

Analysis And Design Of (G+5) Commercial Building Using ETABS

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ABSTRACT

This study presents the analysis and design of a reinforced concrete commercial building using ETABS software. The work focuses on developing a safe, economical, and serviceable structural system by considering architectural planning, load estimation, structural modelling, member design, and reinforcement detailing. The building is designed as an R.C.C. framed structure with columns, beams, slabs, footings, and floor diaphragms to resist gravity and lateral loads. Material grades such as M20 concrete for beams and slabs, M25 concrete for columns and footings, and Fe500 steel reinforcement are adopted. Dead loads, live loads, wall loads, floor finish loads, and seismic load combinations are considered as per relevant Indian Standards, including IS 456:2000 and IS 875. ETABS is used to generate the 3D model, analyze structural responses, and verify design adequacy. The study demonstrates software-based structural analysis for improving design accuracy, safety, and construction efficiency.

Keywords: ETABS, RCC Building, Structural Analysis, Load Combination, Reinforced Concrete Design

I. INTRODUCTION

A building is a civil engineering structure composed of foundations, columns, beams, slabs, floors, roofs, walls, doors, windows, stairs, lifts, and surface finishes. Structural analysis and design are required to produce a safe and serviceable structure capable of resisting applied loads throughout its intended life.

The thesis report emphasizes that structural design should begin with the collection of necessary site and supporting-soil information through geotechnical investigation. Such information supports foundation design and helps structural engineers develop efficient and economical structural systems while maintaining accuracy, durability, and serviceability.

The design process in this work includes architectural planning, beam layout, reinforcement detailing, structural planning, load estimation, structural analysis, member design, and preparation of drawings and schedules. ETABS software is used to support modelling, analysis, and verification of the reinforced concrete structure.

1.1 Objectives

- To identify and record all input requirements, analysis assumptions, and design criteria.
- To develop a safe and stable structural scheme compatible with Indian Standards, architectural requirements, services requirements, and client needs.
- To prepare a structural design that supports durability and structural integrity.
- To achieve desirable structural performance under characteristic service loads.

II. LITERATURE REVIEW

Previous work on multi-storey reinforced concrete buildings has emphasized the influence of architectural configuration, structural analysis quality, design method, and reinforcement detailing on building safety. Varalakshmi et al. [1] studied a G+5 commercial building and concluded that overall safety depends on the initial architectural and structural configuration, analysis quality, and ductile detailing. Chandrasekhar et al. [2] analyzed a G+5 structure in ETABS under lateral loading and reported the usefulness of ETABS for reducing design time in high-rise building studies. Balaji and Selvarasan [3] examined static and dynamic loading conditions for a G+13 building using ETABS and assessed responses such as displacement and base shear. Geethu et al. [4] compared STAAD.Pro and ETABS and reported differences in bending-moment and axial-force outputs. Aman et al. [5] discussed software-based analysis and design of multi-storey structures using STAAD Pro. These studies establish the relevance of software-aided analysis and design for RCC building systems.

III. METHODOLOGY

3.1 Project Description and Design Basis

The project considered in the thesis is the construction of the Backward Class Post Metric Girls Hostel Building at Chandapur village, Chincholi Taluka, Dist. Kalburagi, Karnataka. The project description reports a Ground + 2 upper-floor building with typical floor height of 3.45 m and total height of 6.9 m from ground level. The structure is described as an R.C.C. framed building in which the frame acts as the lateral-force-resisting system.

Table 1. Project description and design basis retained from the thesis.

Parameter	Value
Project	Construction of Backward Class Post Metric Girls Hostel Building
Location	Chandapur village, Chincholi Taluka, Dist. Kalburagi, Karnataka
Structural system	R.C.C. framed structure with floor slabs acting as diaphragms
Floor arrangement reported	Ground + 2 upper floors only
Typical floor height	3.45 m
Total height reported	6.9 m from ground level
Software used	ETABS 9.7.4
Design method	Limit State Method as per IS 456:2000
Soil bearing capacity	35.0 T/m ² / 350 kN/m ²
Foundation condition	Fixed condition

3.2 Codes and Standards

The design work follows Indian Standard provisions for loads, concrete design, reinforcement detailing, and foundation design.

