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Research Paper

ECONOMICAL AND SUSTAINABLE HOUSING DESIGN

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Abstract — *Economical and sustainable housing design is an important approach in modern construction that aims to reduce construction cost, minimize environmental impact, and improve energy efficiency while ensuring safety and comfort. With the rapid growth of population and urbanization, the demand for affordable house. The project includes preparation of plan, elevation, structural layout, and cost estimation using standard engineering methods. A comparison between conventional and sustainable construction highlights the advantages in terms of cost savings and resource conservation. The study shows that sustainable housing can reduce cost, conserve resources, and provide safe and comfortable living, making it suitable for low-income housing and developing areas has increased significantly, especially for low- and middle-income groups. This project focuses on designing a residential building using cost-effective planning, locally available materials, and sustainable construction techniques. Eco-friendly materials such as fly ash bricks, stabilized mud blocks, and recycled materials are considered to reduce cost and environmental impact. The design also incorporates energy-efficient features like natural ventilation, rainwater harvesting, and proper building orientation.*

I. INTRODUCTION

Economical and sustainable housing design focuses on providing affordable, resource-efficient, and environmentally responsible residential buildings. Rapid urbanization, population growth, and rising construction costs have created a strong need for housing that minimizes cost without compromising strength, durability, and comfort. Sustainable housing aims to reduce the consumption of natural resources, energy, and water while improving indoor environmental quality and long-term performance.

This approach includes the use of locally available materials, low-cost construction techniques, energy-efficient planning, and environmentally friendly technologies. Proper orientation, natural lighting,

ventilation, rainwater harvesting, and waste reduction methods help lower operational costs and environmental impact. Economical and sustainable housing not only reduces construction and maintenance expenses but also promotes social and environmental sustainability.

Therefore, economical and sustainable housing design plays a vital role in meeting the growing demand for affordable homes while ensuring efficient use of resources and protection of the environment for future generations.

II. LITERATURE REVIEW

- ◆ **Kumar R. et al. by (2024):** “Sustainable Development of Low-Cost Housing Using Agricultural Waste Materials” (2024) by Kumar R. et al. reports that the use of fly ash bricks and rice husk ash in construction reduces material cost by approximately 20–25%. The study highlights that these materials also improve thermal insulation and reduce environmental impact.
- ◆ **Sharma A. et al. by (2023):** “Cost Effective Housing Techniques for Developing Countries” (2023) by Sharma A. et al. discusses various low-cost construction techniques such as rat-trap bond masonry and filler slab construction. The study shows that these methods can reduce overall construction cost by about 15–30% without compromising structural safety.
- ◆ **Reddy P. et al. by (2024):** “Use of Stabilized Mud Blocks in Sustainable Housing Construction” (2024) by Reddy P. et al. reports that stabilized mud blocks reduce cement consumption by nearly 40% and provide better thermal comfort compared to conventional bricks. The study emphasizes their suitability for rural and semi-urban housing.
- ◆ **Patel V. by (2023):** “Energy Efficient Building Design for Sustainable Housing” (2023) by Patel V. explains that proper building orientation, natural ventilation, and daylight utilization can reduce energy consumption by approximately 25–35%. The study highlights the importance of passive design techniques.
- ◆ **Singh M. et al. by (2025):** “Comparative Study of Conventional and Sustainable Building Materials”

(2025) by Singh M. et al. reports that eco-friendly materials such as fly ash bricks and recycled aggregates reduce carbon emissions by about 30% compared to

traditional materials. The study also highlights long-term cost savings.

♦ **Gupta N. by (2024):** “Rainwater Harvesting Systems in Residential Buildings” (2024) by Gupta N. shows that implementing rainwater harvesting can reduce water demand by approximately 40–50% in residential buildings. The study emphasizes its importance in sustainable housing design.

♦ **Mehta D. et al. by (2023):** “Affordable Housing Design Using Local Materials” (2023) by Mehta D. et al. reports that using locally available materials reduces transportation cost by around 10–20% and supports regional sustainability. The study highlights the importance of site-specific design.

♦ **Verma S. by (2024):** “Green Building Practices for Economical Housing” (2024) by Verma S. explains that incorporating green building practices such as solar panels and efficient insulation can reduce operational cost by approximately 20–30%. The study emphasizes long-term economic benefits.

