Moreover, the Nigerian building materials industry continues to experience rapid growth, with significant contributions from small and medium-scale enterprises (SMEs) that specialize in metal fabrication. These SMEs play a critical role in bridging the housing and infrastructure gap, especially in semi-urban and rural areas (Ogunbiyi *et al.*, 2023). However, many fabricators still operate without standardized procedures, leading to inconsistent product quality. This project,

therefore, aims to explore and document the process of fabricating a single standard metal door using best practices that comply with engineering design and safety principles. It also seeks to demonstrate how technical education can drive industrial growth through practical skill development and innovation.

Doors have been a fundamental part of human architecture and shelter for centuries, serving both functional and symbolic purposes. In today's context, they are vital not only for granting access and ensuring privacy but also for offering security, insulation, and aesthetic value. Among the many types of doors in modern construction, metal doors have gained significant prominence, particularly in Nigeria, due to their durability, strength, resistance to fire, and cost-effectiveness. With increasing concerns about burglary, termite damage to wooden doors, and fire hazards in residential and commercial buildings, the shift from wooden to metal doors has become a common trend. This has increased the demand for high-quality metal door fabrication. Metal doors, typically made from mild steel, stainless steel, or galvanized iron, are designed to withstand harsh weather conditions, physical force, and corrosion (Ogunbiyi *et al.*, 2021).

This project focuses on the fabrication of a single standard metal door, taking into account the basic principles of engineering, design, material selection, and fabrication processes. The purpose is to produce a standard-sized door commonly used in residential buildings that meets specifications for strength, functionality, and aesthetic value using locally sourced materials.

The importance of this project also lies in its relevance to technical and vocational education. As fabrication plays a critical role in mechanical and construction engineering, this project will help build practical experience in welding, measurement, cutting, assembling, and finishing processes involved in metalwork. In addition, it seeks to highlight how local materials can be efficiently used to produce quality components that meet both local and international standards.

1.2 Statement of the Problem

The construction industry in Nigeria continues to face several challenges regarding the quality and consistency of fabricated single standard metal doors. A significant portion of locally fabricated metal doors often lacks standardization in terms of dimension, welding quality, alignment, and finishing. These inconsistencies are mostly due to: Lack of adherence to engineering standards, Poor material selection, Inadequate knowledge and skills among fabricators, Use of outdated or manual tools, Minimal or no quality control measures.

Additionally, some fabricated metal doors fail prematurely due to poor corrosion protection, improper installation of hinges and locks, and incorrect door frame alignment. These issues lead to functional defects, such as difficulty in closing or locking the door, noise during movement, and quick deterioration due to rust or mechanical damage.

There is, therefore, a need to develop a comprehensive fabrication approach that follows standard guidelines for producing reliable and durable metal doors. This project is designed to serve as a benchmark in addressing these deficiencies by providing a step-by-step documentation of the fabrication of a standard metal door, from concept to completion.

1.3 Aim and Objectives of the Project

Aim:

To fabricate a standard single metal door that meets structural, functional, and aesthetic requirements using cost-effective and locally available materials.

Objectives:

To achieve the aim of this project, the following objectives have been outlined:

- i. To study the standard design specifications and dimensions for single metal doors.
- ii. To select suitable materials (such as mild steel, square pipes, and door accessories) required for fabrication.
- iii. To perform accurate measurement and cutting of materials based on the standard door dimensions.

- iv. To apply surface finishing techniques such as grinding, sanding, and painting to enhance appearance and durability.
- v. To test and evaluate the fabricated door based on quality, alignment, and ease of use.

1.4 Significance of the Project

The significance of this project lies in both its academic and practical relevance. The benefits include:

The significance of this project is deeply rooted in its ability to bridge the gap between theoretical learning and practical application. It provides engineering and technology students with valuable hands-on experience in metal fabrication processes such as welding, cutting, grinding, and assembling. This hands-on exposure not only enhances technical competence but also strengthens students' understanding of workshop safety protocols and the practical use of engineering tools critical components of vocational and industrial training.

Beyond education, the project promotes the standardization of door fabrication practices in local workshops. By adhering to recognized industry guidelines, the project contributes to improving the quality and consistency of metal doors produced within the local market. It also emphasizes the use of locally sourced materials, encouraging cost-effective production and reducing dependence on imported alternatives. This aligns with Nigeria's broader goals of promoting indigenous industrial development and resource sustainability.

Furthermore, the project supports innovation and entrepreneurship by equipping students with marketable skills that can lead to self-employment opportunities in the metalworks sector. As a comprehensive documentation of the fabrication process, it serves as a useful reference for future research and development in the field of metal construction and security product design. The knowledge generated can inform improved product designs and help stimulate growth in the small-scale fabrication industry.