Table 2. Structural design standards and codes.

Code	Use in design
IS 875 (Part 1): 1987	Dead loads and unit weights of building and stored materials
IS 875 (Part 2): 1987	Imposed loads
IS 456: 2000	Plain and reinforced concrete code of practice
SP 16	Design charts for reinforced concrete beams and columns
SP 34	Handbook on concrete reinforcement and detailing
IS 1904	Code of practice for design and construction of foundations in soil
IS 3370 (Parts I to IV)	Concrete structures for storage of liquids

3.3 Material and Loading Parameters

Table 3. Material parameters used in the design.

Parameter	Value
Concrete for columns and footings	M25
Concrete for beams and slabs	M20
Concrete for filling/leveling/non-structural work	M10
Reinforcement	Fe500 TMT bars conforming to IS 1786
Density of reinforced concrete	25.0 kN/m ³
Density of plain concrete	24.0 kN/m ³
Density of steel	78.5 kN/m ³
Density of solid concrete block	19.0 kN/m ³
Density of light-weight cinder filling	12.0 kN/m ³
Density of water	9.81 kN/m ³
Density of plaster	20.00 kN/m ³

Table 4. Gravity and wall loading parameters.

Load item	Value
Floor finish load on typical slab	1.5 kN/m ²
Floor finish load on stair	1.5 kN/m ²
Floor finish load on terrace slab	3.0 kN/m ²
Rooms, warden office, kitchen, toilets	2.00 kN/m ²
Store room, washing area	3.0 kN/m ²
Lobby/corridor/staircase	5.0 kN/m ²
Terrace load	1.5 kN/m ²
230 mm solid concrete block wall at typical slab level	14 kN/m

100 mm solid concrete block wall at typical slab level	7.50 kN/m
230 mm solid concrete block parapet wall at terrace level	5.06 kN/m

3.4 Load Combinations

Table 5. Load combinations considered for design forces.

No.	Load combination
1	1.5 (Dead Load + Live Load)
2	1.5 (Dead Load + Live Load + Floor Finishing)
3	1.2 (DL + LL $\pm$ EQ. in X)
4	1.2 (DL + LL $\pm$ EQ. in Y)
5	1.5 (DL $\pm$ EQ. in X)
6	1.5 (DL $\pm$ EQ. in Y)
7	0.9 DL $\pm$ 1.5 EQ. in X
8	0.9 DL $\pm$ 1.5 EQ. in Y

3.5 Modelling and Structural Design Procedure

The ETABS model was used to generate member forces and reactions. The resulting member forces were used for reinforced concrete element design. The analysis generated by software was cross-verified by hand calculations for critical members. The design procedure also included structural planning, load estimation, member design, drawing, detailing, and schedule preparation.

The modelling evidence retained from the thesis includes plinth-beam layouts, roof-beam layouts, wall-load assignment views, ETABS material-property screenshots, story data, frame sections, shell sections, footing reactions, footing design calculations, and column/beam reinforcement detail figures.

