



ROOFING ECONOMICS: ANALYSING THE IMPACT OF DESIGN AND MATERIALS ON CONSTRUCTION COSTS

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Abstract

This study provides a cost assessment of various roof designs, taking into account the current price of wood in Benin City, Edo State, Nigeria. The analysis specifically examines the costs related to building Hip, Flat, Gable 1, and Gable 2 roofs, with a particular emphasis on the crucial role of wood in forming the trusses. The cost breakdown highlights different financial considerations for each type of roof, with Gable 2 being the most expensive, followed by Gable 1, Hip, and Flat roofs. The costs presented do not include labour costs and the selection of roof sheet materials, which are essential elements of construction projects. A closer look of the expenses associated with various roof types, particularly the most expensive option (Gable 2), demonstrates significant potential for reducing costs in construction projects. Flat roofs are a cost-effective option, costing only 47.69% of the price of Gable 2 roofs. This makes them appealing for projects with limited budgets. Hip roofs, in the meantime, achieve a harmonious combination of cost-effectiveness and architectural attractiveness, resulting in a significant cost reduction of 89.39% when compared to Gable 2 roofs. In contrast, Gable 1 roofs offer minimal cost savings, accounting for only 97.06% of the cost of Gable 2 roofs. The slight disparity implies that choices may be swayed by factors other than just cost considerations, underscoring the significance of a thorough assessment of climate, architectural preferences, and long-term maintenance expenses in construction endeavours.

Keywords: Roof design, Wood cost, Construction expenses, Truss formation, Regional cost factors

Introduction

Roofing plays a pivotal role in the construction industry, serving as a critical component that not only protects structures from the elements but also contributes significantly to the overall aesthetics, energy efficiency, and long-term sustainability of buildings. The selection of roofing materials and design is a complex decision-making process, influenced by factors such as climate,

building function, and economic considerations. This article aims to provide a comprehensive analysis of the various facets of roofing in construction, with a focus on the impact of design and materials on construction costs.

Roofing practices have evolved over time, adapting to technological advancements, cultural influences, and changing architectural styles. Traditional roofing materials, such as thatch, wood, and clay tiles, have given way to modern materials like asphalt shingles, metal, and synthetic membranes (Smith, 2008). The industrial revolution marked a significant shift, introducing mass-produced roofing materials and standardized construction practices (Johnson, 2015). Understanding this historical evolution is crucial for appreciating the diversity of roofing options available in contemporary construction.

Roofing practices have traversed a rich historical journey, reflecting the dynamic interplay of cultural, technological, and environmental influences. Understanding the evolution of roofing provides valuable insights into the diversity of materials and designs that have shaped construction practices over the centuries.

1. Thatch, Wood, and Clay: Foundations of Traditional Roofing

In the early stages of human settlement, roofing primarily relied on locally available materials. Thatch, composed of straw, reeds, or grass, was one of the earliest roofing materials. This simple, organic covering provided basic protection from the elements but lacked durability (Smith, 2008). As civilizations advanced, wood and clay tiles became prominent roofing materials, offering increased longevity and structural stability.

2. The Impact of the Industrial Revolution:

The advent of the Industrial Revolution in the 18th and 19th centuries marked a transformative period for roofing practices. Mass production technologies facilitated the creation of standardized roofing materials, reducing costs and increasing accessibility. Asphalt shingles emerged as a popular choice during this era, providing a more affordable and durable alternative to traditional materials (Johnson, 2015).

3. Transition to Modern Materials:

The 20th century witnessed a significant shift towards modern roofing materials, driven by advancements in technology and the desire for enhanced performance. Metal roofing gained prominence for its durability, resistance to fire, and versatility in design. Additionally, the introduction of synthetic materials such as rubber and plastic marked a departure from traditional materials, offering increased resistance to weathering and improved insulation properties (Jones et al., 2020).

4. Contemporary Trends in Roofing:

In the 21st century, roofing practices continue to evolve, guided by sustainability concerns and advancements in materials science. Green roofs, featuring vegetation for environmental benefits, have gained popularity, reflecting a growing emphasis on eco-

friendly construction (Brown & Green, 2019). Furthermore, innovations in solar roofing materials demonstrate a convergence of technology and roofing design, contributing to energy-efficient and sustainable building practices.

The historical progression of roofing demonstrates an ongoing pursuit for materials that effectively combine functionality, longevity, and cultural significance. Roofing has undergone transformations, transitioning from traditional thatch and clay tiles to contemporary metal and synthetic materials. These advancements in roofing materials have been driven by societal demands, as well as advancements in technology and a heightened awareness of the environmental consequences associated with construction methods.

Contemporary Context of Roofing Economics

1. Rising Construction Costs:

The construction industry has witnessed a steady increase in costs, prompting a closer examination of the economic aspects of building components, including roofing (Construction Cost Index, 2022). The choice of roofing materials and design directly influences construction expenses, making it imperative to analyse the economic implications of these decisions.

2. Environmental Considerations:

With a growing emphasis on sustainability, roofing choices are now scrutinized for their environmental impact. The push for eco-friendly solutions has led to a re-evaluation of traditional practices in favour of materials with lower environmental footprints (Brown & Green, 2019).

