

Comparative Cost Optimization in Residential Construction Using Alternative Building Materials: A Detailed Estimation Approach

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Abstract - The escalating price hike of traditional construction materials and the demand for energy-efficient tactics has led to the need for research on cost-effective alternatives in construction. This study is a comparative cost estimation of a building a residential building G+1 using conventional materials and some alternative materials that are Recycled Concrete Aggregate (RCA), Autoclaved Aerated Concrete (AAC) blocks and IPS flooring. Detailed estimates were prepared based on identical drawings, specifications and quantity take-offs in order to ensure consistency in comparison. The most important findings show that the use of alternative materials contributes to the saving of the total cost of construction: from ₹ 34,53,184 to ₹ 31,51,788 (a saving of ₹ 3,01,396 or 8,72%). The strongest savings were realized in masonry and flooring elements, which exhibit the wide swing of material choice in overall project cost. The study pinpoints a research need in the limited use of the component-wise comparative estimation of alternative materials with the same design conditions because most current practice involves studying only conventional materials or aspects of lifecycles without consideration of the practical cost estimations. In terms of future direction, the study suggests the incorporation of life cycle cost analysis, performance evaluation and the inclusion of other alternative materials and modern construction techniques for better decision making relating to sustainable construction. Overall, the results confirm that strategic substitution of material is a suitable method of achieving economical and environmentally responsible construction.

Keywords: AAC Blocks, Alternative Materials, Cost Estimation, Economic Analysis, Recycled Concrete Aggregate

1. Introduction

The construction industry is a crucial sector for economic development and infrastructure expansion, and building construction represents a substantial portion of total construction activities (Tayefeh Hashemi et al., 2020). Rapid urbanization and population growth and the rising demand for residential and commercial infrastructure has resulted in a great increase in construction activities (Olowe et al., 2025). However, this growth has been accompanied by a continuous increase in construction costs, which are mainly raised by the rising prices of conventional building materials, lack of resources, and increased demand (Platace & Gusta, 2016). Under such circumstances, effective planning of costs, accurate estimation, and economic evaluation have become important aspects for successful execution of the construction project within the budgetary period (Mahame et al., 2025).

Cost estimation is one of the basic elements of the management of construction projects, because thanks to it, we have a quantitative basis for the financial planning, budgeting, and decision-making (Stasiak-Betlejewska & Potkány, 2015). Detailed estimation refers to systematic computation of quantities and costs of materials, labour and equipment needed for project execution according to approved drawings and specifications (Stanskova, 2025b). Traditionally, construction of buildings is based on conventional materials such as burnt clay bricks, natural aggregates, cement, steel and river sand because of their proven performance and their widespread availability (Stanskova, 2025a). However, the overuse of these materials has led to higher construction costs, depletion of natural resources and environmental concerns,

rendering conventional construction practices less sustainable and economically efficient (Trejo & Reinschmidt, 2007).

In response to these challenges, the construction sector has increasingly focused on the use of alternative building materials that are cost-effective, environmentally sustainable and technically viable (Lu et al., 2023). Materials like AAC (Autoclaved Aerated Concrete) block, fly ash brick, ready mix concrete (RMC), M-sand, UPVC door and window and recycled aggregate have received attention because of their potential to lower the cost of construction without compromising structural performance and durability (Rampit et al., 2020; Thakur & Kumar, 2022). The replacement of conventional materials with suitable materials in certain building components offers a possibility to optimize the cost of the project and to advance sustainable construction practices (Rampit et al., 2020). However, the use of such materials requires proper evaluation through detailed estimation and comparative economic analysis to determine their feasibility in actual construction projects (Thakur & Kumar, 2022).

Despite the availability of alternative materials, however, their use in routine construction practice is still limited because of a lack of practical component-wise cost comparison and a lack of integration of material substitution into conventional methods for estimating construction costs. Most estimation practices consider only initial costs using traditional materials without considering the potential economic benefits of alternatives. This results in a void in the decision-making process where the engineers and stakeholders are not able to quantitatively justify the material replacement options. Therefore, the present study is aimed at filling this gap by performing a detailed cost estimation and comparative economic analysis of a selected building project. The study consists of the preparation of a detailed estimate using conventional materials and a revised estimate using alternative materials. Both of the estimates are prepared based on the same drawings, same specifications, and same construction methodology so that there is consistency. The comparative analysis assists in quantifying the cost variations and determining the cheapest material choice without compromising structural safety, functionality and performance.