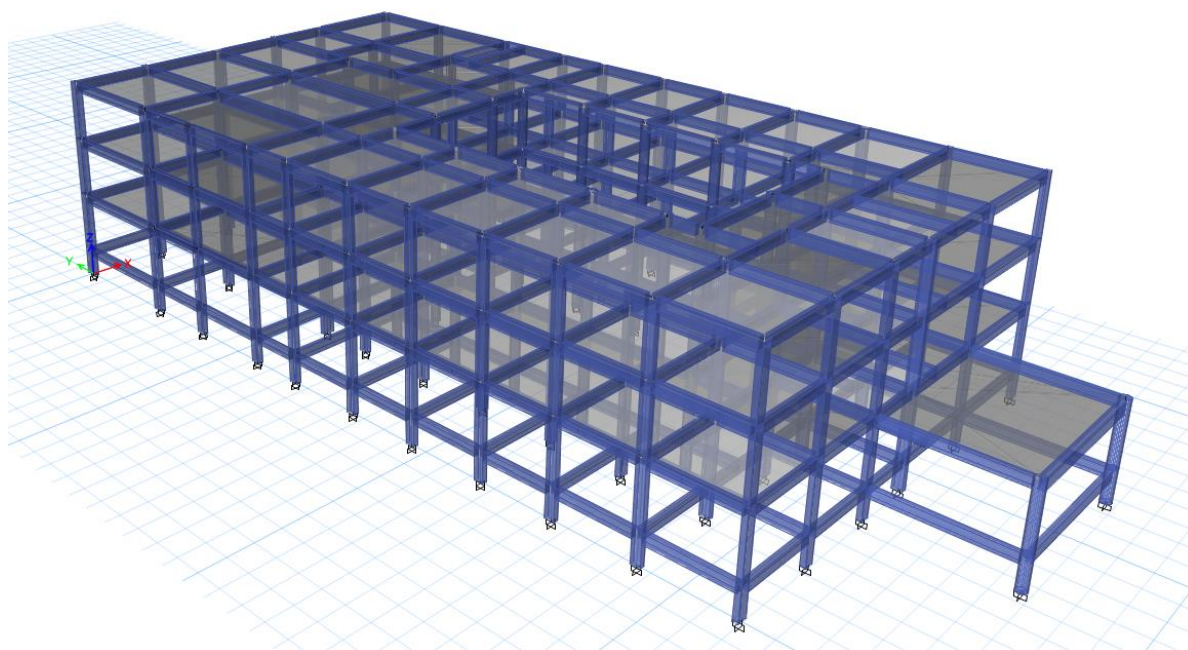


Figure 1. Structural model and layout view retained from the thesis report.

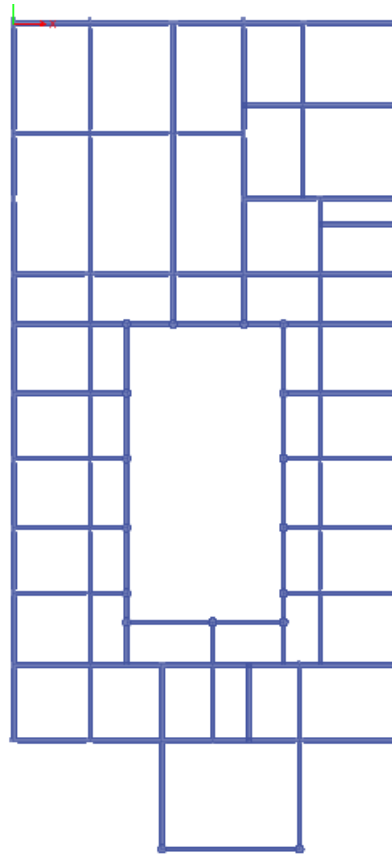


Figure 2. 2D view of plinth beam layout details.

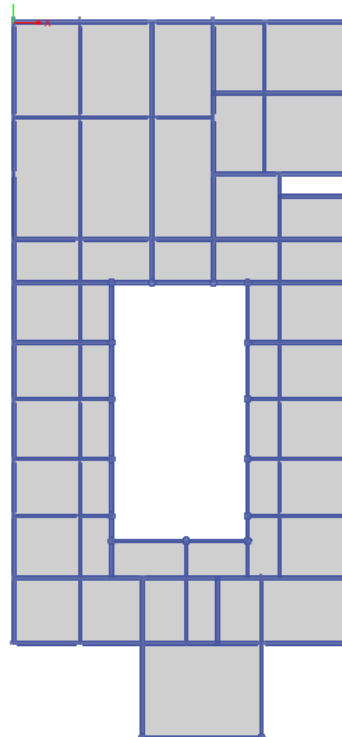


Figure 3. 2D view of ground floor roof beam layout details.