♦ **Khan I. et al. by (2025):** “Waste Recycling in Construction for Sustainable Development” (2025) by Khan I. et al. reports that using recycled materials like construction waste and plastic reduces landfill waste and lowers construction cost by about 10–15%.

♦ **Joshi H. by (2023):** “Thermal Comfort Analysis in Low-Cost Sustainable Housing” (2023) by Joshi H. highlights that sustainable housing designs with proper ventilation and insulation maintain indoor temperature 3–5°C lower than conventional buildings, improving comfort without additional energy use.

III. METHODOLOGY

1. Preliminary Data Collection

An assumed site layout is selected to represent typical residential building conditions.

Basic project requirements such as number of floors (G+1), room distribution, and functional spaces are defined.

2. Site Surveying and Measurement

Standard surveying methods (chain surveying, levelling, and tape measurements) are used to obtain site dimensions, ground levels, and boundary details. The collected survey data forms the base for preparing the plot plan and layout.

3. Architectural Planning & Drawing

Space requirements, ventilation, circulation, and aesthetic considerations are analyzed. AutoCAD is used to prepare the site plan, floor plans, elevations, and sections. Planning adheres to National Building Code (NBC) rules and local building by-laws.

4. Structural Design

Structural components such as footings, beams, slabs, and columns are designed using IS codes (IS 456:2000, IS 875). Load calculations (dead load, live load, and wind load) are performed to ensure safety and stability. Structural drawings are finalized in AutoCAD.

5. Quantity Takeoff (Estimation)

Measurements of each structural and non-structural component are taken from the drawings. Quantities of materials such as cement, steel, aggregate, bricks, and shuttering are calculated following IS 1200 measurement standards. A Bill of Materials (BOM) is prepared.

6. Rate Analysis

Market rates for materials, labor, and machinery are collected from standard sources such as PWD Schedule of Rates.

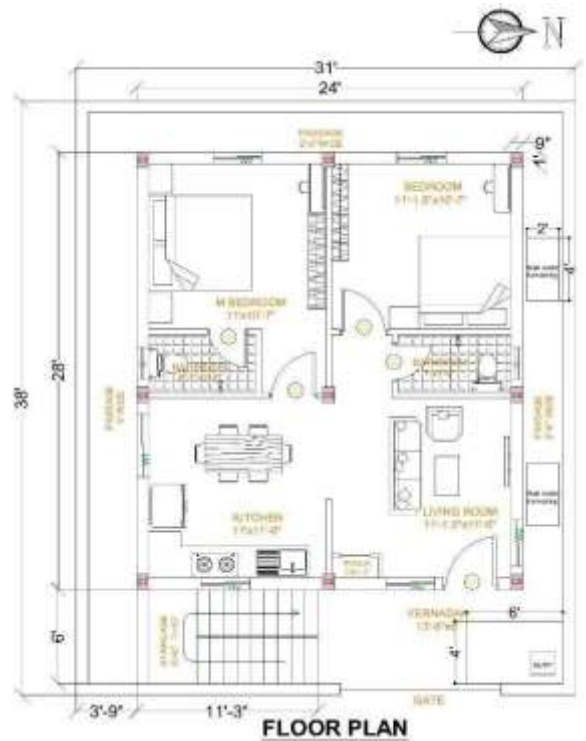
SUSTAINABLE FEATURES

The present study incorporates sustainable materials and practices to achieve an economical and environmentally responsible housing design. Kaavi flooring, a traditional lime-based finish, is adopted due to its low embodied energy, durability, and ability to maintain indoor thermal comfort. Fly ash bricks are utilized as an alternative to conventional clay bricks, effectively reducing soil depletion and promoting the reuse of industrial waste. In addition, AAC (Autoclaved Aerated Concrete) blocks are employed to minimize structural dead load and enhance thermal insulation, thereby contributing to improved energy efficiency of the building. Gypsum plaster is used in place of conventional cement plaster, which eliminates the need for curing, reduces water consumption, and accelerates construction time while providing a smooth surface finish. Furthermore, rainwater harvesting pits are integrated into the design to collect and recharge groundwater, ensuring sustainable water management and reducing dependence on external water sources. Collectively, these materials and techniques significantly reduce environmental impact, construction cost, and resource consumption, making the proposed housing design both economical and sustainable.

