

Design And Analysis of Green Roof Buildings Using ETABS

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Abstract- Green roofs are an innovative solution to urban environmental challenges, offering benefits such as thermal insulation, stormwater management, and extended roof lifespan. With the rapid growth of sustainable construction, integrating structural analysis tools like ETABS in designing green roof systems is vital. This research focuses on the structural design and performance analysis of buildings with green roofs using ETABS. A comparative study with conventional roofs is also presented, considering various load conditions and structural behavior under Indian building codes. The results demonstrate the structural feasibility of green roofs and their influence on building performance.

I. INTRODUCTION

Urbanization has led to environmental issues like the urban heat island effect, excessive stormwater runoff, and energy inefficiencies in buildings. Green roofs—comprising vegetation, a drainage layer, waterproof membranes, and soil—offer a sustainable architectural response.

This paper explores the design, structural behavior, and analysis of green roof buildings using ETABS. The study involves modeling a green-roof-integrated G+5 RCC building and comparing it with a similar building using a conventional roof system.

II. LITERATURE REVIEW

Research indicates green roofs improve energy efficiency, reduce rooftop temperatures, and mitigate storm water runoff. Studies by Berndtsson (2010) and Oberndorfer et al. (2007) validate the environmental and structural benefits of green roofs.

Structural challenges identified include increased dead loads, waterproofing issues, and potential plant-root interactions with concrete. Modern design tools like ETABS are being increasingly adopted to simulate real-world performance and ensure structural adequacy.

III. METHODOLOGY

3.1 Building Model Details

- Building Type: G+5 RCC residential
- Location: Bhopal, India
- Design Code: IS 456:2000, IS 875 (Part 1-5), NBC 2016

3.2 Green Roof Composition

- Soil and vegetation layer: 150 mm
- Drainage and waterproofing: 100 mm
- Total load: approx. 2.5 to 3.5 kN/m²

3.3 Software Used: ETABS 2018

- Load analysis: dead load, live load, green roof load, wind load, seismic load
- Load combinations: per IS 875 and IS 1893
- Structural checks: member sizing, deflection, support reactions

(Diagram 1: 3D model of green roof building in ETABS)

IV. LOAD CONSIDERATIONS

The green roof increases the dead load significantly compared to conventional roofs. Additional considerations include:

- Live Load: 1.5 kN/m²
- Green Roof Dead Load: ~3.5 kN/m² (vegetation, soil, membrane)
- Wind Load: As per IS 875 Part 3
- Seismic Load: Zone II, medium soil (IS 1893)

(Diagram 2: Load distribution comparison between green roof and normal roof)

V. STRUCTURAL ANALYSIS USING ETABS

5.1 Modeling

- RCC frame modeled with M30 grade concrete
- Slab thickness: 150 mm

- Beams: 230x450 mm
- Columns: 300x600 mm

5.2 Results

- Story displacements within permissible limits\
- Slight increase in bending moments due to green roof
- Column axial loads increased by 10–15%

5.3 Comparative Summary

Parameter	Green Roof	Conventional Roof
Roof Dead Load	~6.5 kN/m ²	~3.0 kN/m ²
Max Beam BM	90 kNm	72 kNm
Column Load	650 kN	580 kN
Deflection	14 mm	11 mm

VI. SUSTAINABILITY AND ENERGY EFFICIENCY

Green roofs reduce building energy demands:

- Decreased HVAC loads
- Enhanced thermal mass
- Reduced roof surface temperatures by 20–30°C

ETABS modeling doesn't directly simulate thermal effects but helps accommodate structural design adjustments to incorporate insulation benefits.

VII. COST-BENEFIT ANALYSIS

Though green roofs involve higher initial costs (15–25% more), long-term savings arise from:

- Lower energy bills
- Reduced HVAC equipment wear
- Extended roof membrane life
- Potential LEED/BEE credits

VIII. RECOMMENDATIONS FOR IMPLEMENTATION

- Use lightweight soil alternatives to reduce loading
- Regular maintenance plan to prevent waterlogging
- Use waterproofing membranes resistant to root penetration
- Account for irrigation system loads

IX. CONCLUSION

Green roof buildings are structurally viable and environmentally beneficial. ETABS is an effective tool for analyzing such systems under Indian standards. This research establishes a methodology to design and assess green roof buildings, supporting their widespread adoption in sustainable urban development.

REFERENCES

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