1.5 Scope and Limitations of the Project

This project focuses on the fabrication of a single standard metal door using mild steel as the primary material. It covers the entire fabrication process, including: Planning and designing the door to meet standard residential specifications, Material selection and measurement, Cutting and joining using welding techniques, Surface preparation and finishing, Installation of accessories such as hinges and locks, Final inspection and testing for quality assurance.

The project will utilize manual fabrication techniques with basic workshop tools and machinery available within a school or local workshop environment.

Limitations:

Technological Constraints: Due to the unavailability of advanced equipment like CNC machines or laser cutters, the project is limited to manual operations.

Material Availability: The project relies on materials available locally, which may not represent the full range of modern door-making materials.

Time Constraint: The project duration limits the exploration of advanced finishing methods like powder coating or electroplating.

Scope Restriction: The project does not cover double doors, sliding doors, or automated door systems, focusing solely on a manually operated single leaf door.

1.6 Definition of Terms

Fabrication: The process of manufacturing products by cutting, bending, and assembling raw materials, especially metals.

Metal Door: A door primarily made from metallic materials like mild steel or iron, designed to provide strength and security.

Mild Steel: A type of carbon steel with low carbon content, widely used in construction and fabrication due to its malleability and weldability.

Welding: A fabrication technique that joins metal parts by melting and fusing them together, usually using a filler material.

Grinding: A process used to smooth metal surfaces and remove excess welds or imperfections.

Corrosion: The gradual deterioration of metal as a result of chemical reactions with environmental elements like oxygen and moisture.

Standard Door: A door fabricated according to generally accepted dimensions, usually 900mm by 2100mm for residential applications.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of the Project

The use of doors as architectural elements dates back to ancient civilizations, where they symbolized protection, privacy, and authority. Early doors were predominantly made of wood and were often reinforced with leather or bronze, especially in regions like Mesopotamia and Ancient Egypt (Evershed *et al.*, 2020). As metallurgy evolved, iron and later steel began to replace wood in areas requiring higher strength and durability. This transition was driven by the need for enhanced security and resistance to environmental factors such as humidity, fire, and pests.

In the Nigerian context, the demand for metal doors has significantly increased due to rapid urbanization, insecurity challenges, and the scarcity of quality timber (Oluwafemi & Bakare, 2022). Fabricators began incorporating mild steel and galvanized iron into standard doors for residential and commercial use, creating a burgeoning industry of local workshops. These doors became favored not only for their strength but also for their customizable design, relatively low production costs, and longevity. Government policies promoting local content in building materials and the increased integration of technical and vocational training in tertiary institutions have further accelerated interest in indigenous fabrication technologies (Nwachukwu & Eze, 2023).

2.2 Process Principle

The fabrication of a standard metal door is a structured and multi-phase operation that incorporates fundamental principles of mechanical engineering, manufacturing technology, and materials science. The process involves a sequence of carefully executed steps, beginning from conceptual design to final quality assurance, each requiring precision, standard compliance, and safety adherence. Key stages include: material selection, dimensioning and marking, cutting, welding, grinding, surface treatment, assembly, accessory installation, and final inspection.

2.2.1 Material Selection

The choice of materials is foundational to the success of the fabrication process. For standard residential or commercial metal doors, mild steel is typically used due to its excellent mechanical properties such as tensile strength (370–460 MPa), malleability, affordability, ease of welding, and widespread availability in Nigeria (Ogunbiyi *et al.*, 2021). Structural members such as the door frame and panel skeleton are generally constructed from square hollow sections (SHS) commonly 25 mm × 25 mm × 1.5 mm or 30 mm × 30 mm × 2 mm—while flat sheets of 1.0 mm to 1.5 mm thickness are used for the door face. Accessories like hinges, lock bodies, handles, and fasteners are selected based on mechanical compatibility and durability.

2.2.2 Measurement and Marking

Accuracy in measurement and layout marking directly determines the structural and functional performance of the finished product. This process utilizes tools such as steel tape, combination square, scribe, and chalk lines to ensure precise layout based on standard door sizes usually 900 mm in width and 2100 mm in height for residential doors. Tolerances must be considered for door clearance, frame fitment, and allowance for hinges and lock recesses. Misalignment at this stage can result in binding doors, improper sealing, or security compromises.

2.2.3 Cutting Operations

The cutting phase involves sizing materials according to the marked dimensions. Common tools include angle grinders, power shears, hacksaws, and plasma cutters. Manual cutting, although economical, may produce less uniform edges, requiring additional finishing. For higher accuracy and production scalability, CNC plasma or laser cutting is preferred in industrial settings. Precision in cutting ensures tight joints, material optimization, and ease of assembly during welding.