3. Energy Efficiency Demands:

The rising costs of energy and a heightened awareness of environmental issues have increased the demand for energy-efficient roofing designs. This shift in consumer preferences and industry standards introduces new economic considerations, as initial costs must be weighed against long-term energy savings (Energy Information Administration, 2021).

5. Roofing Design and Construction Cost:

The design of a roof, including its slope, pitch, and architectural complexity, can significantly impact construction costs. Highly intricate designs may require specialized materials and skilled labour, leading to higher upfront expenses. Moreover, the choice of design influences long-term maintenance costs, as certain designs may be more prone to issues like water pooling or debris accumulation (Jones et al., 2020).

Roofing Materials and Construction Cost

The selection of roofing materials is a critical decision that directly affects both initial construction costs and long-term expenses. Different materials have varying price points, durability, and maintenance requirements. For example, while asphalt shingles are a cost-

effective option initially, they may have a shorter lifespan compared to more durable materials like metal or slate (National Roofing Contractors Association, 2022). Assessing the cost implications of different materials is essential for making economically sound decisions in construction.

Roofing materials constitute a critical component of construction, influencing not only the initial construction costs but also long-term expenses associated with maintenance and durability. The selection of roofing materials involves a careful consideration of factors such as cost, longevity, energy efficiency, and environmental impact.

1. Asphalt Shingles: Cost-Effective but Consideration-Worthy

Asphalt shingles have long been a staple in roofing due to their cost-effectiveness and ease of installation. These shingles are available in various styles and colors, making them a versatile choice for residential and commercial structures. While the upfront costs are relatively low, it's crucial to weigh these against the material's lifespan and potential maintenance requirements, as asphalt shingles may have a shorter lifespan compared to more durable alternatives (National Roofing Contractors Association, 2022).

2. Metal Roofing: Durable Investment with Initial Costs

Metal roofing has gained popularity for its durability and longevity. It provides excellent resistance to elements such as fire, wind, and hail, making it a cost-effective choice in the long run. However, the initial installation costs of metal roofing can be higher than some traditional materials. The economic analysis of metal roofing should encompass both the upfront investment and the extended lifespan, potentially resulting in lower lifecycle costs (National Roofing Contractors Association, 2022).

3. Synthetic Membranes: Waterproofing and Longevity:

Synthetic roofing membranes, such as ethylene propylene diene monomer (EPDM) or thermoplastic olefin (TPO), offer excellent waterproofing properties. These materials are commonly used in flat or low-slope roofs. While their initial costs may be higher compared to traditional options, the durability and low maintenance requirements make them a financially sound investment over time (Jones et al., 2020).

4. Sustainability and Environmental Impact:

The construction industry's increasing emphasis on sustainability has prompted a shift towards eco-friendly roofing materials. Options like recycled metal, wood shingles, or green roofs, which feature living vegetation, align with environmental consciousness. While these materials may have higher upfront costs, their long-term environmental benefits and potential energy savings contribute to a more holistic economic assessment (Brown & Green, 2019).

5. Integrated Cost Analysis:

An integrated cost analysis considers not only the initial material and installation costs but also the anticipated lifespan, maintenance needs, and potential energy efficiency gains. For instance, a roofing material that requires minimal maintenance and contributes to energy savings may prove more economical in the long term, even if the initial investment is higher.

Cost of roofing to the overall cost of construction

The cost of roofing as a percentage of the overall construction budget can vary widely based on several factors, including the type of roofing material chosen, the complexity of the design, and the size and scope of the construction project. While it is challenging to provide an exact percentage that universally applies, industry estimates and guidelines can offer some insights.

According to a report from the National Association of Home Builders (NAHB) in the United States, roofing costs typically account for about 15% of the total construction budget for a new home (NAHB, 2021). However, it's important to note that this is a general guideline, and the actual percentage may differ based on factors like regional variations, the type of roofing material selected, and specific project requirements.

For commercial construction projects, roofing costs can vary but are generally a significant portion of the overall budget. A study by RSMeans, a construction cost data provider, found that roofing costs can represent around 4% to 8% of the total construction cost for commercial buildings, depending on factors such as the roof type and the complexity of the roofing system (RSMeans, 2021).

It's crucial for project managers, architects, and contractors to conduct a detailed cost analysis early in the planning stages to accurately estimate the specific costs associated with roofing for a given project. This analysis should include not only the material and installation costs but also considerations for long-term maintenance, energy efficiency, and potential environmental impact.

Roof design and complexity on construction cost

The design and complexity of a roof have significant implications for the overall construction cost. The architectural intricacies of a roof influence material requirements, labour intensity, and the overall construction timeline, all of which contribute to the final expenses.

1. **Increased Labour Costs:**

Roof designs with multiple angles, dormers, or intricate features often require specialized labour and skilled craftsmen. The complexity of the design can increase the time and effort needed for installation, leading to higher labour costs (Peterson & Dagostino, 2018 and Builders Book Inc., 2007).