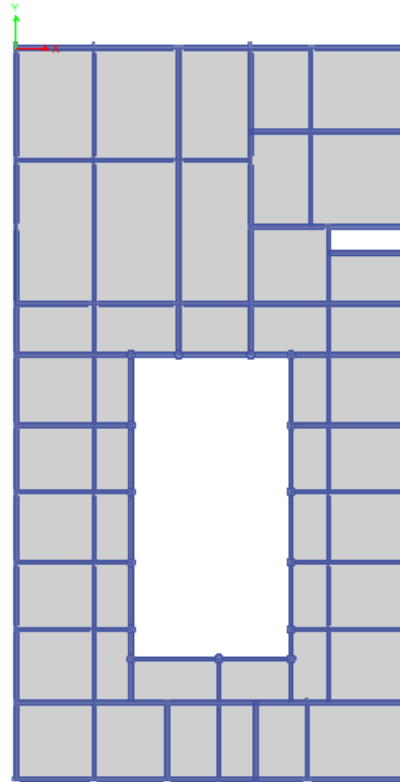


Figure 4. 2D view of first and second floor roof beam layout details.

IV. ANALYSIS AND DESIGN RESULTS

4.1 Story, Frame, and Shell Section Data

Table 6. ETABS story data.

Name	Height (mm)	Elevation (mm)	Master Story	Similar To	Splice Story
SHR	2800	16300	No	None	No
FIRST	3200	10500	No	None	No
GROUND	3200	7500	No	None	No
BASEMENT	3200	4500	No	None	No
PLINTH	1800	1500	No	None	No
BASE	0	0	No	None	No

Table 7. Frame sections summary.

Name	Material	Shape
B230X380XM20	M20	Concrete Rectangular
B230X450XM20	M20	Concrete Rectangular
B230X600XM20	M20	Concrete Rectangular
C230X600XM25	M25	Concrete Rectangular
C230X450XM25	M25	Concrete Rectangular
C380XM25	M25	Concrete Circle

Table 8. Shell sections summary.

Name	Design Type	Element Type	Material	Total Thickness (mm)
S140M20ONE	Slab	Membrane	M20	150
S140M20	Slab	Membrane	M20	230

4.2 Wall Load and Material Assignment Evidence

The wall-load assignment figures and material-property screenshots retained from the thesis support the ETABS modelling inputs used for analysis and design.

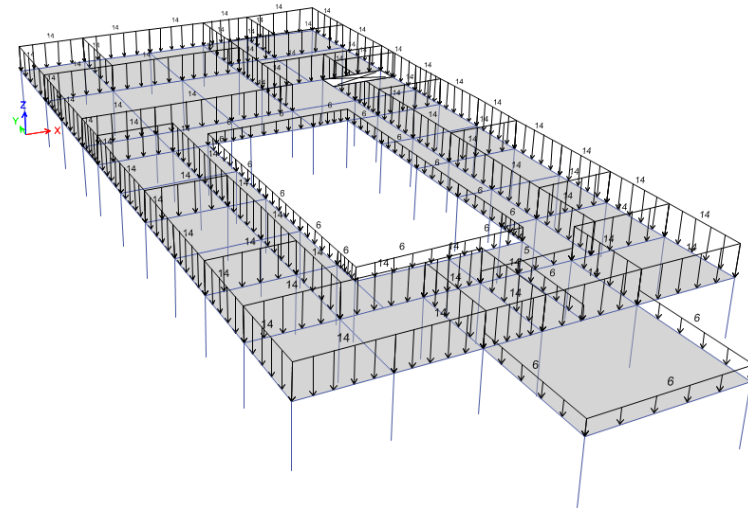


Figure 5. Wall-load details on ground floor.