2. Literature Review

Recent studies highlight the growing importance of cost optimization and sustainable material selection in building construction. (Stanskova, 2025b) emphasized the integration of Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) for evaluating long-term economic benefits of sustainable materials, noting that operational savings can outweigh initial costs. Similarly, (Stanskova, 2025a) highlighted the role of automated estimation systems in capturing both initial and lifecycle costs, demonstrating potential energy savings of 15–30%. From an economic comparison perspective, (Mahame et al., 2025) applied a cost-benefit analysis and found that alternative materials such as compressed stabilised earth blocks can reduce costs by approximately 18%. Likewise, (Tayefeh Hashemi et al., 2020) reported significant cost savings of about 26% using materials like AAC blocks and M-sand, highlighting the economic feasibility of material replacement. Advancements in estimation techniques have also contributed to improved accuracy. (Chandra & Polley, 2024) showed that traditional methods result in higher cost overruns (18–20%), whereas modern techniques such as BIM and AI reduce overruns significantly. Supporting this, (Tayefeh Hashemi et al., 2020) on machine learning techniques identified machine learning models, particularly ANN, as effective tools for improving prediction accuracy. Furthermore, (Olowe et al., 2025) emphasized the importance of material price prediction using data-driven approaches to reduce uncertainty in budgeting. Studies by (Platace & Gusta, 2016) and (Trejo & Reinschmidt, 2007) further highlighted that material selection significantly influences overall project cost, and lifecycle considerations are essential for optimal decision-making.

2.1 Research Gap

Despite the methods of estimation already existed, the degree of using conventional materials in construction practice remains high because of the familiarity and the Schedule of Rates, resulting in high initial cost. Existing estimation approaches mostly concentrate on the initial cost and do not systematically evaluate alternative materials at the component level. Additionally, there is a lack of structured frameworks for direct comparison between conventional and alternative materials based on detailed estimation. Most of the previous works focus on the importance of sustainability and lifecycle benefits, however, a short-term cost optimization

process in the estimation stage requires more exploration. In addition, there are limited practical case-based studies comparing material replacement using the same building design and specifications. Therefore, there is a need for a systematic and component-wise

comparative analysis of conventional and alternative materials by a detailed estimation. This study makes an effort to fill this gap by including a practical comparison of cost in terms of the same building layout, so as to have a realistic and economical comparison.

3. Methodology



Fig 1 Methodology

A Fig 1 shows G+1 residential building plan was chosen and detailed quantity take-off was completed for all the construction components based on the standard drawings and specifications. Cost estimation was first prepared in conventional material and then the revised cost estimate was prepared using alternative materials without changing design and structural parameters.

Material rates have been gathered from standard sources to calculate the cost and the calculations have been done using Microsoft Excel to ensure accuracy, consistency and efficiency. Finally, a comparative analysis of both estimates was undertaken in order to assess cost variation and determine the least cost material alternative.

