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Comparative Cost Analysis of Conventional Building Materials and Smart Low-Cost Alternatives for G+1 Residential Building

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Abstract: The construction industry in India is experiencing a rapid increase in material and labor costs, making conventional construction methods increasingly expensive and less sustainable. Traditional materials such as clay bricks, Ordinary Portland Cement (OPC), steel, and river sand contribute not only to higher construction costs but also to significant environmental degradation due to high energy consumption and carbon emissions. In this context, the use of smart and low-cost construction materials has emerged as an effective alternative for achieving economical and sustainable building solutions. This study presents a comparative analysis of cost estimation between conventional building materials and smart/green construction materials for a G+1 residential building. The analysis is carried out using the central line method of estimation, ensuring consistent material quantities for both cases. Parameters such as cost, material consumption, dead load, construction time, labor requirement, and sustainability are evaluated. The results indicate that the use of smart materials such as AAC blocks, EPS panels, and gypsum plastering reduces the overall construction cost by approximately 18.44%. Additionally, these materials contribute to reduced structural load, faster construction, and improved energy efficiency. The study concludes that smart and low-cost materials provide a viable solution for affordable housing while promoting sustainable construction practices

Keywords: Cost-effective construction, Smart building materials, EPS wall panels, Sustainable housing, Cost estimation, etc.

I. INTRODUCTION

A. Overview of cost analysis

The construction sector is considered to be a major contributor to the economic development and infrastructure support of a country. In India, the industry is a key factor in the creation of jobs and the fast growth of cities; on the other hand, it also has the largest share in the consumption of the natural resources and energy. For more than a century, the construction industry has mainly relied on burnt clay bricks, Ordinary Portland Cement (OPC), steel, river sand, and natural aggregates for the civil works. At the same time, rising material and labor costs have caused construction prices to increase so sharply that they are now growing at a rate of nearly 15% per annum, which is significantly above the average inflation rate [1].

As a result of the fast rising costs, people who belong to economically weaker sections can no longer afford to buy houses, and the middle-income groups experience ever increasing difficulties in doing so. Besides, the use of traditional materials leads to a significant amount of damage to the environment. The production of cement alone is responsible for almost 8% of the total CO2 emissions worldwide, and the over-exploitation of river sand and clay has caused serious ecological disruption in some places [2]. It is the awareness of such challenges which has started the trend of seeking alternate building materials that are, besides being economical, also environmentally responsible by the researchers, engineers and policymakers together.

Smart and low-cost construction materials have come into limelight as potential options that could replace the traditional materials. These materials include fly ash bricks, AAC blocks, stabilized mud blocks, EPS wall panels, geopolymer concrete, and precast construction units. A large number of materials rely on industrial by-products such as fly ash and slag thus not only minimizing waste disposal problems but also cutting down the embodied energy and emissions [3]. Furthermore, the lightweight nature of materials like AAC blocks and EPS panels helps in the reduction of dead load significantly which translates into savings in structural elements such as foundations, beams, columns, and reinforcement steel [4].

Different studies have shown that in many occasions the adoption of alternative materials allows for huge cost savings without any sacrifice to structural safety or durability. In the case of fly ash bricks, for example, the compressive strength, homogeneity, and water absorption of the bricks are already stipulated to be better than that of the regular clay bricks and on top of that, their use has lessened the cost of construction due to less consumption of mortar [5]. The advantage of AAC blocks in thermal insulation and the speed of construction are the main factors contributing to long-term operational energy savings [6]. The EPS wall panel system not only promotes the efficiency but also combines the insulation and structural performance and therefore is ideal for low-rise residential applications [7]. Research has pointed out several technical and economic advantages of smart materials, yet still their practical implementation is limited in India. A strong set of reasons including lack of knowledge among both builders and house owners, wrong assumptions regarding durability and fire resistance, limited supplier networks, and non-existence of area-specific cost data are all hindering the fast spread of smart materials [8] . Besides, most of the research works done so far have been more or less centered around environmental benefits or large-scale commercial projects, with very little research focusing on small residential buildings such as G+1 or G+2 structures, which are the major part of the housing demand in India [9].