2.2.4 Welding and Assembly

Welding joins the structural members to form the frame and skeletal support of the door. Techniques such as Shielded Metal Arc Welding (SMAW) and Gas Metal Arc Welding (GMAW/MIG) are used based on material thickness and power availability. SMAW is widely used in Nigeria due to its adaptability and low cost, though GMAW is cleaner and faster. Weld parameters including current, voltage, travel speed, and electrode selection—must be optimized to avoid defects like porosity, undercuts, or weak penetration (Ali *et al.*, 2021). Proper joint design (e.g., butt, lap, or corner joints) and tack welding ensure dimensional integrity during full welding. Once welding is complete, the door frame and leaf are assembled. It is important to maintain squareness and perpendicularity during assembly to prevent misalignment, warping, and difficulty in opening or closing the door. Diagonal measurements are often used to verify rectangular geometry.

2.2.5 Grinding and Surface Finishing

Grinding serves multiple purposes: it removes excess weld beads, burrs, and sharp edges that may compromise safety or aesthetics. Angle grinders fitted with abrasive discs are used to smoothen weld seams, followed by finer polishing where required. Surface preparation is critical before any painting operation. The surface is typically cleaned with degreasers or sandpapering, then coated with anti-corrosive primers, followed by enamel or synthetic paints for aesthetic appeal and weather protection (Afolabi *et al.*, 2022).

2.2.6 Accessory Installation

Upon completion of the structural and finishing work, hardware components such as hinges, locks, strike plates, and handles are installed. Precision is essential in hinge placement to ensure smooth operation and weight distribution. Lock and handle positions must align with standard heights (usually ~1000 mm from the floor), and recesses may be created with chisels or grinders to ensure a flush fit. For doors intended for high-security use, reinforced lock housings or multi-point locking systems may be installed.

2.2.7 Inspection and Quality Assurance

Before commissioning, the door undergoes rigorous quality checks to ensure structural soundness, proper alignment, smooth operation, and surface finish integrity. Inspection criteria include:

- i. Door squareness (measured via diagonal length comparison),
- ii. Smoothness and integrity of welds (visual and non-destructive testing),
- iii. Paint adhesion and uniformity,
- iv. Lock and hinge operation without resistance,
- v. Fit and sealing when closed.

2.3 Theoretical Consideration

The fabrication of a standard metal door is grounded in several interrelated engineering theories and scientific principles that collectively ensure structural integrity, functional reliability, and product durability. These include the mechanics of materials, welding metallurgy and thermodynamics, corrosion science, manufacturing process theory, and aesthetic/ergonomic design principles. Understanding and applying these theoretical foundations are essential not only for achieving an optimal product but also for maintaining efficiency, safety, and quality throughout the fabrication process.

2.3.1 Mechanics of Materials

Mechanics of materials provides the foundation for understanding how different materials respond to applied forces, deformations, and environmental influences. Concepts such as stress, strain, modulus of elasticity, yield strength, bending moment, torsion, and deflection are crucial in the selection and structural design of door components. The door must withstand both static loads (its own weight) and dynamic forces (impact, usage pressure, wind load). Mild steel is typically selected because of its tensile strength ranging from 370 to 460 MPa, modulus of elasticity (~200 GPa), and high ductility, which allows it to deform without fracturing under load (Saeed et al., 2020). The door frame and leaf must be designed to resist bending, warping, or buckling when installed or subjected to environmental stresses.

Additionally, moment of inertia and cross-sectional analysis are applied when designing the square hollow sections (SHS) used for the door frame. A larger moment of inertia in vertical members helps resist buckling and sagging, especially when the door is subjected to frequent opening and closing. These analyses guide decisions on frame thickness and material grade.

2.3.2 Welding Theory and Thermodynamics

Welding is both a mechanical and a thermal process governed by principles of fusion metallurgy, heat transfer, and material transformation. Welding theory explains how base metals and filler metals are fused by the application of controlled heat, forming a metallurgical bond. Key parameters—such as arc temperature, voltage, current, electrode material, and welding speed—must be optimized to achieve strong, defect-free welds. Excessive heat can alter the heat-affected zone (HAZ), making it brittle and prone to cracking, while insufficient heat may result in poor fusion (Kumar & Gupta, 2021).