2. **Specialized Materials:**

Unique roof designs may necessitate the use of specialized materials to accommodate specific architectural elements. Customized or non-standard materials can be more

expensive than conventional ones, adding to the overall construction cost (Builders Book Inc., 2007 and Dagostino & Feigenbaum, 2002).

3. Extended Construction Timeline:

Complex roof designs often require more time for planning, fabrication, and installation. Delays in the construction timeline can result in increased labour costs, project management expenses, and potential financial penalties (Peterson and Dagostino, 2018).

4. Engineering and Structural Considerations:

Unconventional roof designs may demand additional engineering analysis and structural considerations. The need for custom solutions or structural modifications can escalate both design and construction costs (Mehta et al., 2017).

5. Higher Maintenance Costs:

Complex roof designs may have intricate features that are more challenging and costly to maintain over time. Accessing and repairing certain components may require specialized equipment and expertise, contributing to increased maintenance expenses (Booty 2009).

6. Material Wastage:

The complexity of a roof can lead to higher material wastage during the construction process. Custom cuts, intricate shapes, and design changes may result in increased scrap material, driving up material costs (Peterson & Dagostino, 2018).

7. Architectural and Design Fees:

Designing complex roofs requires a higher level of architectural expertise. As a result, architects may charge higher fees for the planning and execution of intricate designs, contributing to the overall project cost (Ballastm, 2009).

8. Regulatory Compliance:

Some unique roof designs may require additional compliance with building codes and regulations. Ensuring that the design meets structural and safety standards can involve extra costs related to obtaining approvals and permits⁶.

The cost of construction is influenced by the design and complexity of the roof, which are characterised by multiple factors. Although intricate designs can enhance the visual attractiveness of a building, they typically incur higher costs in terms of labour, materials, and design. Project stakeholders must meticulously evaluate the compromises between architectural vision and budgetary limitations in order to guarantee a prosperous and economically efficient construction project.

Roofing design under investigation and cost

1. Hip Roof:

Offers good stability and durability, provides more shade and ventilation, aesthetically pleasing. Generally, more complex to construct, may require more materials. The

complexity of the design and the amount of materials needed will influence costs. Hip roofs typically require more labour and materials than simpler designs.

2. Flat Roof:

Modern and minimalist design, provides usable space on the roof, easy access for maintenance. Requires proper drainage to avoid water pooling, may have a shorter lifespan compared to sloped roofs. Flat roofs can be cost-effective, but the cost may increase if additional features like drainage systems or protective coatings are needed.

3. Gable Roof:

Simple and classic design, allows for good ventilation and natural light. May be more susceptible to wind damage in certain conditions. Gable roofs are generally cost-effective. The pitch of the roof, materials used, and local building codes can affect costs.

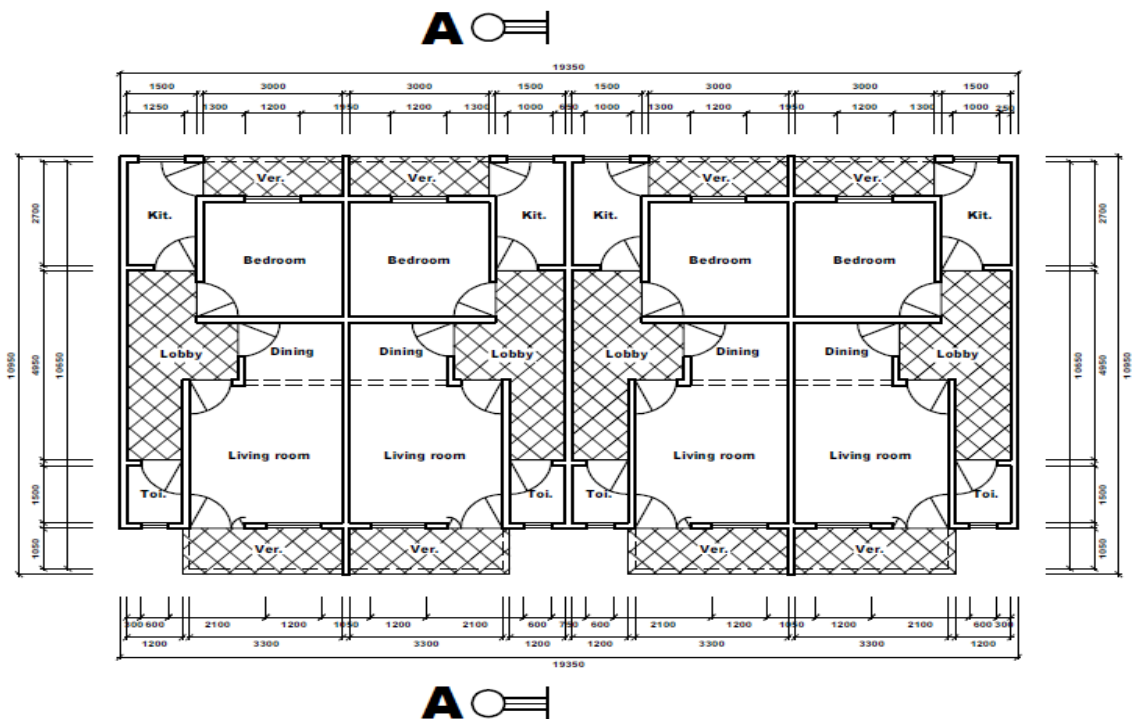
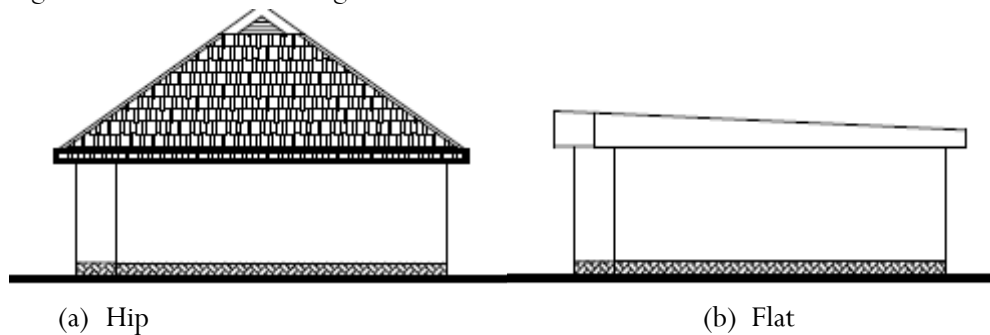
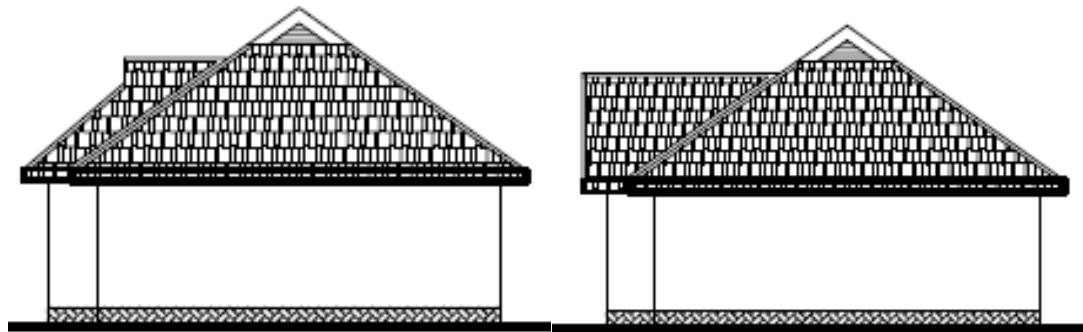


