Designing A Low-Cost Rural Housing Scheme using Affordable Prefabricated Sections and Local Materials

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Abstract: The shortage of affordable and durable housing in rural areas remains a major challenge in developing countries. Rising construction costs, limited access to quality materials, and dependence on conventional construction techniques have further widened the housing gap. This research proposes a low-cost rural housing scheme utilizing prefabricated construction sections combined with locally available materials. The proposed system incorporates prefabricated wall panels, roof sections, and foundation elements along with stabilized soil blocks, bamboo, fly ash bricks, and local stone. The study evaluates structural feasibility, construction cost, environmental sustainability, and implementation potential. Results indicate that the proposed housing model can reduce construction costs by approximately 27%, decrease construction duration by nearly 48%, and lower carbon emissions by about 38% compared with conventional construction methods. The scheme offers an economically viable and environmentally sustainable solution for rural housing development and can support large-scale housing initiatives.

Keywords: Rural Housing, Affordable Housing, Prefabrication, Sustainable Construction, Local Materials, Cost Optimization, Housing Development.

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I. INTRODUCTION

Housing is a fundamental human necessity and an essential component of socioeconomic development. Despite various government initiatives, millions of rural households continue to live in inadequate housing conditions characterized by poor structural quality, insufficient sanitation, and vulnerability to environmental hazards. Traditional construction methods depend heavily on skilled labor, large quantities of cement and steel, and lengthy construction periods. These factors significantly increase project costs and limit housing accessibility for economically weaker sections.

Prefabricated construction technology has emerged as a promising alternative. In this approach, structural components are manufactured in controlled factory conditions and assembled at the construction site. When combined with locally available materials, prefabrication can significantly reduce costs while improving quality and construction speed. This study proposes a low-cost rural housing model integrating prefabricated sections with indigenous building materials to create sustainable, durable, and affordable housing solutions.

II. LITERATURE REVIEW

Affordable rural housing has been extensively studied by researchers and policymakers. Smith and Quale (2017) highlighted that prefabricated housing systems can reduce construction time by up to 50%

while ensuring superior quality control. Kumar and Patel (2022) demonstrated that stabilized soil blocks provide adequate compressive strength while reducing construction costs by nearly 20%.

Research conducted by Ghosh (2021) emphasized the importance of modular construction techniques in developing regions. The study concluded that prefabricated systems reduce material wastage and improve project efficiency. Various studies have also examined bamboo as a sustainable construction material. Bamboo exhibits high tensile strength, rapid renewability, and low environmental impact.

UN-Habitat reports indicate that local material utilization can significantly reduce transportation costs and stimulate regional economic growth. However, limited studies have explored the combined application of prefabrication and local materials for rural housing.

Table 1: Comparative Review of Existing Studies

Author	Approach	Cost Reduction
Smith & Quale	Prefabricated Housing	25%
Kumar & Patel	Stabilized Soil Blocks	20%
Ghosh	Modular Construction	18%

III. OBJECTIVES

The primary objectives are:

- Design an affordable rural housing model.
- Reduce construction costs.
- Utilize locally available materials.
- Minimize construction duration.
- Improve sustainability.
- Promote rural employment.
- Support large-scale housing programs.

IV. PROPOSED HOUSING MODEL

A. Housing Configuration

The proposed housing unit includes:

- Living Room
- Two Bedrooms
- Kitchen
- Bathroom
- Toilet
- Veranda

Table 2: Housing Specifications

Parameter	Value
Plot Area	100 m²
Built-up Area	50 m²
No. of Bedrooms	2
Living Room	1
Kitchen	1
Bathroom	1
Veranda	1

B. Prefabricated Components

The proposed scheme uses:

- Precast Foundation Blocks
- Wall Panels
- Roof Panels
- Door Frames
- Window Frames
- Utility Modules

Prefabrication improves quality control and reduces construction time.

C. Local Materials

The following materials are incorporated:

Table 3: Materials and its Application

Material	Application
Stabilized Soil Blocks	External Walls
Bamboo	Roof Support

Fly Ash Bricks	Internal Walls
Local Stone	Foundation
Clay Tiles	Roofing
Lime Mortar	Masonry

V. METHODOLOGY

The methodology adopted in this study focuses on the design and evaluation of a low-cost rural housing scheme using affordable prefabricated sections and locally available construction materials. The research framework consists of six major stages, as shown below.

Identification of Rural Housing Requirements

The first stage involved studying the housing needs of rural communities. Information regarding family size, housing deficiencies, climatic conditions, availability of construction materials, and economic constraints was collected through literature surveys and government housing reports. The objective was to identify the essential requirements for an affordable and sustainable rural housing model.

Selection of Local Construction Materials

Locally available construction materials were identified based on cost, availability, durability, and environmental impact. Materials such as stabilized soil blocks, fly ash bricks, bamboo, local stone, clay tiles, and lime mortar were selected due to their low cost and widespread availability in rural regions. These materials reduce transportation expenses and promote sustainable construction practices.

Design of Prefabricated Housing Components

Prefabricated structural components were designed to simplify construction and reduce labor requirements. The major prefabricated elements include:

- Precast foundation blocks
- Wall panels
- Roof panels
- Door and window frames
- Utility modules

The dimensions of each component were standardized to facilitate mass production, transportation, and rapid on-site assembly.