Among the many critical limitations in the literature, the absence of detailed, rate-based comparative cost estimation that encompasses the costs of materials, labor, transportation and finishing under local market conditions is probably the most severe. Life-cycle cost analysis and maintenance considerations are also often neglected, despite their crucial role in determining affordability over the long run [10]. Proposals to overcome these obstacles through systematic reviews and practical estimation-based studies are necessary to establish the use of smart construction materials in the mainstream housing sector. This review paper is set to compile and evaluate the foremost recent studies on the two fronts of conventional versus smart construction materials with a spotlight on cost estimation, sustainability, and the practicality of the latter. By converging the results of recent literature, the investigation attempts to establish a grounding for succeeding research and help the movement of cost-efficient and environmentally friendly building practices that are in harmony with India's goal of sustainable development and housing-for-all initiatives.

B. Problem Definition

The rising price of construction in India has turned out to be a major issue, especially for the housing projects aimed at the low and middle households. The basic building materials like burnt clay bricks, Ordinary Portland Cement (OPC), steel, and river sand have seen a continuous rise in price due to the scarcity of resources, the energy-consuming production processes, and the increase in labor costs[1], [2]. Consequently, the use of traditional materials has become financially unfeasible for a considerable portion of the populace. Besides the economy-related issues, the significant use of traditional materials has brought about severe environmental consequences, such as high carbon emissions, the exhaustion of natural resources, and the disturbance of nature due to the excessive mining of sand and clay[3]. Nevertheless, smart and low-cost construction materials such as fly ash bricks, AAC blocks, EPS wall panels, and geopolymer concrete, although they are claimed to be having a big impact on overall costs and the environment, their use is still not wide-spread[4], [5]. The existing research is mainly directed towards the theoretical or environmental benefits without much discussing the practical, area-specific cost estimation and implementation problems in case of low-rise residential buildings[6]. This void calls for and thus makes it imperative to have realistic, rate-based comparative studies to underpin the provision of affordable and sustainable housing solutions.

II. METHODOLOGY

A. Proposed System

Figure 1. Flow Diagram of system

1) This research employs a working principle that compares conventional building materials and smart/low-cost materials for a house model.
2) The structure of a G+1 house is then chosen as the reference building to demonstrate the practices and to be practical.
3) Jointly working with such materials as clay bricks, OPC cement, RCC, and cement plaster for the base model, smart materials such as fly ash bricks/AAC blocks, EPS wall panels, geopolymer or PPC cement, and gypsum plastering are selected for the other model.
4) Both models are subjected to structural analysis to find out the load distribution, internal forces, and material quantities under the assumption of dead load variation.
5) Standard schedule rates and current market prices are applied to increase the accuracy of quantities and costs.
6) The cost estimates are put side by side to evaluate the reduction of materials and labor and the efficiency of the construction.
7) Indicators like steel and concrete reduction, construction time, and sustainability benefits are studied.
8) The final result points out the Economic and Environmental friendly construction system that is to be used in affordable housing sector.

B. *Main Parameters:*

1) Material Cost: Comparison of unit rates and total cost of conventional materials like clay bricks, OPC cement, and cement plaster with smart/low-cost materials such as AAC blocks, EPS wall panels, fly ash bricks, and gypsum plastering.
2) Structural Weight (Dead Load): Impact of lightweight materials evaluation on the dead load reduction and the resultant size of structural members.
3) Quantity of Materials: Comparison of con crete, reinforcement steel, masonry, and plastering quantities for the two construction systems.
4) Construction Time: Time assessment for the entire process considering prefabrication, easy handling, and quick installation of smart materials.
5) Labor Requirement: Skilled and unskilled labor requirement and cost comparison for conventional and alternative construction methods.
6) Cost of Finishing Works: Plastering, putty, and painting costs evaluation with special reference to the impact of gypsum plastering.
7) Sustainability Factors: Assessment of environmental impact through material usage, waste minimization, and energy efficiency.

C. *Main Parameters Considered for Study*

Table 1 : Main parameters considered for this study

Sr. No.	Main Parameter	Description
1	Material Cost	Comparison of unit rates and total material cost of conventional materials and smart/low-cost construction materials.
2	Dead Load	Evaluation of reduction in self-weight of structure due to use of lightweight materials such as AAC blocks and EPS wall panels.
3	Material Quantity	Analysis of quantities of concrete, reinforcement steel, masonry, and plastering required for both construction systems.
4	Construction Time	Comparison of execution time considering prefabrication, ease of installation, and speed of construction.
5	Labor Requirement	Assessment of skilled and unskilled labor involvement and corresponding labor cost.
6	Structural Performance	Study of structural adequacy in terms of strength, stability, and safety under design loads.
7	Finishing Cost	Comparison of plastering, putty, and painting costs, especially with gypsum plastering.
8	Sustainability Aspect	Evaluation of environmental benefits such as reduced material consumption, waste utilization, and energy efficiency