Figure 1. Plan of the building and section



(a) Hip

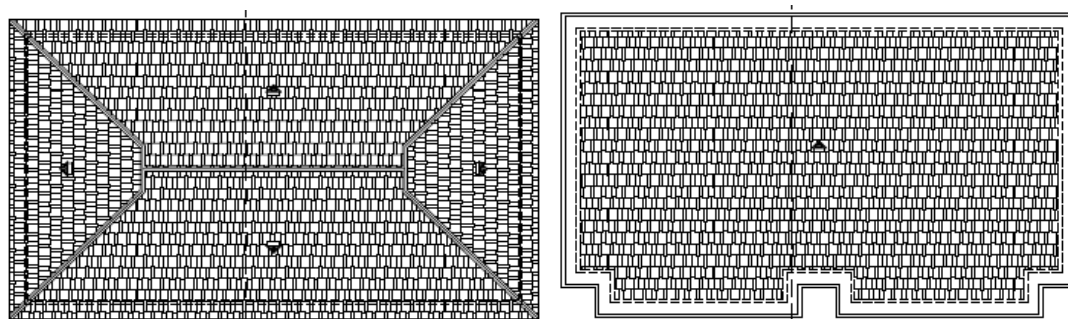
(b) Flat



(c) Gable 1

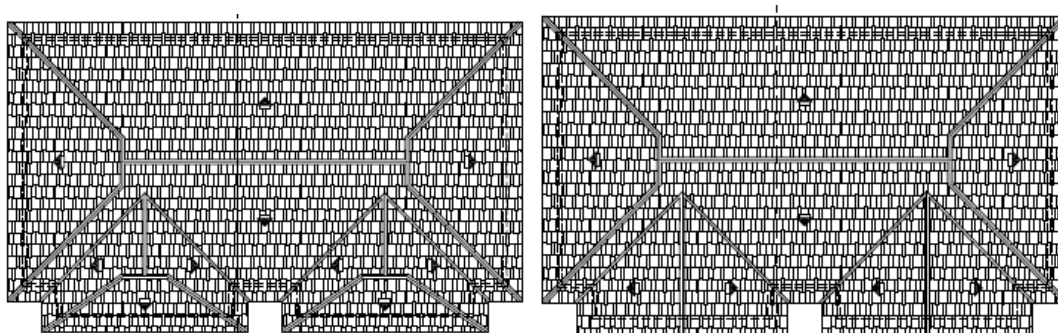