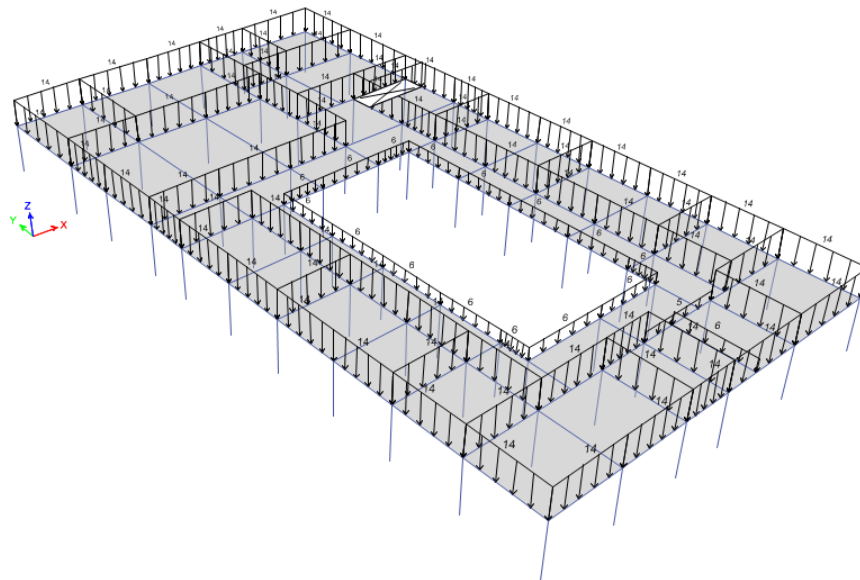


Figure 6. Wall-load details on first floor.

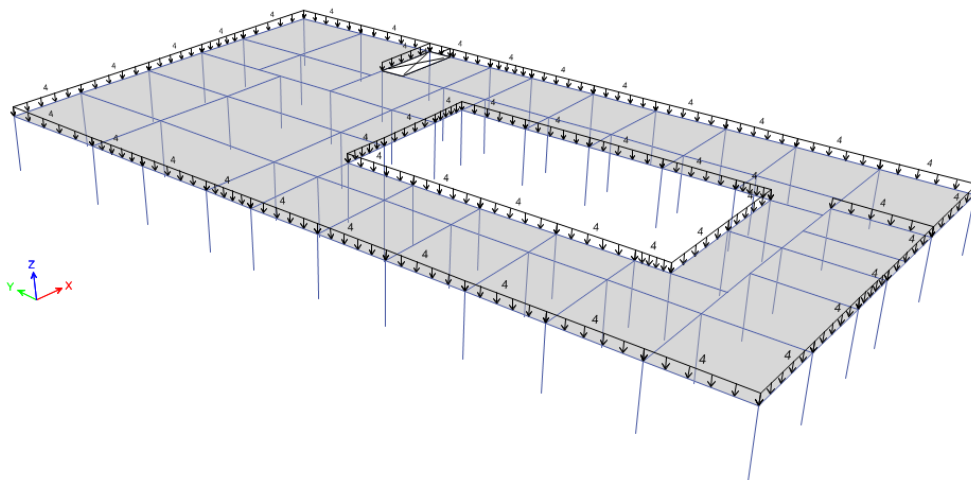


Figure 7. Wall-load details on terrace floor.

General Data

Material Name: M20

Material Type: Concrete

Directional Symmetry Type: Isotropic

Material Display Color:  Change...

Material Notes: Modify/Show Notes...

Material Weight and Mass

☒ Specify Weight Density ☐ Specify Mass Density

Weight per Unit Volume: 25 kN/m³

Mass per Unit Volume: 2549.29 kg/m³

Mechanical Property Data

Modulus of Elasticity, E: 22360.68 MPa

Poisson's Ratio, U: 0.2

Coefficient of Thermal Expansion, A: 0.000018 1/C

Shear Modulus, G: 9316.95 MPa

Design Property Data

Modify/Show Material Property Design Data...

Advanced Material Property Data

Nonlinear Material Data... Material Damping Properties... Time Dependent Properties...

OK Cancel

Figure 8. ETABS material-property data for M20 concrete.