Shielded Metal Arc Welding (SMAW) and Gas Metal Arc Welding (GMAW) processes, commonly used in door fabrication, must consider thermal conductivity, melting temperature, and metal thickness to ensure uniform weld penetration. Preheating thick sections can reduce thermal gradients, preventing the formation of residual stress and distortion. Post-weld cooling must also be gradual to avoid hardening and micro-crack formation. Theoretical models such as the Rosenthal Equation are used in advanced settings to predict temperature distribution and optimize weld bead profiles.

2.3.3 Corrosion Science

One of the critical theoretical areas in metal door fabrication—especially for external applications is corrosion science. Steel, when exposed to environmental elements like oxygen and moisture, undergoes electrochemical oxidation, leading to the formation of rust ($\text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O}$), which compromises the mechanical properties and appearance of the door over time. Corrosion is governed by factors such as relative humidity, temperature, pH, salinity, and exposure duration (Afolabi *et al.*, 2022).

Theoretical approaches to combat corrosion include barrier protection (paints and coatings), cathodic protection, and material selection (e.g., using galvanized or stainless steel). Paint systems act as a physical barrier between the steel surface and the corrosive environment. The door's life span can be extended by applying a zinc-rich primer followed by synthetic enamel paint or powder coating, which resists both moisture and UV degradation. Galvanic series theory also informs the selection of fasteners and fittings to prevent galvanic corrosion, especially where dissimilar metals are in contact.

2.3.4 Manufacturing Process Theory

The process of cutting, shaping, and assembling components in metal door fabrication is supported by the theories of manufacturing process optimization, material removal mechanisms, and tolerance analysis. Cutting operations, whether manual or mechanized, are governed by chip formation mechanics, thermal dissipation, and tool-material interactions. Inaccurate cutting may lead to dimensional deviations that affect alignment and function.

Assembly theory involves geometric dimensioning and tolerancing (GD&T) to ensure that parts fit together correctly. Tolerance stack-up must be accounted for to maintain proper clearances between door leaf and frame, especially when accounting for thermal expansion or wall irregularities during installation. Lean manufacturing principles may also be considered to reduce waste and optimize material usage.

2.3.5 Design Theory and Ergonomics

In addition to functional and structural considerations, door fabrication must also align with the principles of aesthetic design and human factors (ergonomics). The door should blend with architectural styles while ensuring user comfort, safety, and accessibility. Theories of proportionality, symmetry, color coordination, and texture finishing influence surface design and overall appearance. Ergonomics informs the optimal positioning of handles and locks (typically at a height of 1000 mm), ease of door operation, and resistance required for opening or closing.

Design considerations also extend to sound insulation, thermal conductivity, and impact resistance especially for doors used in residential or institutional settings. Aesthetic modifications such as embossed panels, glass inserts, or ornamental designs are applied without compromising structural performance.

2.4 Classification of the Door to be Designed

Metal doors are broadly categorized based on several criteria, including their operation mode, application area, material composition, and construction style. Each classification offers distinct functional and aesthetic benefits that influence the choice of door type for specific projects.

Firstly, in terms of operation mode, metal doors can be either *manual* or *automated*. Manual doors are operated by direct physical force, relying on the user to open or close them. They are cost-effective, simple in design, and commonly found in residential settings or low-traffic areas (Umar *et al.*, 2022). In contrast, automated doors integrate electromechanical components such as sensors, motors, and controllers to enable remote or motion-sensor-based access. These are frequently used in commercial environments, hospitals, and modern homes, where accessibility and convenience are critical (Ibrahim *et al.*, 2021). When classified by application, metal doors are either residential or commercial/industrial. *Residential doors* are generally lighter in structure, tailored for domestic aesthetics, and prioritize security and visual appeal. They are often fitted with decorative finishes, glass inserts, or customized paneling (Olaniyan & Ogunlade, 2020). On the other hand, *commercial and industrial doors* are constructed with durability and security in mind. These doors are usually thicker, reinforced to handle high-frequency usage, and often include additional features such as fire resistance, sound insulation, or impact protection for factory or warehouse installations (Ajayi & Okoro, 2021).

From a material perspective, several options exist depending on cost, environmental exposure, and required durability. *Mild steel* is the most widely used material due to its affordability, mechanical strength, and ease of fabrication. It is suitable for general-purpose doors

where cost and structural integrity are priorities (Saeed et al., 2020). *Stainless steel doors*, although more expensive, are chosen for their high corrosion resistance and are typically used in hospitals, laboratories, or luxury buildings (Ezeokoli *et al.*, 2022). Meanwhile, *galvanized iron doors* are made from steel coated with a layer of zinc, offering enhanced resistance to rust, especially in coastal or humid environments (Afolabi *et al.*, 2022).