(d) Gable 2

Figure 2. Side elevations for the roof designs



(a) Hip

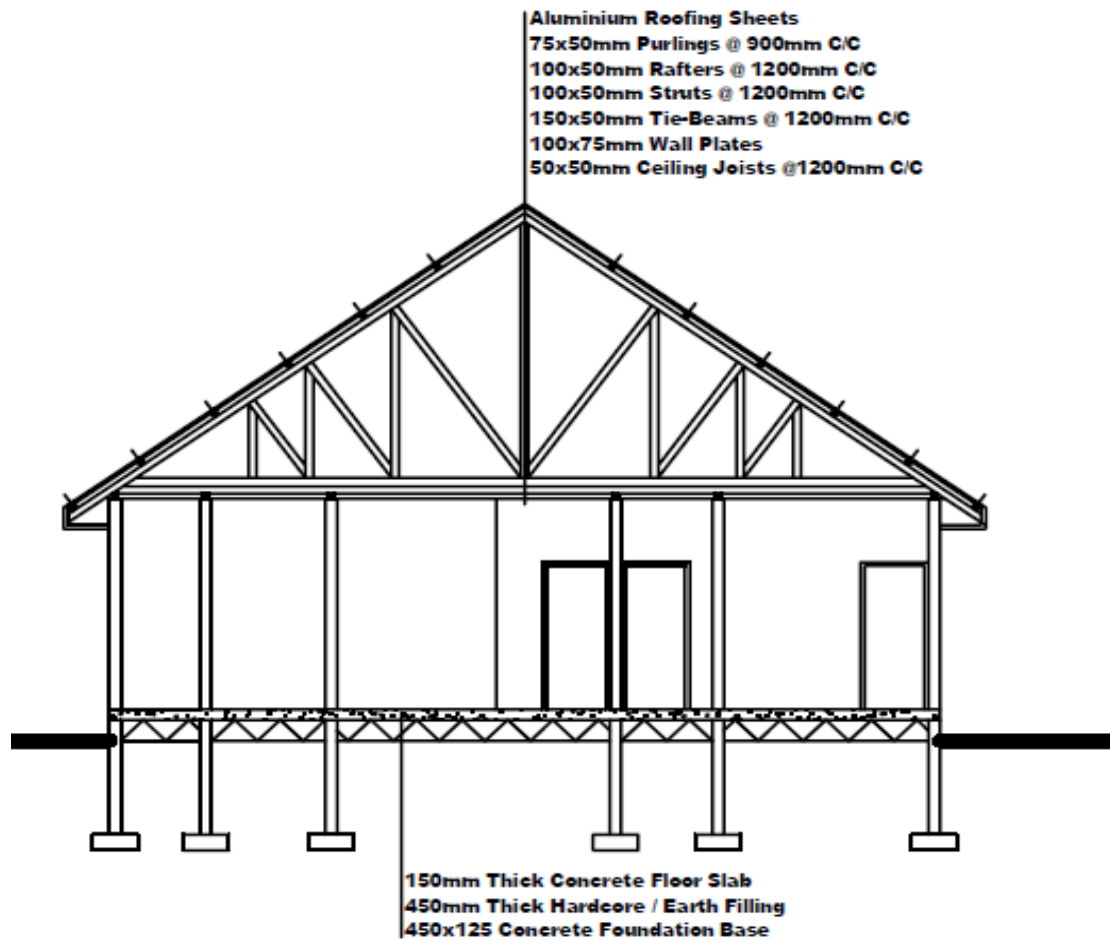
(b) Flat