The comparative study of traditional building materials and smart/low-cost alternatives shows significant differences in terms of cost, material efficiency, and performance. The choice of lightweight materials like AAC blocks and EPS wall panels results in a considerable reduction of the structure's dead weight, hence lowering the amount of concrete and reinforcement steel used. This process directly leads to cost savings and better structural efficiency. The category of alternative materials includes the expensive gypsum plaster, which indeed has a higher unit cost than traditional cement plaster; however, the initial cost is compensated by the absence of extra finishing works, like putty and whitewashing. Moreover, the smart materials make the construction faster because of their unproblematic handling and prefabrication, thus resulting in less labor and shorter project duration. Additionally, from a sustainability edge, the use of industrial waste and energy-efficient materials brings down the environmental footprint and backs up the sustainable construction practice. In summary, the results support the claim that the smart and low-cost materials in construction are an effective way of getting not only economical buildings but also durable and environmentally responsible ones, knowing that the safety and functionality lines are not crossed.

D. Details Of G+1 R.C.C Structure

A G+1 storied R.C.C. framed residential building is proposed for cost estimation on a plot area of 241.12 m², fronting a 7.0 m wide road. After providing necessary side margins as per development control regulations, the building footprint is designed as 8.19 m × 12.78 m. An offset is incorporated in the layout to accommodate car parking efficiently within the plot.

Table 2: Specifications of G+1 Building

Parameter	Specification
Type of Structure	G + 1 R.C.C. framed structure
Floor to Floor Height	3.1 m
Number of Storeys	G + 1
Plot Area	236.33 m²
Built-up Area	198.94 m²
Carpet Area	92.00 m²
Soil Bearing Capacity	300 kN/m²
Flooring	Mosaic tiles
Wall Thickness	0.23 m
Slab Thickness	0.15 m
Plinth Height	0.6 m

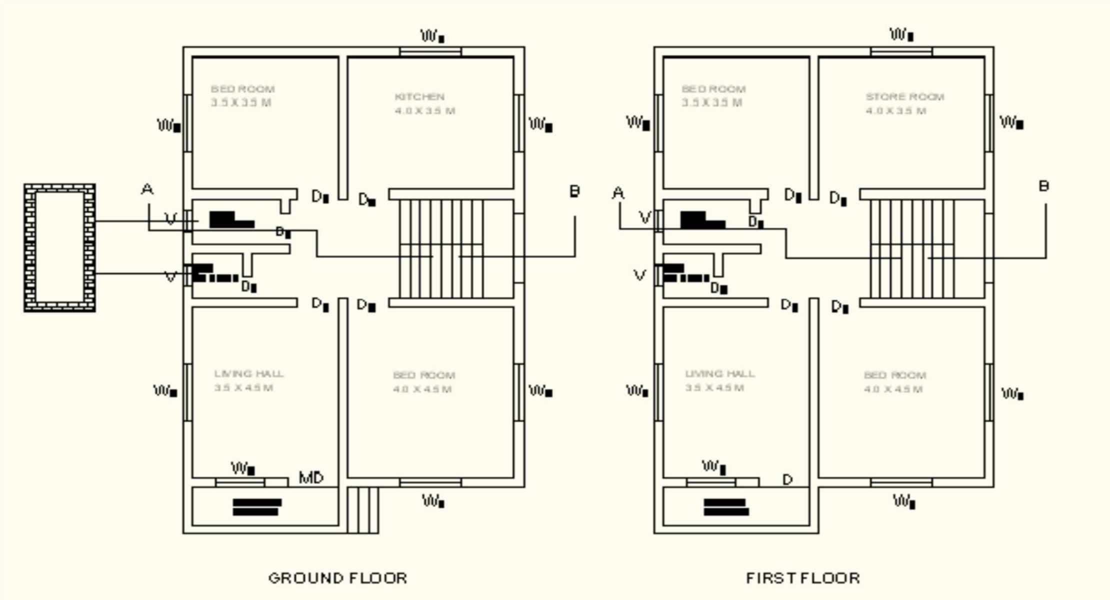

Figure 2. Plan of G+1 Conventional and Green building

III. RESULTS AND DISCUSSION

The present study focuses on the comparative evaluation of a G+1 R.C.C residential building constructed using conventional materials and smart/low-cost construction materials. The analysis includes cost estimation, material consumption, structural performance, construction time, and sustainability aspects. The quantities of materials were calculated using the central line method, and cost estimation was carried out based on standard schedule rates and prevailing market prices.