IV BUILDING PLANNING AND DESIGN

1. Plot Details

The selected plot for the proposed economical and sustainable housing design is planned to utilize maximum available space efficiently. The plot size is considered to accommodate basic residential requirements such as living room, kitchen, bedrooms, and sanitary facilities. Proper setbacks are maintained for ventilation, lighting, and future expansion. The plot selection also considers accessibility, drainage, and orientation for sustainable performance.

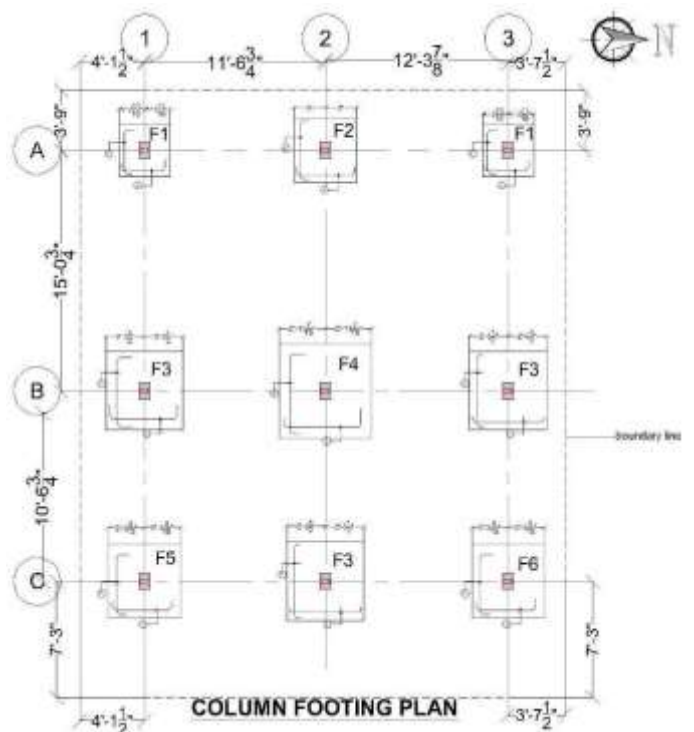


COLUMN FOOTING PLAN

3. Building Layout

The building layout is designed to provide functional space planning with minimum circulation area to reduce construction cost. All rooms are arranged in a compact manner to avoid wastage of space. The living room is placed near the entrance, followed by bedrooms for privacy. The kitchen is located with proper ventilation and access to utility space. Toilets are grouped together to reduce plumbing cost and improve efficiency. The plan of the proposed house includes essential rooms such as living room, bedrooms, kitchen, and bathroom. The room sizes are designed based on minimum standard dimensions to maintain economy. Proper door and window positions are provided to allow natural light and cross ventilation. The planning also ensures smooth movement between rooms and effective use of floor area.

Different footing types from F1 to F6 are provided for columns C1 to C9. Footing sizes vary from 1.0 m × 1.0 m to 1.8 m × 1.8 m based on load. Footing depth ranges from 250 mm to 400 mm. Reinforcement is provided using 8 mm and 10 mm bars at 150 mm spacing. This footing layout safely transfers column loads to the soil.