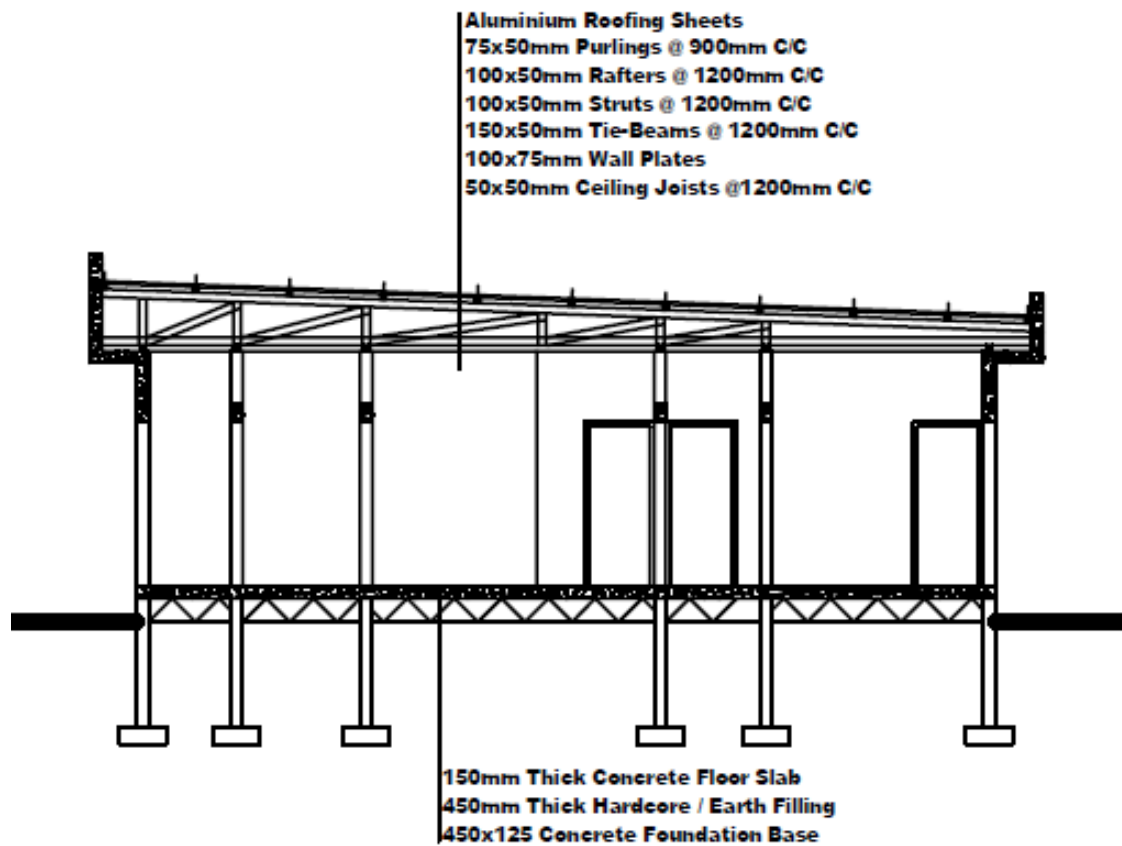
(c) Gable 1

(d) Gable 2

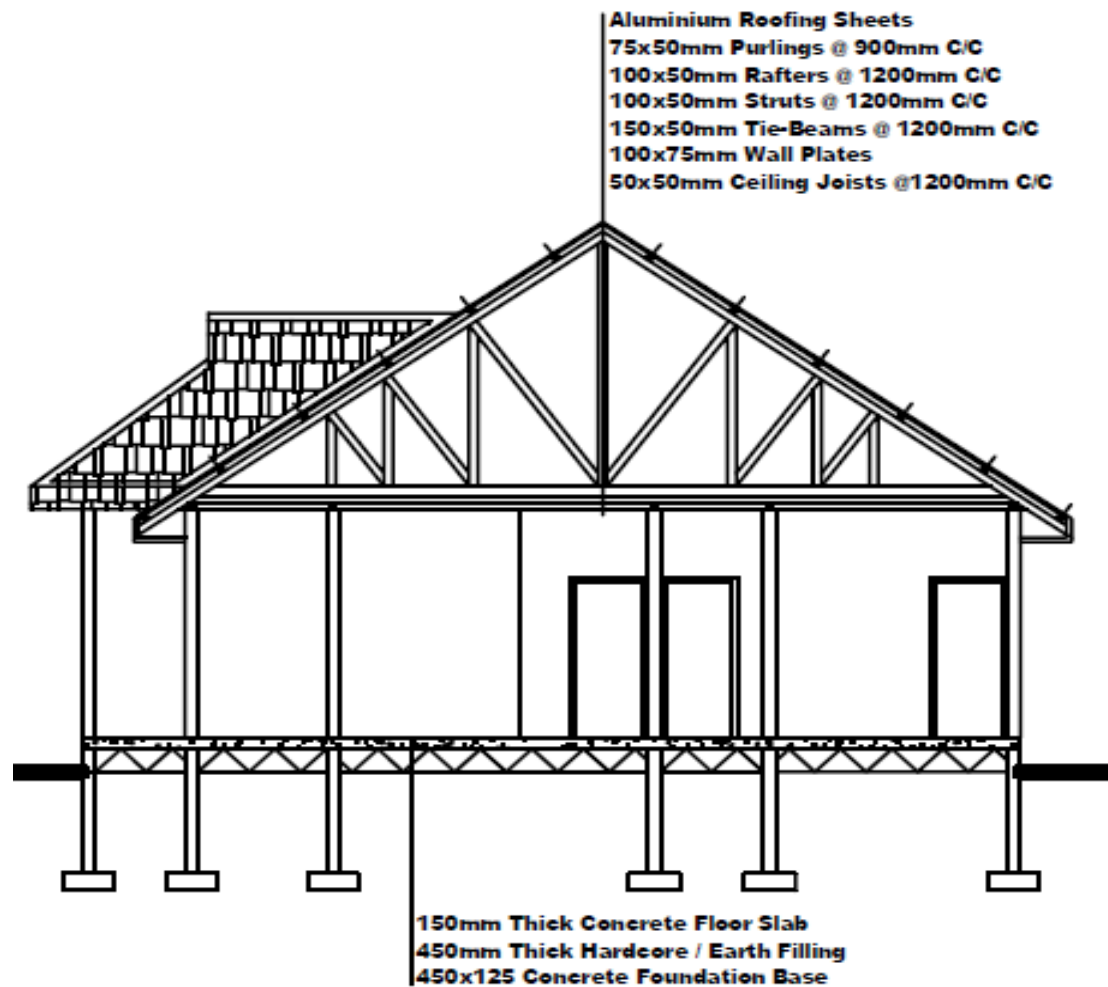
Figure 3. Roof plans (a-d)