4. Case Study

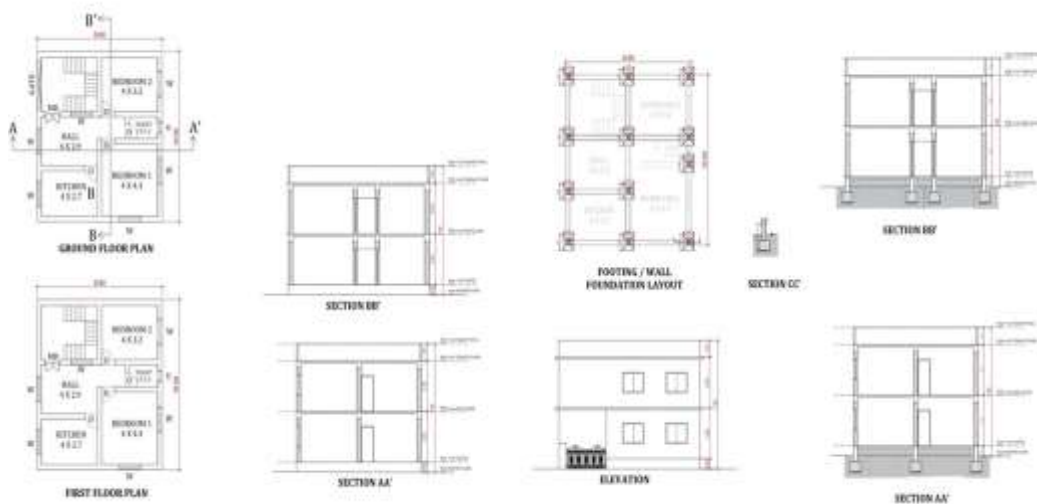


Fig 2 Building Plan

The Fig 2 Shows building chosen is a G+1 (Ground + First Floor) residential structure that has been designed with a compact and functional layout. The overall plan is almost rectangular in shape of about 8.90m x 10.00m in order to utilize the available space efficiently.

- **Ground Floor Plan**

The ground floor is made of key residential spaces such as a hall, kitchen, two bedrooms, and a toilet. The central space is the hall (4x2.9 m) from which the access to all other rooms is provided. The kitchen (4X2.7 m) is located next to the hall for easy circulation. Two bedrooms of size 4 x 3.2m, 4 x 4.3m are provided to accommodate the occupants comfortably. A common toilet (2 X 1.3 m) is provided for convenience. A staircase is also integrated within a layout to provide vertical circulation to the top floor.

- **First Floor Plan**

The first floor is similar in layout to the ground floor, and maintains the uniformity of design and structural alignment. It has a hall, kitchen, two bedrooms and a toilet, which guarantees functional residential use. The staircase also links the two floors efficiently and retains ease of movement.

- **Foundation Layout**

The system of foundation consists of isolated footings provided at the locations of the columns as shown in the footing layout. These footings are distributed uniformly

so as to transfer the structural loads safely to the ground. The layout provides proper distribution of load and structural stability.

- **Sections and Elevation**

The sectional views (AA', BB' and CC') show the vertical arrangement of the building in terms of foundation, plinth level, floor levels and roof slab. The sections illustrate appropriate alignment of elements of a structure like columns, beams, and slabs. The elevation gives the exterior appearance of the building, including the placement of doors and windows and the proportions of the overall height.

- **Structural Features**

The building is made of RCC framed structure including columns, beams, slabs and footing. Infill in between structural members is brick masonry walls. The design is made to ensure proper transfer of load from superstructure to foundation and ensure stability and durability.

5. Result and Discussion

Two different detailed estimates were prepared for the same building based on identical drawings, specifications and quantity calculations. The only difference between the two estimates was the type of materials used in selected components. Fig 3 Shows the details.