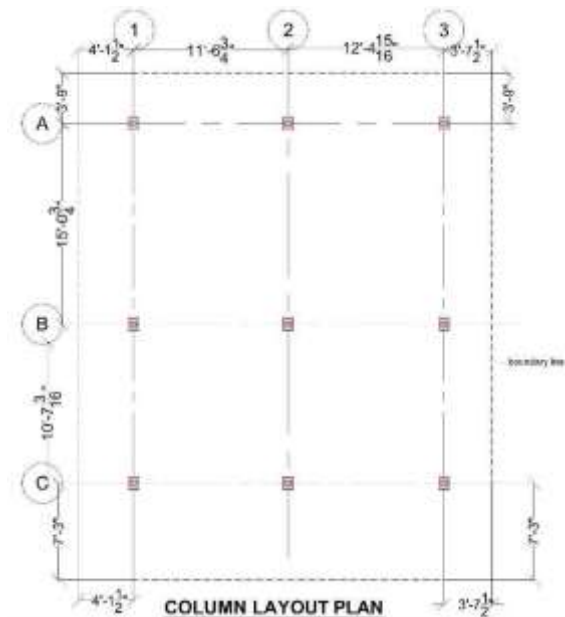


FOOTING	COLUMN	SIZE(mm)	DEPTH(mm)	REINFORCEMENT
F1	C1,C3	1.0x1.0	250	8mm @150 c/c both direction
F2	C2	1.2x1.2	300	8mm @150 c/c both direction
F3	C4,C6,C8	1.5x1.5	350	10mm @180 c/c both direction
F4	C5	1.8x1.8	400	10mm @180 c/c both direction
F5	C7	1.6x1.6	350	10mm @180 c/c both direction
F6	C9	1.6x1.6	350	8mm @150 c/c both direction

GROUP	COLUMN	SIZE(mm)	MAIN STEEL	TIE BAR	DRAWING	Scale (1/2)
G1	C1,C3	230x300	#4-18mm dia	8mm @100 (joint upto 500mm) @150(mid span)		
G2	C2	230x300	#4-18mm dia	8mm @100 (joint upto 500mm) @150(mid span)		
G3	C4,C6	230x300	#6-18mm dia	8mm @100 (joint upto 500mm) @150(mid span)		
G4	C5	230x300	#6-18mm dia	8mm @100 (joint upto 500mm) @150(mid span)		
G5	C7	230x300	#6-18mm dia	8mm @100 (joint upto 500mm) @150(mid span)		
G6	C8,C9	230x300	#6-18mm dia	8mm @100 (joint upto 500mm) @150(mid span)		

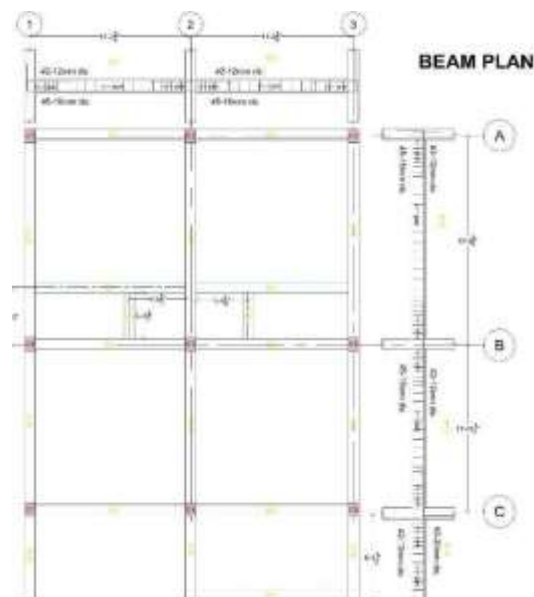
COLUMN LAYOUT

This is a Column Layout Plan that shows the position of columns, distance between them, and structural details. Columns (C1–C9) are arranged using grid lines (A–C, 1–3). Each column has a size of 230×300 mm with different steel reinforcement as per groups (G1–G6). Tie bars (8mm) are provided at specified spacing. The plan also includes dimensions, boundary line, and north direction, which helps in accurate construction at site.



BEAM PLAN

This is a Beam Layout and Reinforcement Table that shows the grouping of beams, their sizes, and reinforcement details. Beams are categorized into groups (G1–G7), where each group includes specific beam numbers (B1, B2, B3, etc.). All beams generally have a uniform size of 230×300 mm. The main reinforcement consists of different combinations of 12 mm, 16 mm, and 20 mm diameter bars depending on the load and position of the beam. Shear reinforcement (stirrups) of 6 mm diameter is provided with closer spacing near supports (around 100 mm c/c) and wider spacing at mid-span (around 200 mm c/c). This table helps in identifying beam details, ensuring proper reinforcement placement, and guiding accurate construction on site.