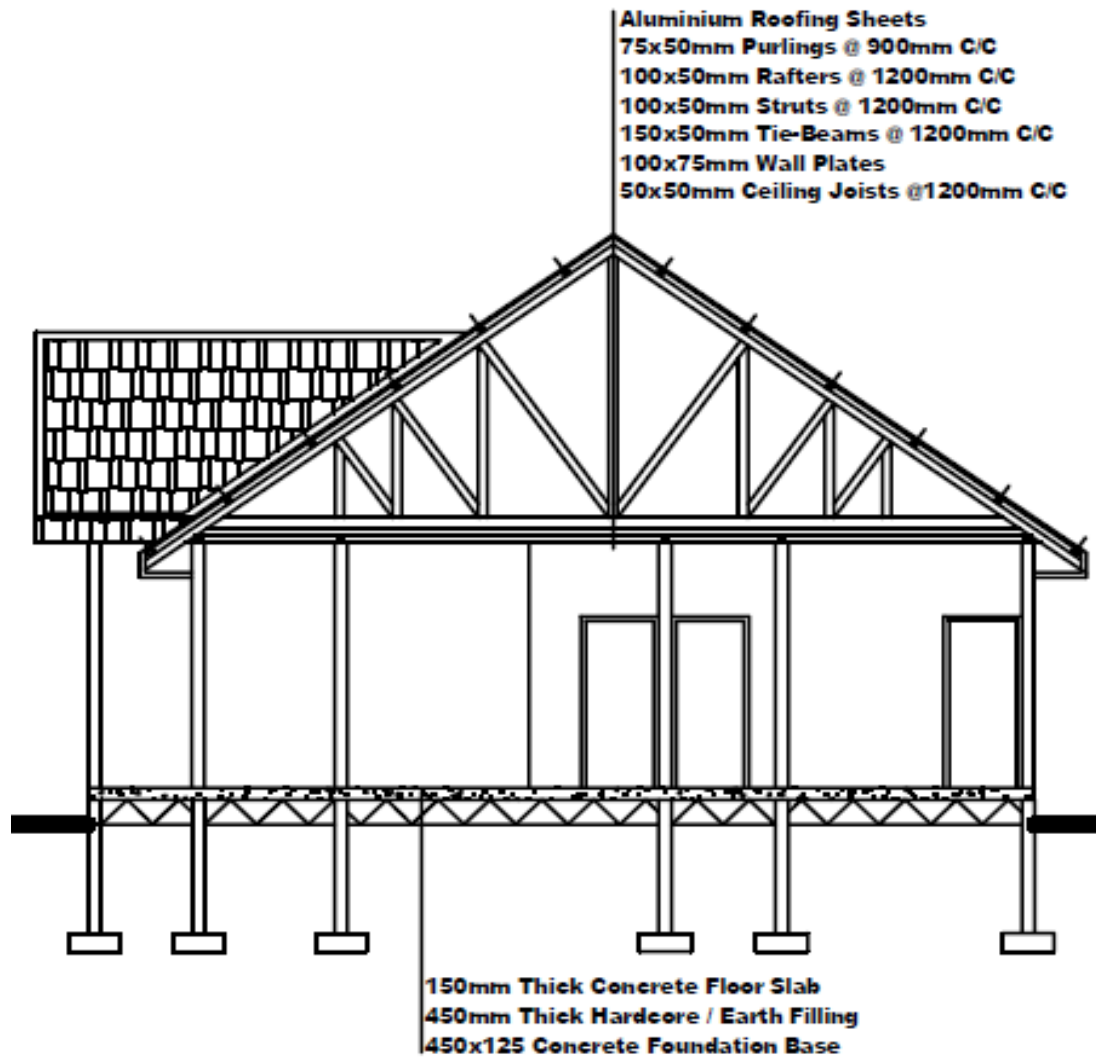
(a) Hip



(b) Flat



(c) Gable 1



(d) Gable 2

Figure 4. Roof details (a-d)

Roof Cost Evaluation

Table 1: cost of woods use in roofing

Wood Sizes	Hip	Amount	Flat	Amount	Gable 1	Amount	Gable 2	Amount
4x6	14	58800	14	58800	17	71400	17	71400
3x4	50	180000	27	97200	56	201600	58	208800
3x2	80	156000		0	88	171600	90	175500
2x2	84	117600	84	117600	84	117600	84	117600
Total		512400		273600		562200		573300

The cost evaluation you provided is a breakdown of the estimated costs for different roof types based on the prevailing cost of wood in Benin City, Edo State, Nigeria. The breakdown is as follows:

- Hip Roof Cost: 512,400 Naira
- Flat Roof Cost: 273,600 Naira
- Gable 1 Roof Cost: 562,200 Naira
- Gable 2 Roof Cost: 573,300 Naira

Here are some observations and considerations based on the provided information:

The costs vary for each roof type, with Gable 2 being the most expensive followed by Gable 1, Hip, and Flat. This difference in cost is likely influenced by the design complexity, size, and material requirements of each roof type.

The cost evaluation is specifically based on the wood used for the trusses. This suggests that the choice of wood and the amount required for each roof type significantly impacts the overall cost. Different roof designs may require varying amounts and types of wood, affecting the final expenses.