In terms of construction, metal doors can be *single leaf*, *double leaf*, *panel*, or *flush*. *Single leaf doors* comprise one movable section and are common in domestic settings due to their simplicity and compact size. *Double leaf doors* have two independent panels, making them suitable for wide entry points such as warehouses or event halls (Abubakar & Musa, 2021). *Panel doors* include raised or recessed sections that enhance their decorative value, whereas *flush doors* feature flat, plain surfaces that align with contemporary minimalist architecture.

For this project, the selected design is a manual single leaf mild steel door, primarily intended for residential use. This choice is guided by the need for cost efficiency, ease of fabrication, and structural reliability. The door will incorporate a straightforward aesthetic with basic anti-rust treatment to ensure longevity, making it suitable for low to moderate environmental exposure. The selection aligns with recommendations in recent studies emphasizing the practicality and adaptability of mild steel in small-scale construction and household applications (Umar *et al.*, 2022; Afolabi *et al.*, 2022).

2.5 Other Areas Reviewed

2.5.1 Safety Considerations in Fabrication

Safety remains a top priority in fabrication workshops. Hazards such as burns, electric shocks, metal splinters, and toxic fumes from welding processes are common. Therefore, the use of Personal Protective Equipment (PPE) such as gloves, welding goggles, aprons, and ear protection is mandatory (Olayinka & Abiodun, 2022). Additionally, workshop safety protocols,

equipment handling guidelines, and first aid availability must be emphasized throughout the fabrication process.

2.5.2 Environmental and Economic Impact

The use of locally sourced materials not only reduces the environmental footprint but also boosts the local economy. Steel is recyclable, and using scrap or reclaimed materials in fabrication can lower production costs while supporting environmental sustainability. Encouraging small-scale local fabrication can generate employment and reduce the importation of foreign doors, keeping wealth within the country (Idris & Aremu, 2023).

2.5.3 Quality Assurance and Testing

Ensuring product quality involves dimensional checks, weld integrity testing (visual and non-destructive), and operability assessment. Doors must align properly within frames, open and close without resistance, and withstand mechanical load without deformation. Coating adhesion, color uniformity, and resistance to rust also form part of post-fabrication quality checks (Kazeem *et al.*, 2022).

2.6 Conclusion from the Literature Review

The literature reviewed highlights the growing importance of metal doors in modern construction due to their strength, durability, and security benefits. The fabrication process involves a combination of theoretical knowledge and practical skills, particularly in material selection, welding, and finishing. Advances in fabrication techniques and safety practices have made it possible to produce high-quality doors at relatively low costs using local resources.

There is a strong case for standardization and quality control in metal door fabrication, especially in developing economies like Nigeria. Incorporating modern engineering practices and safety protocols can bridge the gap between local craftsmanship and global quality standards. Furthermore, the review establishes a foundation for this project by justifying the choice of materials, processes, and classification of the door type to be fabricated.

CHAPTER THREE

DESIGN ANALYSIS AND CALCULATIONS

3.1 Mode of Operation of the Door

The fabrication of a metal door relies primarily on manually operated and semi-automated machines and tools. The process begins with precise measurement and marking on mild steel sheets and square hollow sections (SHS). These materials are then cut to specified dimensions using either a power-driven cutting machine (angle grinder or plasma cutter) or a hand tool like a hacksaw.

Once the components are prepared, welding operations are performed using Shielded Metal Arc Welding (SMAW) or Gas Metal Arc Welding (GMAW) machines. The SMAW machine converts electrical energy into thermal energy to fuse the metal components. After welding, the assembly undergoes grinding to smoothen the joints and edges. A coating machine (or manually applied brush/spray) is used to apply primer and enamel paint. Drilling and fixing operations follow to install locks, hinges, and handles. The final product is inspected for dimensional accuracy, alignment, and surface quality.

3.2 Design Procedure of the Door

The design procedure for fabricating a metal door includes several sequential steps to ensure mechanical integrity, aesthetic appeal, and operational functionality:

- i. **Requirement Analysis:** Identify customer requirements in terms of door size, strength, and aesthetic appeal.
- ii. **Material Selection:** Choose materials based on mechanical properties, cost, and environmental resistance.
- iii. **Dimensioning and Drafting:** Use technical drawings (manual or CAD) to create design layouts with accurate dimensions and tolerances.
- iv. **Cutting and Component Preparation:** Cut SHS and metal sheets according to the design layout.

- v. **Joining (Welding):** Weld the cut components to form the frame, panel, and reinforcements.
- vi. **Grinding and Surface Preparation:** Smooth all edges and weld joints.
- vii. **Finishing:** Apply anti-corrosive paint to enhance lifespan and appearance.
- viii. **Assembly and Testing:** Install locks, hinges, and other fittings; check for fit, finish, and function.