The results demonstrate that the selection of construction materials plays a crucial role in determining the overall project cost, structural efficiency, and environmental impact. Smart materials such as AAC blocks, EPS wall panels, and gypsum plastering have shown significant advantages over conventional materials like clay bricks and cement plaster. The detailed comparative analysis is presented below.

A. Cost Comparison Analysis

Table 3: Cost Comparison Analysis

Sr. No.	Component	Conventional Cost (₹)	Smart/Green Cost (₹)	Difference (%)
1	Earthwork	4,419	4,419	0%
2	Concrete Work	3,61,394	3,21,417	-11.05%
3	Brickwork / Walling	5,17,991	3,83,468	-25.98%
4	Plinth Filling	63,213	4,512	-92.86%
5	Internal Plaster	88,207	89,752	+1.75%
6	Flooring	15,433	10,845	-29.73%
7	Finishing Works	84,232	97,805	+16.12%
Total	—	12,12,883	9,89,213	-18.44%

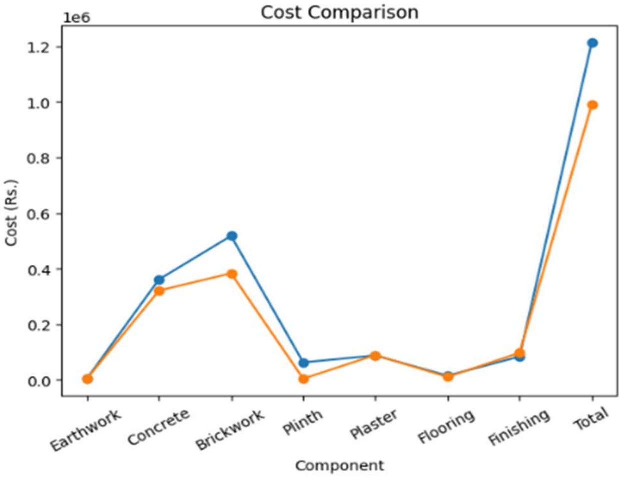

Figure 3. Cost Comparison

The cost comparison clearly shows that smart construction materials significantly reduce total construction cost by approximately 18.44%. Major savings occur in brickwork, plinth filling, and concrete work due to lightweight materials and alternative resource usage, while slight increases in finishing costs are offset by overall savings.

B. Material Quantity Comparison

Table 4: Material Quantity Comparison

Material	Conventional Building	Smart Building	Reduction (%)
Concrete (m^3)	83.08	75.50	9.12%
Steel (kg)	12,500	11,200	10.40%
Bricks/Blocks (m^3)	92.58	70.00	24.40%
Plaster (m^2)	443.60	443.60	0%

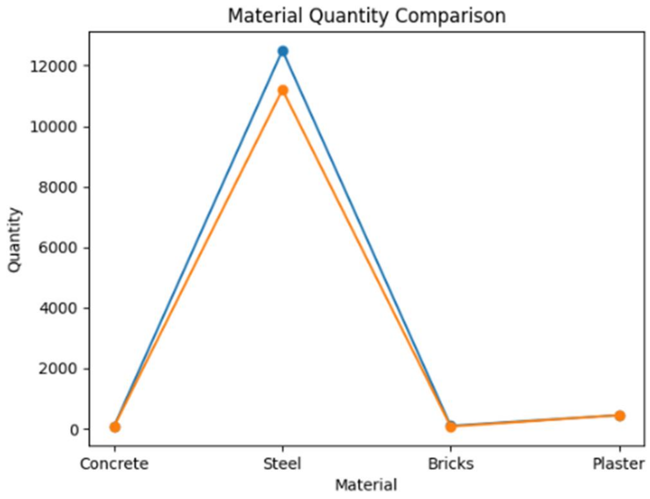

Figure 3. Material Quantity Comparison

The use of lightweight materials reduces the quantity of concrete and steel required due to decreased structural loads. AAC blocks and EPS panels reduce masonry volume, leading to efficient material utilization. However, plastering area remains constant as it depends on wall surface area rather than material type.