It is important to note that the provided costs exclude the expenses related to labour and the type of roof sheets to be used. Labour costs can be a substantial part of the overall expenditure, and the choice of roof sheets (materials, quality, etc.) can also influence the total project cost. The costs are based on the prevailing cost of wood in Benin City, Edo State. It's a good practice to consider local factors such as material availability, market conditions, and regional labour costs, as these can vary across different locations.

While the cost of wood for trusses is a significant component, the overall cost of a roofing project involves multiple factors, including other construction materials, labour, roof sheet materials, and potential additional costs such as insulation, ventilation, and finishing.

The cost of a roof depends on various factors, and it is not solely determined by the roof type. However, if we are comparing the roof types mentioned in a general sense, the most expensive is likely to be the Hip Roof.

Analysing the percentages of the different roof types with respect to the most expensive (Gable 2 roof) provides insights into potential cost-saving opportunities in building construction:

- Flat Roof (47.69% of Gable 2 cost):

- **Potential Cost Savings:** Flat roofs are significantly less expensive than Gable 2 roofs, representing an opportunity for cost savings. Choosing a flat roof design may be an economical option, especially for projects with budget constraints.
- **Considerations:** While flat roofs offer potential cost savings, it's essential to consider factors such as drainage, maintenance, and insulation requirements. Additionally, local climate conditions and aesthetic preferences should be taken into account.

Hip Roof (89.39% of Gable 2 cost):

- **Moderate Cost Savings:** Hip roofs are less expensive than Gable 2 roofs, presenting a moderate opportunity for cost savings. The design complexity of hip roofs contributes to their lower cost compared to Gable 2 roofs.
- **Considerations:** Hip roofs provide a balance between cost savings and architectural appeal. Their stability and durability make them a viable option for those seeking a middle ground between cost and aesthetics.

Gable 1 Roof (97.06% of Gable 2 cost):

- **Limited Cost Savings:** Gable 1 roofs are relatively close in cost to Gable 2 roofs, offering limited potential for savings. The slight difference suggests that the design features of Gable 1 roofs contribute to a cost structure comparable to Gable 2 roofs.
- **Considerations:** If the goal is substantial cost savings, Gable 1 roofs may not represent a significant departure from the more expensive Gable 2 design. Other factors, such as aesthetic preferences, may become more influential in the decision-making process.

Conclusion

Ultimately, the assessment of costs, taking into account the current price of wood in Benin City, Edo State, Nigeria, offers valuable insights into the projected expenditures linked to various roof designs. The cost breakdown highlights the financial factors associated with each design, underscoring the crucial significance of wood in the fabrication of trusses. The disparity in costs among the various roof types, namely Hip, Flat, Gable 1, and Gable 2, is a result of the intricate factors that impact expenses, including the intricacy of the design, the size of the roof, and the particular wood specifications for each style of roof. Significantly, Gable 2 stands out as the costliest, with Gable 1, Hip, and Flat roofs following suit.

It is important to note that the costs provided only include the wood used for trusses and do not include two important factors: labour and the type of roof sheets. The overall financial expenditure of a construction project is greatly influenced by labour costs, which constitute a significant portion, as well as the choice of roofing materials. The omission of these elements from the given costs requires further deliberation when calculating the overall expenditure of a roofing project.

Moreover, the assessment is based on the specific circumstances of Benin City, highlighting the significance of taking into account local elements such as the availability of resources, market dynamics, and expenses related to workforce. Recognising and adjusting to the local nuances of construction costs is crucial for precise project budgeting, as these costs can significantly differ across various locations.

The cost analysis comparing the Gable 2 roof type to other options reveals substantial potential for reducing expenses in construction projects. Flat roofs are a highly cost-effective choice, accounting for only 47.69% of the cost of Gable 2 roofs. The significant disparity in cost implies that selecting a flat roof design may be a financially prudent decision, particularly for projects with strict budget limitations. Conversely, hip roofs offer a harmonious balance between cost efficiency and aesthetic appeal, resulting in a modest cost reduction of 89.39% when compared to Gable 2 roofs. Hip roofs are a practical choice for individuals who want to balance cost considerations and aesthetic preferences, thanks to their stability and durability.

Nevertheless, Gable 1 roofs exhibit minimal cost savings, amounting to only 97.06% of the cost of Gable 2 roofs. The marginal difference suggests that factors beyond design considerations may have a greater impact on decision-making, potentially making other factors like aesthetic preferences more influential. To summarise, the analysis highlights the significance of thoroughly evaluating cost considerations in relation to factors such as climate, architectural preferences, and long-term maintenance costs. This is crucial for making well-informed decisions in building construction projects.

When planning a roofing project, it is advisable to take a comprehensive approach. To gain a more precise and comprehensive understanding of the financial investment needed, it is advisable to acquire detailed quotations for labour, roof sheet materials, and any other related expenses. Engaging in discussions with nearby contractors and construction experts enables a customised evaluation that takes into account the unique demands of the project and the local environment. This guarantees a more accurate comprehension of the financial consequences associated with the selected roof design.

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