GROUP	BEAM	SIZE(mm)	MAIN STEEL	STIRRUPS	DRAWING	Scale (1:2)
G1	R1,R2,R11, R15,R7	250x300	<ul style="list-style-type: none"> Φ12-12mm dia Φ8-12mm dia 	Stirrups @100 (cont upto 500mm @200) (1st storey)		
G2	R13,R14,R13,B8	250x300	<ul style="list-style-type: none"> Φ12-12mm dia Φ8-12mm dia 	Stirrups @100 (cont upto 500mm @200) (1st storey)		
G3	R3,B4,B5,B6	230x300	<ul style="list-style-type: none"> Φ12-12mm dia Φ8-12mm dia 	Stirrups @100 (cont upto 500mm @200) (1st storey)		
G4	R5,S51,R52	250x300	<ul style="list-style-type: none"> Φ12-12mm dia Φ8-12mm dia 	Stirrups @100 (cont upto 500mm @200) (1st storey)		
G5	R13	250x300	<ul style="list-style-type: none"> Φ12-12mm dia Φ8-12mm dia 	Stirrups @100 (cont upto 500mm @200) (1st storey)		
G6	R16,B18	250x300	<ul style="list-style-type: none"> Φ12-12mm dia Φ8-12mm dia 	Stirrups @100 (cont upto 500mm @200) (1st storey)		
G7	R17	250x300	<ul style="list-style-type: none"> Φ12-12mm dia Φ8-12mm dia 	Stirrups @100 (cont upto 500mm @200) (1st storey)		

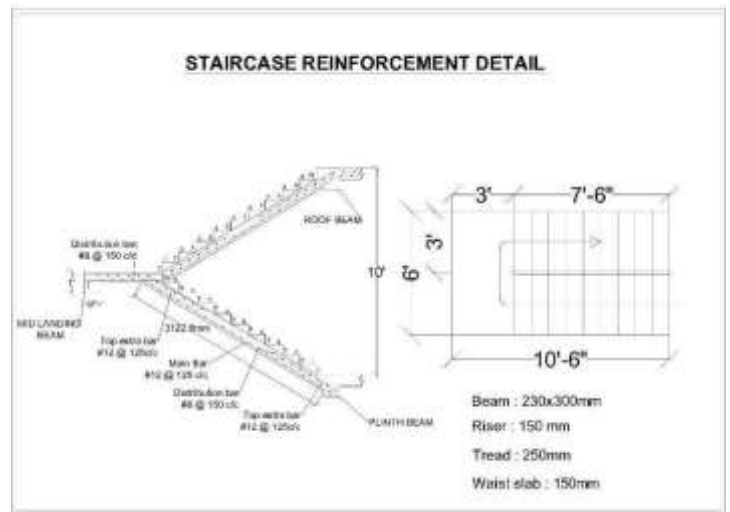
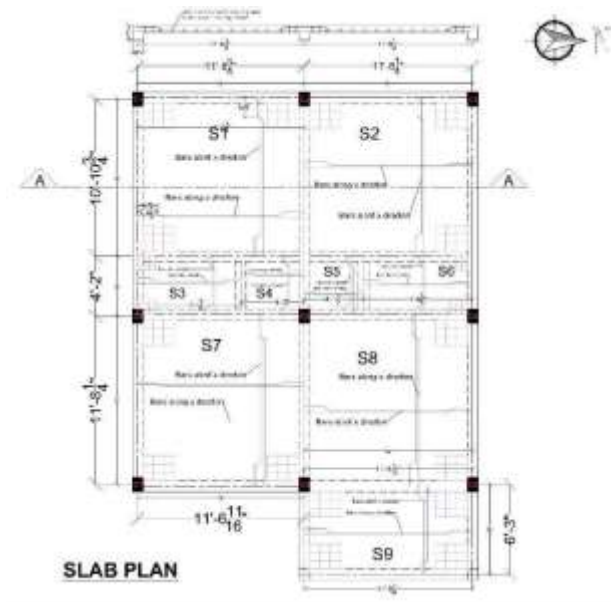
GROUP	SLAB	DEPTH(mm)	REINFORCEMENT		TORSION REINFORCEMENT
			Along x-axis	Along y-axis	
G1	S1,S2	140	mid - 8mm @250c/c edge - 8mm @200c/c	mid - 8mm @250c/c edge - 8mm @200c/c	T1 - 6mm @150c/c T2 - 6mm @200c/c
G2	S3,S4,S5,S6	140	mid - 8mm @250c/c edge - 8mm @200c/c	mid - 8mm @250c/c edge - 8mm @200c/c	T1 - 6mm @150c/c T2 - 6mm @200c/c
G3	S7	140	mid - 8mm @250c/c edge - 8mm @150c/c	mid - 8mm @250c/c edge - 8mm @200c/c	T1 - 6mm @150c/c T2 - 6mm @200c/c
G4	S8	140	mid - 8mm @250c/c edge - 8mm @150c/c	mid - 8mm @250c/c edge - 8mm @200c/c	T - 6mm @150c/c
G5	S9	140	mid - 8mm @250c/c edge - 8mm @250c/c	mid - 8mm @250c/c edge - 8mm @200c/c	T1 - 6mm @150c/c T2 - 6mm @200c/c