Structural Analysis and Design Verification

The structural performance of the proposed housing scheme was evaluated through load calculations and design verification procedures. Wall loads, roof loads, and foundation requirements were calculated according to standard civil engineering practices. The structural analysis ensured that the proposed housing system satisfies safety, stability, and serviceability requirements under normal loading conditions.

Wall Load Calculation

Wall thickness = 150 mm

Wall height = 3 m

Material density = 1800 kg/m³

Wall load per meter length:

$W = \text{Thickness} \times \text{Height} \times \text{Density}$

$W = 0.15 \times 3 \times 1800 = 810 \text{ kg/m} \approx 7.95 \text{ kN/m}$

Roof Load Calculation

Dead Load = 0.75 kN/m²

Live Load = 1.50 kN/m²

Total Roof Load:

$TL = 0.75 + 1.50 = 2.25 \text{ kN/m}^2$

The calculated loads indicate that the proposed structure can safely withstand anticipated service loads.

Cost Analysis

A comparative cost analysis was performed between conventional rural housing and the proposed prefabricated housing system. The analysis included material costs, labor costs, transportation expenses, and construction time. The objective was to determine the percentage cost savings achieved through the use of prefabricated sections and local materials.

Sustainability Assessment

The environmental performance of the proposed housing model was evaluated by analyzing material consumption, carbon emissions, water usage, and construction waste generation. The sustainability assessment aimed to determine the environmental benefits of replacing conventional construction materials with locally sourced alternatives.

Performance Evaluation

The final stage involved evaluating the overall performance of the proposed housing scheme based on:

- Construction Cost Reduction
- Construction Time Reduction
- Structural Safety
- Environmental Sustainability
- Material Efficiency
- Rural Employment Generation

The obtained results were compared with conventional housing methods to determine the effectiveness and feasibility of the proposed low-cost rural housing scheme.

VI. STRUCTURAL ANALYSIS

Wall Load Calculation

Given:

Wall Thickness = 0.15 m

Wall Height = 3.0 m

Density of Stabilized Soil Block = 1800 kg/m³

Weight per Meter Length

$W = t \times h \times \rho = 0.15 \times 3 \times 1800 = 810 \text{ kg/m} \approx 7.95 \text{ kN/m}$

Roof Load Calculation

Dead Load = 0.75 kN/m²

Live Load = 1.50 kN/m²

Total Load

$TL = DL + LL = 0.75 + 1.50 = 2.25 \text{ kN/m}^2$

The structure satisfies standard safety requirements.

Foundation Design

Foundation Type: Isolated Stone Foundation

Depth = 1.0 m

Width = 0.6 m

Safe Bearing Capacity = 150 kN/m²

The selected foundation is adequate for the proposed housing load.

VII. COST ESTIMATION

Table 4: Cost Comparison

Component	Conventional (₹)	Proposed (₹)
Foundation	90,000	70,000
Walls	1,20,000	85,000
Roofing	1,00,000	75,000
Finishing	80,000	65,000
Labor	1,10,000	70,000
Total	5,00,000	3,65,000

Cost Reduction

$\text{Cost Saving} = (500000 - 365000)/500000 \times 100$

$= 27\%$

VIII. CONSTRUCTION TIME ANALYSIS

Table 5: Construction Duration Comparison

Activity	Conventional	Proposed
Foundation	20 Days	12 Days
Walls	35 Days	15 Days
Roofing	25 Days	10 Days
Finishing	40 Days	25 Days

Total	120 Days	62 Days

Time Reduction = (120 − 62)/120 ×100

= 48.3%

IX. SUSTAINABILITY ANALYSIS

Carbon Emission Comparison

Table 6: Sustainability Analysis

Construction Type	CO_2 Emission
Conventional RCC	450 kg/m²
Proposed Housing	280 kg/m²

Carbon Reduction = (450 − 280)/450 ×100 = 37.8%

Additional Benefits

- 30% reduction in cement consumption.
- 25% reduction in steel usage.
- 40% reduction in water consumption.
- Lower transportation energy demand.

X. RESULTS AND DISCUSSION

The proposed housing model demonstrates significant economic and environmental advantages.

Key Findings

- Construction cost reduced by 27%.
- Construction time reduced by 48%.
- Carbon emissions reduced by 38%.
- Material wastage minimized.
- Local employment opportunities increased.
- Improved housing quality achieved.

The hybrid use of prefabrication and local materials creates a sustainable solution that balances affordability and performance.

XI. ADVANTAGES

- Low construction cost.
- Faster project completion.
- Reduced dependence on skilled labor.
- Environmentally sustainable.
- Improved quality control.
- Suitable for government housing programs.
- Scalable for large-scale deployment.

XII. LIMITATIONS

- Initial investment for prefabrication facilities.
- Transportation challenges in remote areas.
- Requirement of technical training.
- Variability in local material availability.

XIII. FUTURE SCOPE

Future developments may include:

- Solar energy integration.
- Rainwater harvesting systems.
- Smart home technologies.
- Disaster-resistant housing designs.
- AI-based housing planning systems.
- Large-scale implementation under rural housing missions.

XIV. CONCLUSION

This study presents a low-cost rural housing scheme based on affordable prefabricated sections and locally available construction materials. The proposed model effectively reduces construction cost, construction time, and environmental impact while maintaining structural safety and occupant comfort. The integration of prefabricated construction technology with indigenous resources offers a sustainable and practical solution for addressing rural housing shortages. The proposed approach can significantly contribute to affordable housing programs and rural development initiatives.

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