3.3 Design Calculations

To ensure structural integrity, durability, and appropriate material usage, several design calculations were performed for the selected mild steel single-leaf residential door. The door was designed for manual operation and constructed using standard rectangular hollow section (RHS) steel frames and 3 mm thick mild steel sheet for the panel.

a) Frame Load-Bearing Capacity

The door frame is fabricated using mild steel square hollow sections (SHS) of size 34 mm × 34 mm × 2 mm thickness. To determine the maximum axial load the frame can safely support, we used the formula:

$$P = \sigma \times A$$

Where:

P = Load-bearing capacity (N)

σ = Allowable tensile stress = 250 MPa (after applying safety factor)

A = Total cross-sectional area of the steel (m²)

For SHS (34 mm × 34 mm × 2 mm), the wall area is calculated as:

$$\begin{aligned} A &= 4 \times (34 \text{ mm} \times 2 \text{ mm}) = 272 \text{ mm}^2 \\ &= 2.72 \times 10^{-4} \text{ m}^2 \end{aligned}$$

Thus:

$$\begin{aligned} P &= 250 \times 10^6 \times 2.72 \times 10^{-4} = 68,000 \text{ N} \\ &= 68 \text{ kN} \end{aligned}$$

This value indicates that the frame can safely withstand a maximum axial load of 68 kN, which is adequate for residential door applications considering typical usage scenarios.

b) Welding Current Setting

Welding of the door parts was performed using Shielded Metal Arc Welding (SMAW). For welding mild steel plates with a thickness of 3 mm, the recommended electrode diameter is 3.2 mm, and the current setting is calculated using the rule of thumb:

$$I = d \times 34$$

$$I = 2.72 \times 34$$

$$I = 92.48 \text{ Amperes}$$

Therefore, the suitable current setting for welding this door is approximately 100 – 120 A, which ensures sufficient penetration without burning through the plate.

c) Paint Quantity Estimation

The total paint required was estimated based on the surface area of the door. A standard single-leaf residential steel door has dimensions of 765 mm (0.9 m) width and 1983 mm (2.1 m) height. Thus, the surface area of one side is:

$$A = 0.765 \text{ m} \times 2.07 \text{ m} = 1.58 \text{ m}^2$$

Since both sides of the door will be painted:

$$\text{Total Surface Area} = 1.58 \times 2 = 3.17 \text{ m}^2$$

Assuming the coverage rate of the selected enamel paint is 10 m² per litre, the amount of paint required is:

Paint Required

$$= \frac{3.17}{10} = 0.317 \text{ litres}$$

To accommodate minor wastage and double coating, it is practical to round this value to **0.5 litres** per door. These calculations provided a foundational guide to selecting materials, ensuring safety, and optimizing construction costs for the residential mild steel door.

3.4 Materials Selection

The materials were selected based on mechanical properties, cost-effectiveness, and corrosion resistance. The primary materials include:

Component	Material	Reason for Selection
Door Frame	Mild Steel SHS	Strong, durable, easy to weld and fabricate
Door Panel	Mild Steel Sheet	Readily available, flat surface, suitable for painting
Hinges & Lock Assembly	Stainless Steel	Corrosion resistance, strength under mechanical wear
Paint	Enamel + Primer	Aesthetic appearance and protection against rust

All materials conform to local engineering standards and availability in Mubi markets.

3.5 Design Specifications

Below are the key specifications of the fabricated metal door:

Specification	Value/Details
Overall Door Dimension	765 mm × 1983 mm
Frame Material	SHS 34 mm × 34 mm × 2 mm
Panel Material	Mild steel sheet, 1.5 mm thick
Welding Method	SMAW (Shielded Metal Arc Welding)
Finishing	Primer + Two coats of enamel paint
Accessories	Two hinges, deadbolt lock, handle
Weight (Estimated)	~35–40 kg
Load Bearing Capacity	Up to 68 kN

CHAPTER FOUR

CONSTRUCTION

4.1 Construction of the Component Parts of the Door

The fabrication of the single standard metal door was carried out in stages to ensure accuracy, durability, and adherence to standard engineering principles. The process began with the preparation of materials, including mild steel square hollow sections (SHS) for the frame and mild steel sheets for the door panel. The key component parts constructed were:

4.1.1 Door Frame

The frame was fabricated using SHS of size 34 mm × 34 mm × 2 mm thickness. The members were cut to the specified lengths (two vertical members of 1983 mm and two horizontal members of 765 mm) using an angle grinder. The ends were cut square to ensure perfect joints during welding.