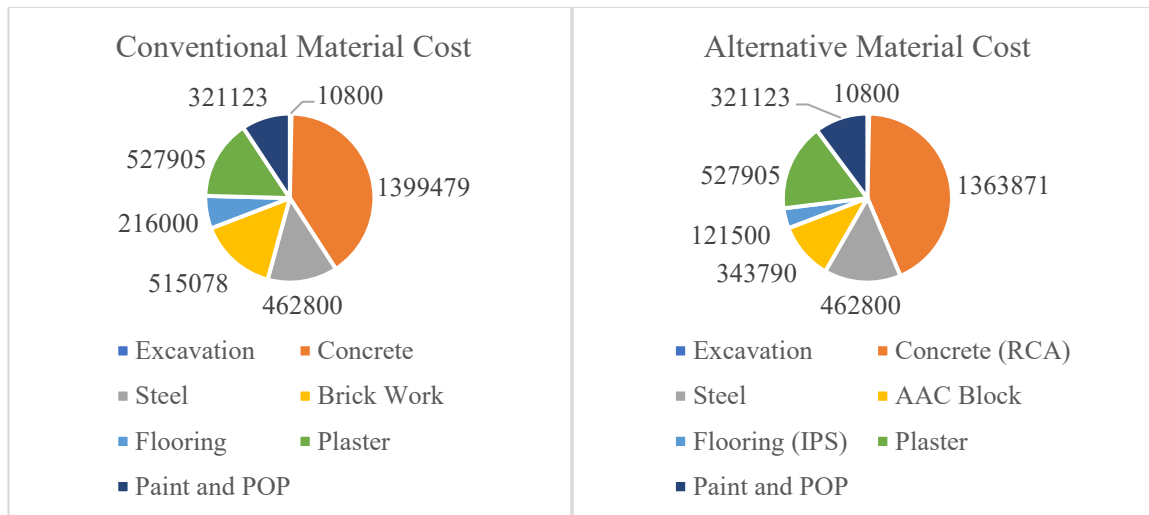


Fig 3 Cost Estimation

The total cost of construction using conventional materials was found to be ₹ 34,53,184, whereas the total cost using alternative materials was ₹ 31,51,788. This indicates a total cost saving of ₹ 3,01,396, which corresponds to an approximate 8.72% reduction in overall construction cost.

A detailed comparison of individual components shows that:

1. Flooring work saw a huge cost saving in replacing conventional flooring with IPS flooring.
2. Masonry work cost reduced quite a lot with the use of AAC blocks rather than burnt clay bricks.
3. Concrete work proved to be slightly less costly than normal thanks to the use of Recycled Concrete Aggregate (RCA).
4. Other components such as steel, plastering, and painting remained unchanged, ensuring a fair comparison.

The results clearly indicate that the major contribution to cost savings comes from flooring and masonry works, which are substantial components of total building cost.

The results of this study have shown that material selection is an important factor in determining overall efficiency of a construction project in terms of cost. Conventional materials, despite being widely accepted and widely used, result in an increase in construction costs due to rising prices in the market, the cost of transportation, as well as the depletion of natural resources. The use of alternative materials, like RCA, AAC blocks and IPS flooring offer a practical solution to reduced construction costs without compromising structural performance. The use of AAC does not only save masonry cost, but it also saves the dead load of the

structure, which can indirectly save the size of structural members. Similarly, the IPS flooring provides a durable and inexpensive flooring finish alternative to costly ones, which makes it an ideal option for budget-conscious projects. From a sustainability point of view, the use of RCA helps minimizing the effective use of construction and demolition waste, so reducing the environmental pollution and saving natural aggregates. AAC blocks make building more thermally insulated and energy efficient, while IPS flooring cuts down material consumption and maintenance costs. The research also emphasizes on the importance of detailed estimation and comparative analysis as a decision-making tool in construction projects. By keeping the same design parameters and only varying the type of materials, the analysis helps to have results whose change in cost is solely useful for replacing materials, making results reliable and applicable.

Overall, the results can confirm that the combination with other materials in building construction can have an economic and environmental benefit. The cost saving observed which was about 8.72%, is significant for residential projects and could contribute to affordable housing solutions.

6. Conclusion

This research focused on the cost effect of replacing the traditional construction materials with some alternatives in a way that will improve the cost of a residential home. By making two independent estimates under similar design and quantity conditions, there was a direct and not biased comparison. The analysis provides a conclusion that the modified estimate with alternative materials results in a significant saving on the total

project expenditure as compared to the conventional approach. The reduction is not marginal but has a practical meaning which shows that material selection alone can play an important role in project affordability. The main cost efficiency can be witnessed in the changes of the masonry and flooring materials where the structural and finish elements have not been much affected regarding the costs as they contribute relatively little to the final cost. From an engineering standpoint, this result implies that if we can find technically viable alternatives to traditional materials, the functional performance will not be affected negatively. Instead, it increases construction efficiency by minimizing dead load, simplifying and in some cases optimizing utilization of resources. The results strengthen that cost optimization in construction is not only design-changing related but could be successfully carried out at the material selection stage itself. Another important inference is that economic evaluation during the estimation phase plays an important role in the decision-making process. When alternate materials are evaluated quantitatively as opposed to theoretically it reduces uncertainty and increases confidence within engineers and stakeholders. This approach is a way of bridging the gap between traditional practices and modern and cost-efficient construction strategies. In summary, the research has affirmed that the use of strategic material substitution is a viable means to achieve economical construction without changing the structural design, or compromising performance. It gives us a clear direction of adopting cost-efficient and resource-conscious construction practices in residential projects.

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