SLAB PLAN

This is a Slab Layout and Reinforcement Plan that shows the grouping of slabs, their thickness, and reinforcement details. Slabs are categorized into groups (G1–G5), which include slab panels (S1, S2, S3, etc.). All slabs have a uniform depth of 140 mm. Reinforcement is provided in both x and y directions with 8 mm diameter bars, where spacing varies between mid-span and edges (closer spacing at edges for higher stress zones). Additional torsion reinforcement is provided at slab corners using 6 mm bars with specified spacing and length, especially where slabs are discontinuous. This plan helps in proper placement of reinforcement, ensures structural stability, and guides accurate slab construction at site.

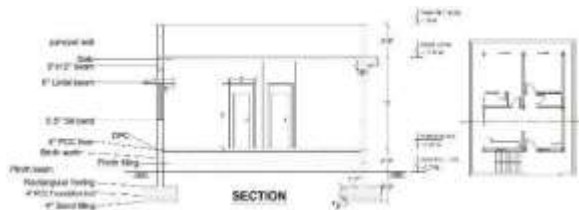
STAIRCASE DETAIL

This is a Staircase Reinforcement Detail that shows the structural arrangement, dimensions, and steel reinforcement of the staircase. The staircase consists of two flights with a mid-landing, connecting the plinth beam to the roof beam. The riser is 150 mm and the tread is 250 mm, providing comfortable movement. The waist slab thickness is maintained uniformly, and the beam size supporting the staircase is 230x300 mm. Main reinforcement bars (12 mm dia) are provided along the slope of the staircase, with additional top extra bars near supports and landings to resist negative bending moments. Distribution bars (8 mm dia) are placed perpendicular to the main bars for proper load distribution. This detail ensures strength, stability, and safe load transfer throughout the staircase structure.



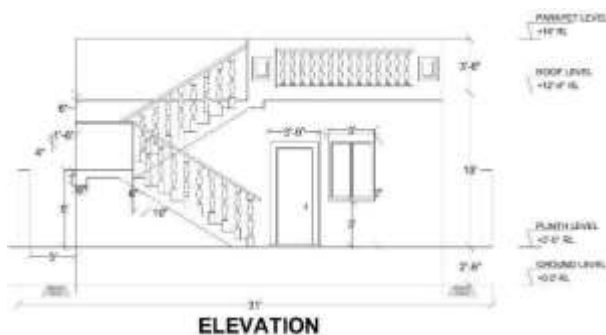
4. Section

The sectional view of the building shows the internal structural details such as foundation, plinth level, floor height, lintel level, and roof slab. Standard floor-to-floor height is maintained to reduce material consumption. Proper damp proof course is provided at plinth level to prevent moisture entry. The section also shows roof insulation and ventilation provisions for sustainable performance.



5. Elevation

The elevation of the building is kept simple to reduce construction cost. Minimal architectural projections and decorative elements are used. The design includes standard window sizes, sunshades, and simple roof profile. Light-colored exterior finish is suggested to reduce heat absorption and improve thermal comfort. The elevation is designed to achieve both economy and aesthetic appearance.



6. ROOF PLAN

The roof plan is designed as a flat RCC slab to ensure economy and ease of construction. The layout follows the building plan without unnecessary projections, reducing material and labor costs. A proper slope is provided towards rainwater outlets to ensure effective drainage, with a limited number of rainwater pipes placed at suitable positions.

A weatherproofing course is applied over the slab to prevent leakage and improve durability. The roof surface is finished with a light-colored or reflective treatment to reduce heat absorption and enhance thermal comfort inside the building. A parapet wall of standard height is provided along the edges for safety and a clean appearance.

Provision is also made for overhead water tank placement and future solar panel installation. Overall, the roof plan is simple, functional, and cost-effective while maintaining durability and efficiency.