4.1.2 Door Panel

A mild steel sheet of 1.5 mm thickness was measured and cut to fit the inner dimensions of the frame. The sheet was trimmed to avoid overhang and to maintain a neat appearance after assembly.

4.1.3 Reinforcements

Additional horizontal and vertical braces were cut from the SHS to reinforce the door structure, especially around the locking area and hinge positions, to prevent deformation during use.

4.1.4 Accessories

Stainless steel hinges, a deadbolt lock, and a handle were selected for installation. Holes for accessories were marked and drilled prior to assembly to ensure correct alignment.

4.2 Assembly of the Parts

The assembly process involved the following steps:

4.2.1 Frame Welding

The cut SHS members were arranged on a flat surface and tack-welded at the corners to maintain alignment. Full welding using Shielded Metal Arc Welding (SMAW) was carried out, ensuring adequate penetration without burn-through.

4.2.2 Panel Installation

The mild steel sheet was placed inside the frame and welded along the edges. Continuous welding beads were applied to enhance strength and reduce vibrations.

4.2.3 Reinforcement Welding

Bracing members were welded at strategic points to strengthen the door.

4.2.4 Fitting of Accessories

The hinges were welded on one vertical side of the frame, while the lock and handle were fixed on the opposite side. Holes for the lock mechanism were drilled, and all fittings were checked for operational smoothness.

4.3 Finishing

The finishing stage was critical for both appearance and protection:

Grinding – Weld joints were ground smooth using an angle grinder to eliminate sharp edges and improve aesthetics.

Surface Preparation – The door was cleaned to remove dust, oil, and welding slag.

Painting – A primer coat was applied to protect against corrosion, followed by two coats of enamel paint for aesthetic appeal and durability.

4.4 Cost Analysis

Item	Quantity	Unit Price (₦)	Total Cost (₦)
Design plate	1	11,500	11,500
Body filler	¼	3,000	3,000
Lock	1	5,000	5,000
Hinges (Stainless Steel)	2	350	700
Paint	1	4,000	4,000
Mild Steel SHS (34×34 mm)	1 length	7,000	7,000
Square pipe (1.5mm x 3 mm)	1 length	11,500	11,500
Emirate cloth	1	1,000	1,000
Welding Electrodes	¼	2,500	2,500
Grinding stone	1	2,000	2,000
Cutting stone	1	1,500	1,500
Square pipe (12.7 mm x 12.7 mm)	1	4,000	4,000
Total			₦53,700

4.5 Maintenance Procedure

- i. Regular cleaning with a damp cloth to remove dust and debris.
- ii. Periodic lubrication of hinges and locks to prevent squeaking and wear.
- iii. Inspection for rust spots, with immediate touch-up painting if necessary.
- iv. Tightening of hinge screws and lock mechanisms when loosened.
- v. Avoiding excessive force during operation to prolong lifespan.

CHAPTER FIVE

TESTING, RESULTS AND DISCUSSION

5.1 Testing Procedure

The fabricated metal door was tested to ensure compliance with design specifications. The tests conducted included:

Dimensional Accuracy Test – Using a measuring tape to verify frame and panel dimensions.

Operational Test – Opening and closing the door multiple times to check smoothness of movement.

Locking Mechanism Test – Ensuring that the deadbolt lock operates correctly.

Load Test – Applying a controlled load on the door to assess frame strength.

Surface Finish Inspection – Checking paint uniformity and absence of rust spots.

5.2 Results

Test Parameter	Expected Value	Observed Value	Status
Door Height	1983 mm	1983 mm	Pass
Door Width	765 mm	765 mm	Pass
Smooth Operation	No obstruction	No obstruction	Pass
Lock Functionality	Full engagement	Full engagement	Pass
Load Bearing Capacity	≥ 68 kN	68 kN (safe)	Pass
Surface Finish	Uniform, no rust	Uniform, no rust	Pass

5.3 Performance Analysis

The fabricated single standard metal door successfully met all the established design specifications and operational requirements outlined at the beginning of the project. The load-bearing capacity, calculated at approximately 68 kN, fell well within the safe limits for residential applications, ensuring that the door can withstand both static and dynamic loads during daily use without experiencing structural deformation.

The surface finishing was effectively executed, with the application of a primer and two coats of enamel paint providing adequate protection against corrosion and environmental degradation. This protective coating not only improves the door's resistance to rust in humid or rainy conditions but also enhances its aesthetic appeal, making it suitable for both indoor and outdoor installations.

The welding quality was consistent, with joints exhibiting adequate penetration and bonding strength. The weld beads were smooth after grinding, eliminating sharp edges and potential safety hazards. The use of reinforcement members at critical points, such as the hinge and lock areas, improved the door's resistance to bending or twisting during operation.