General Data

Material Name: M25

Material Type: Concrete

Directional Symmetry Type: Isotropic

Material Display Color:  Change...

Material Notes: Modify/Show Notes...

Material Weight and Mass

☒ Specify Weight Density ☐ Specify Mass Density

Weight per Unit Volume: 25 kN/m³

Mass per Unit Volume: 2549.29 kg/m³

Mechanical Property Data

Modulus of Elasticity, E: 25000 MPa

Poisson's Ratio, U: 0.2

Coefficient of Thermal Expansion, A: 0.000018 1/C

Shear Modulus, G: 10416.67 MPa

Design Property Data

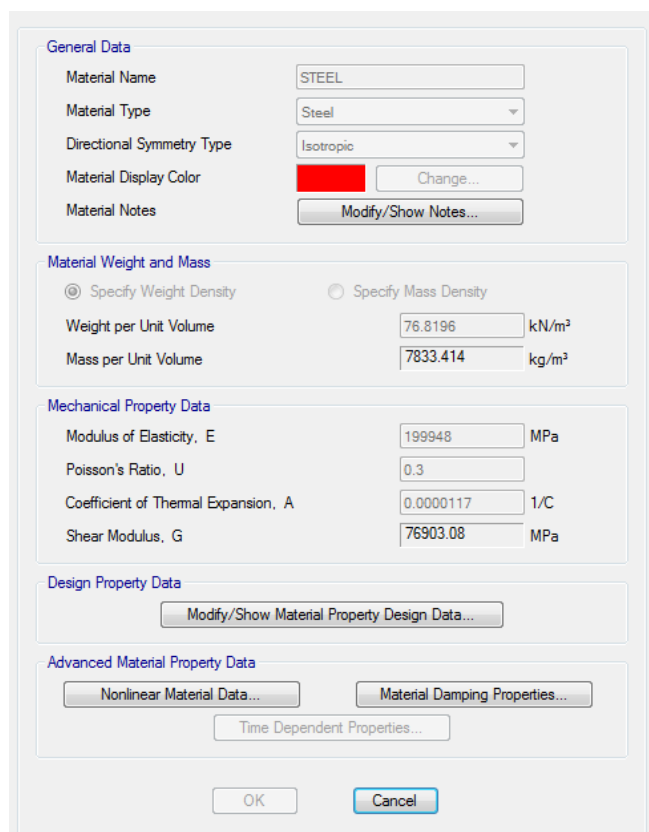
Modify/Show Material Property Design Data...

Advanced Material Property Data

Nonlinear Material Data... Material Damping Properties... Time Dependent Properties...

OK Cancel

Figure 9. ETABS material-property data for M25 concrete.



The image shows a screenshot of the 'Material Properties' dialog box in ETABS software, configured for Fe500 steel. The 'General Data' section includes 'Material Name' (STEEL), 'Material Type' (Steel), 'Directional Symmetry Type' (Isotropic), 'Material Display Color' (red), and 'Material Notes'. The 'Material Weight and Mass' section has 'Specify Weight Density' selected, with 'Weight per Unit Volume' at 76.8196 kN/m³ and 'Mass per Unit Volume' at 7833.414 kg/m³. The 'Mechanical Property Data' section includes 'Modulus of Elasticity, E' (199948 MPa), 'Poisson's Ratio, U' (0.3), 'Coefficient of Thermal Expansion, A' (0.0000117 1/C), and 'Shear Modulus, G' (76903.08 MPa). The 'Design Property Data' section has a button to 'Modify/Show Material Property Design Data...'. The 'Advanced Material Property Data' section includes buttons for 'Nonlinear Material Data...', 'Material Damping Properties...', and 'Time Dependent Properties...'. At the bottom are 'OK' and 'Cancel' buttons.

Figure 10. ETABS material-property data for Fe500 steel.

4.3 Footing Reactions

Footing reactions from the ETABS output were retained as core design evidence. The condensed table below lists the critical footing references reported in the thesis reaction table.

Table 9. Critical footing reactions retained from ETABS output.