C. Dead Load Comparison

Table 5: Dead Load Comparison

Component	Conventional (kN/m²)	Smart Building (kN/m²)	Reduction (%)
Wall Load	5.5	3.0	45.45%
Slab Load	3.75	3.50	6.67%
Total Dead Load	9.25	6.50	29.73%

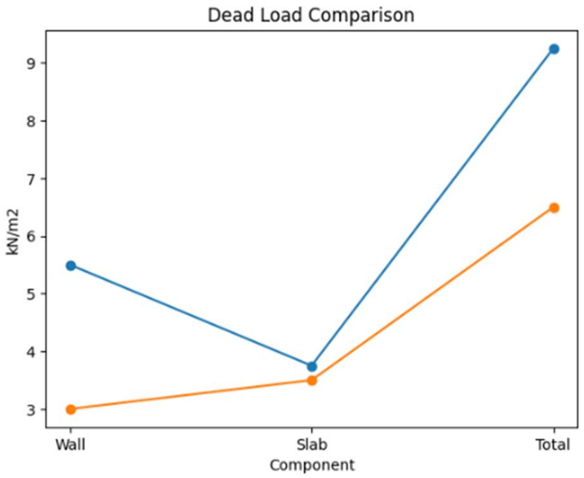

Figure 5. Dead Load Comparison

Smart materials significantly reduce dead load, especially in wall systems where AAC blocks or EPS panels replace heavy brick masonry. This reduction decreases structural stress and allows optimization of beams, columns, and foundations, leading to material and cost savings in the structural system.

D. *Construction Time Analysis*

Table 6: Construction Time Analysis

Activity	Conventional (Days)	Smart Building (Days)	Time Saved (%)
Foundation Work	10	9	10%
Masonry Work	20	12	40%
Plastering	12	8	33%
Finishing	15	10	33%
Total Duration	57 Days	39 Days	31.58%

Figure 6. Construction Time Analysis

Construction time is significantly reduced when smart materials are used due to prefabrication, larger block sizes, and faster installation methods. Reduced curing time and elimination of multiple finishing processes further contribute to faster project completion, leading to lower labor costs and improved efficiency.

E. *Labor Requirement Analysis*

Table 7: Labor Requirement Analysis

Work Type	Conventional (Workers)	Smart Building (Workers)	Reduction (%)
Masonry	10	6	40%
Plastering	8	5	37.5%
Finishing	6	4	33.33%

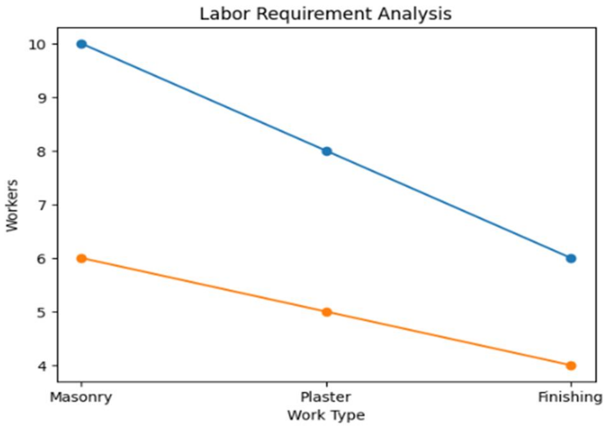

Figure 7. Labor Requirement Analysis

Smart construction materials reduce labor dependency due to ease of handling and faster installation. Larger block sizes and prefabricated components minimize manual effort and repetitive work. This leads to reduced labor cost, lower dependency on skilled workers, and improved construction productivity.