ROOF PLAN

QUANTITY TAKEOFF

Quantity takeoff is a fundamental step in construction project planning, involving the systematic calculation of material quantities from architectural and structural drawings. It includes detailed estimation of components such as concrete, reinforcement steel, masonry, plastering, flooring, and finishing works based on standard measurement practices. The quantities are derived by analyzing dimensions, specifications, and design details provided in plans, sections, and elevations. Accurate quantity takeoff plays a vital role in cost estimation, budgeting, and resource management. It also helps in minimizing material wastage, optimizing construction efficiency, and ensuring effective project execution.

S.No	Particulars	Quantity	Units
1	Site cleaning	109.4305152	sqm
2	Excavation	29.418	cum
3	Sand filling	1.99	cum
4	PCC For Footing	1.735	cum
5	Footing	5.8645	cum
6	Footing concrete shuttering	16.26	sqm
7	Pedestrial column	0.29808	cum
8	Pedestrial column shuttering	4.284	sqm
9	Back filling	10.0143	cum
10	Plinth beam base	0.6224	cum
11	Plinth beam	3.7347	cum
12	Plinth beam shuttering	32.47608	sqm
13	Brick work up to DPC bottom	5.27838	cum
14	DPC on brick work (1:4:8)	0.6109	cum
15	Bitumen coat on dpc	12.2184	sqm
16	Plinth filling	34.95	cum
17	Floor PCC	5.2793	cum
18	Brick work super structure	19.763	cum
19	Sill bend	0.1355	cum
20	Sill bend shuttering	8.766	sqm
21	Lintel beam	0.99	cum
22	Lintel beam shuttering	13.868	sqm
23	Column	2.15	cum
24	Column shuttering	33.02	sqm
25	Staircase	1.3132	cum
26	Staircase shuttering	11.3	sqm
27	Slab beam	11.3	cum
28	Slab beam shuttering	4.3591	sqm
29	Slab	25.88	cum
30	Slab shuttering	7.2335	sqm
31	6mm plastering	55.64	sqm
32	Gypsum plaster	177.222	sqm
33	15mm plaster	151.722	sqm
34	White wash	207.365	sqm
35	PUTTY	55.64304151	sqm
36	Primer	55.64304151	sqm
37	Inner paint	232.865	sqm
38	Outer paint	151.722	sqm
39	Door frame	0.24	cum
40	Door shutter	7.536	sqm
41	Door fitting		
	L-drop	5	no.s
	Latch	5	no.s
	Handle	10	no.s
	Tower bolt	5	no.s

	Hinges	15	no.s
42	Aluminium windows	5.95	sqm
43	Mosquito net	5.95	sqm
44	Window grill	5	no.s
45	kaavi flooring	45.508	sqm
46	Tile flooring	4.037	sqm
47	Kota flooring	30.3211	sqm
48	Skirting tile	4.7752	sqm
49	Wall tile	28.92	sqm

RATE ANALYSIS

Rate analysis is the process of determining the cost per unit of various construction activities by considering material, labor, equipment, and overhead expenses. It involves detailed calculation of quantities of materials, labor requirements, and their respective rates based on standard data and local market conditions. The analysis also includes additional factors such as transportation, wastage, contractor’s profit, and contingencies. Rate analysis is essential for preparing accurate cost estimates, tender documents, and project budgeting. It ensures transparency in cost calculation and helps in achieving economical and efficient construction management.

The estimated cost is calculated by multiplying the quantities of materials with their respective unit rates obtained from standard schedule of rates and market analysis. The overall cost of the building is approximately ₹24,40,000, and the total proposed area is 1178 sq.ft.

CONCLUSION

The study on economical and sustainable housing design demonstrates that it is possible to achieve cost-effective construction without compromising structural safety and functional requirements. By adopting efficient planning, optimized structural design, and the use of alternative materials such as fly ash bricks, AAC blocks, and gypsum plaster, the overall construction cost can be significantly reduced. The integration of sustainable practices like rainwater harvesting and proper orientation for natural lighting and ventilation further enhances environmental performance.

The project also highlights the importance of accurate quantity takeoff and simplified cost estimation methods in effective project planning and budgeting. The comparison with conventional construction methods shows that the proposed approach is both economical and environmentally responsible. Hence, this design can serve as a practical solution for affordable housing while promoting sustainability in the construction industry.

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