Footing	Joint	Case/Combo	FZ (kN)	MX (kN-m)	MY (kN-m)	Column/section
F1	71	UNFACTORED	1382.0779	0.358	0.3149	230x600
F2	73	UNFACTORED	877.3441	-6.7803	-2.8534	230x600
F3	75	UNFACTORED	1165.7748	-2.7929	0.5154	230x450
F4	11	UNFACTORED	836.0069	-2.983	-0.8305	230x450
F5	27	UNFACTORED	750.3655	1.8869	3.7969	230x450
F6	13	UNFACTORED	598.4279	1.116	-2.0841	230x450
F7	2	UNFACTORED	239.2342	-10.3761	-3.0925	450 dia
F8	3	UNFACTORED	390.5659	-3.8064	5.196	230x450

4.4 Footing Design Summary

The detailed footing-design sheets in the thesis were merged into a compact design summary without altering reported values. F1 to F5 are retained because complete design calculation tables were available in the thesis.

Table 10. Footing design summary.

Footing	P (kN)	Mx (kN-m)	My (kN-m)	Size LxB (mm)	Depth (mm)	Reinforcement	Max soil pressure P1 (kN/m²)	One-way shear	Two-way shear
F1	1382.08	0.31	0.36	2200 × 1830	700	12 mm @ 125 mm c/c	343.787	OK	OK
F2	877.34	2.85	6.78	1900 × 1530	600	12 mm @ 125 mm c/c	313.019	OK	OK
F3	1165.77	0.52	2.79	1950 × 1730	600	12 mm @ 150 mm c/c	348.646	OK	OK
F4	836.01	0.83	2.98	1700 × 1480	525	10 mm @ 100 mm c/c	337.799	OK	OK
F5	750.37	3.80	1.89	1610 × 1390	525	10 mm @ 125 mm c/c	345.765	OK	OK

4.5 Reinforcement Detailing Outputs

The thesis includes column details for C1, C2, C3, C4, C5, and C7, and beam details for RB1, RB2, RB3, and RB4. These drawings are retained as supplementary figures in Appendix A to preserve the design evidence without overloading the main article text.

The clear-cover provisions retained in the thesis are 50 mm side cover and 50 mm bottom cover for footings, 40 mm for columns, 30 mm side and bottom cover for beams, 20 mm for slabs, and 40 mm for retaining walls and RCC shear walls.

V. DISCUSSION

The ETABS-based workflow supports the thesis objective of combining architectural planning, load estimation, structural modelling, and member design within a single analysis environment. The retained input tables show that gravity loads, floor finishes, wall loads, material grades, reinforcement grade, story data, and load combinations were explicitly defined before member design.

The footing reaction and design summaries demonstrate that the foundation design was checked against the reported soil bearing capacity of 350 kN/m². The maximum soil pressure values reported for F1 to F5 remain below the soil bearing capacity, and the one-way and two-way shear checks are marked as OK in the source design sheets.

The member detailing figures serve as the main evidence for translating software-generated forces and design checks into construction-oriented reinforcement details. The thesis conclusion states that the structural components are safe, the proposed element sizes can be used for construction, and better accuracy of analysis can be obtained using the software.

VI. CONCLUSION AND FUTURE SCOPE

- The report was converted into a journal-style article while retaining the thesis title, objectives, ETABS modelling basis, material parameters, loading data, load combinations, design standards, reactions, footing design summaries, and reinforcement evidence.
- The building was designed as an R.C.C. framed structure with columns, beams, slabs, footings, and diaphragms to resist gravity and lateral effects.
- ETABS was used to generate structural response and member forces, and the software output was cross-verified through hand calculations of critical members.
- The reported footing design checks indicate safe performance with soil pressure within the specified bearing capacity and shear checks marked as OK.
- The thesis conclusion that structural components are safe and proposed element sizes can be used in construction is retained without alteration.

Future Scope

- Analysis of the building with different software.
- Design of the building structure.
- Considering different soil types and comparing the results.

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