The accessories including hinges, deadbolt lock, and handle were installed accurately, resulting in smooth and noiseless operation. The alignment of the door frame with the panel ensured ease of closing and locking, while the hinges allowed for effortless swinging motion without excessive friction. Overall, the fabricated door demonstrated a high level of functionality, structural stability, and visual appeal.

5.4 Discussion of the Results

The results from the fabrication and testing phases clearly demonstrate that locally sourced mild steel and accessories can be effectively utilized to produce a durable, functional, and aesthetically appealing metal door suitable for residential applications. By adhering to standard engineering practices including precise measurement, proper material selection, and correct welding techniques the door achieved dimensional accuracy, structural integrity, and a professional finish comparable to commercially manufactured alternatives.

One of the key strengths of the project was its cost-effectiveness. The total fabrication cost remained significantly lower than the retail price of equivalent market-available doors, primarily due to the use of locally available materials and manual workshop techniques. This suggests that such fabrication methods could be economically viable for small-scale fabricators and vocational trainees, promoting self-reliance and entrepreneurship within local communities.

From a structural performance standpoint, the load-bearing calculations and field tests confirmed that the fabricated door could withstand normal residential stresses without compromising functionality. The applied corrosion protection measures also indicate that the door is likely to have a long service life, provided routine maintenance—such as repainting and lubrication—is performed. However, the project also highlighted certain limitations. The reliance on manual fabrication techniques resulted in minor variations in weld bead uniformity and alignment precision, which could be further minimized through the adoption of CNC machining, laser cutting, or automated welding systems. These advanced techniques would improve dimensional tolerance, repeatability, and overall production speed.

In addition, while enamel painting provided satisfactory corrosion resistance, modern finishing techniques such as powder coating or electroplating could further enhance durability, scratch resistance, and appearance. Incorporating these methods in future projects would increase the product's market competitiveness. In conclusion, the project demonstrates that with proper design planning, skilled manual fabrication, and quality control, locally produced mild steel doors can meet the performance standards required for residential use, bridging the gap between low-cost production and high-quality output.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

This project presented the design, fabrication, and evaluation of a single standard metal door using mild steel as the primary construction material. The work was undertaken to address the challenges of inconsistent quality and lack of standardization in locally fabricated doors within Nigeria's construction industry. The fabrication process followed a systematic approach, beginning with material selection based on strength, durability, cost-effectiveness, and corrosion resistance. Cutting operations were performed using angle grinders to achieve precise dimensions, followed by welding of the frame and panel using Shielded Metal Arc Welding (SMAW). Reinforcement members were incorporated at hinge and lock points to improve structural rigidity.

Surface finishing involved grinding to smooth weld joints, surface cleaning to remove impurities, and application of primer and enamel paint to provide corrosion resistance and enhance aesthetic appeal. Accessories including hinges, locks, and handles were installed to ensure full functionality. The door underwent a series of tests to evaluate dimensional accuracy, load-bearing capacity, operational smoothness, and corrosion resistance. Results indicated that the fabricated door met all design specifications, offering structural strength, ease of use, and an appealing finish comparable to commercially available products. This work not only demonstrated the feasibility of producing cost-effective, high-quality doors using locally sourced materials but also provided a practical platform for enhancing vocational and technical training in welding, measurement, assembly, and finishing techniques.

6.2 Conclusion

The successful completion of this project underscores the potential of manual fabrication techniques to produce reliable, durable, and aesthetically pleasing metal doors suitable for residential use. By applying engineering best practices—such as accurate measurement, appropriate material selection, and quality welding methods—the fabricated door achieved

structural integrity and operational efficiency. The use of locally available mild steel and accessories significantly reduced costs without compromising performance, making this fabrication approach both economically and technically viable for small-scale workshops and SMEs. Furthermore, the hands-on fabrication process strengthened technical competencies in metalworking skills, which are essential in mechanical and construction industries.

However, the project also revealed certain limitations inherent in manual fabrication processes, such as minor variations in weld uniformity and dimensional accuracy. While these did not significantly affect performance, they suggest that future work could benefit from precision fabrication tools like CNC cutting machines, automated welding systems, and advanced finishing technologies to improve repeatability and quality.

6.3 Recommendations

- i. Adoption of standard fabrication guidelines in local workshops to improve consistency.
- ii. Incorporation of corrosion-resistant coatings such as powder coating for longer lifespan.
- iii. Use of jigs and fixtures to improve welding alignment and accuracy.
- iv. Future projects should explore automated or CNC fabrication for higher precision.