F. Sustainability Comparison

Table 7: Sustainability Comparison

Parameter	Conventional Building	Smart Building
CO_2 Emissions	High	Low
Resource Consumption	High	Reduced
Waste Generation	High	Low
Energy Efficiency	Moderate	High

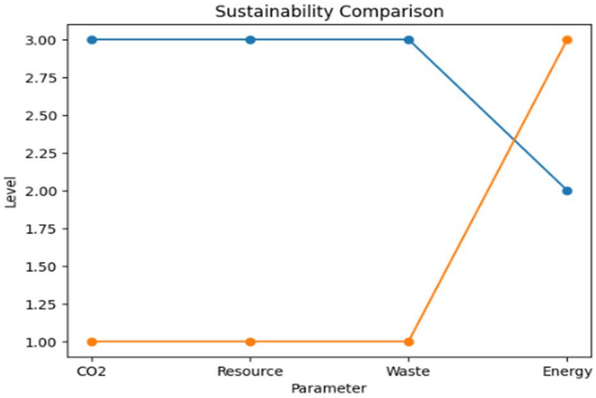

Figure 8. Sustainability Comparison

Smart materials enhance sustainability by utilizing industrial by-products such as fly ash and reducing reliance on natural resources. They lower carbon emissions, minimize construction waste, and improve energy efficiency through better insulation, making them environmentally friendly compared to conventional construction methods.

G. Finishing Cost Analysis

Table 8: Finishing Cost Analysis

Item	Conventional (₹)	Smart Building (₹)
Cement Plaster	88,207	—
Gypsum Plaster	—	89,752
Putty & Whitewash	59,272	—
Total	1,47,479	89,752

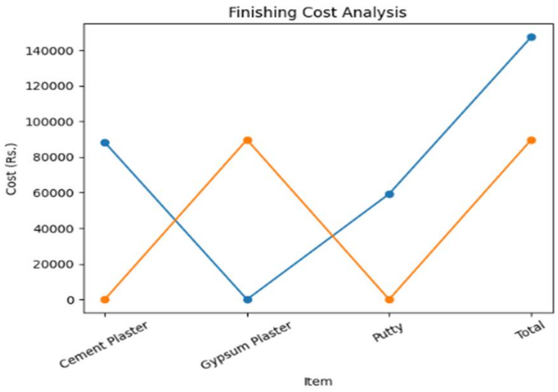

Figure 9. Finishing Cost Analysis

Although gypsum plastering has a slightly higher unit cost than cement plaster, it eliminates the need for additional finishing layers such as putty and whitewashing. This results in overall cost savings and improved surface finish quality, reducing maintenance requirements over time.

The results obtained from this study clearly demonstrate that smart and low-cost construction materials offer substantial advantages over conventional building materials in terms of cost, efficiency, and sustainability. The overall cost reduction of approximately 18.44% highlights the economic feasibility of adopting alternative materials in residential construction.

One of the key factors contributing to cost savings is the reduction in dead load due to lightweight materials such as AAC blocks and EPS wall panels. This reduction directly impacts the design of structural elements, leading to lower consumption of concrete and reinforcement steel. Additionally, the use of industrial waste materials such as fly ash not only reduces construction cost but also contributes to environmental sustainability.

The study also shows that construction time is significantly reduced when smart materials are used. Faster construction not only reduces labor cost but also minimizes project delays, which is a major advantage in modern construction practices. Reduced labor requirement further enhances cost efficiency, especially in regions where skilled labor is scarce.

From a sustainability perspective, smart construction materials play a vital role in reducing carbon emissions, conserving natural resources, and minimizing construction waste. These materials also improve energy efficiency through better thermal insulation, which reduces long-term operational costs of buildings.

However, certain challenges remain, including higher initial cost of some materials, lack of awareness, and limited availability in certain regions. Despite these challenges, the benefits outweigh the limitations, making smart construction materials a viable solution for future construction.

IV. CONCLUSIONS

The present study provides a detailed comparative analysis between conventional construction materials and smart/low-cost (green) construction materials for a G+1 residential building. The results clearly demonstrate that the adoption of smart materials leads to significant economic, structural, and environmental advantages. A total cost reduction of approximately 18.44% is achieved in the green building, primarily due to reduced expenses in brickwork, concrete, plinth filling, and finishing works.

The use of lightweight materials such as AAC blocks and EPS panels reduces the dead load of the structure, resulting in lower quantities of concrete and reinforcement steel. This not only decreases construction cost but also enhances structural efficiency and seismic performance. Additionally, construction time is reduced by nearly 30%, leading to lower labor requirements and improved project efficiency.

From a sustainability perspective, smart materials contribute to reduced CO_2 emissions, efficient utilization of industrial waste, and improved energy efficiency through better thermal insulation. Although certain components like gypsum plaster may have slightly higher initial costs, the elimination of additional finishing processes results in overall savings.

Smart and low-cost construction materials offer a practical, economical, and sustainable solution for modern housing needs and should be widely adopted in future construction practices.

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