

ANALYSIS AND DESIGN OF A MULTI – STOREY RC FRAMED BUILDING (G+9 STOREY) SUBJECTED TO WIND AND SEISMIC LOADS USING ETABS

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ABSTRACT

Rapid urbanization has increased the demand for multi-storey buildings, particularly in metropolitan regions where vertical development is essential. As building height increases, lateral loads such as wind and earthquake forces significantly influence structural behaviour. This study presents the structural modelling, wind analysis, and seismic analysis of a 10-storey reinforced concrete (RCC) building using ETABS software. The building is analysed for gravity loads as per IS 875 (Part 1 & 2), wind loads as per IS 875 (Part 3), and seismic loads as per IS 1893 (Part 1): 2016. Wind analysis is carried out using the equivalent static method, while seismic analysis is performed using the response spectrum method. Key response parameters such as storey displacement, inter-storey drift, storey shear, base shear, and natural time period are evaluated. Results indicate that seismic forces produce higher base shear compared to wind loads in moderate seismic zones, while wind load governs serviceability criteria such as displacement. The study demonstrates that ETABS provides efficient and reliable modelling for multi-storey buildings and confirms that the structure satisfies codal requirements for safety and serviceability.

Keywords: Multi-storey building, Wind load, Seismic analysis, RCC structure, ETABS, Storey drift, Base shear, Response spectrum.

1. INTRODUCTION

The construction of multi-storey reinforced concrete buildings has become increasingly common due to land scarcity and urban population growth. As building height increases, the influence of lateral loads becomes significant. Unlike low-rise buildings where gravity loads dominate, medium- and high-rise buildings are governed by wind and seismic effects. India is vulnerable to both high wind speeds and seismic activity. Therefore, structural design must consider wind loads as per IS 875 (Part 3) and seismic forces as per IS 1893 (Part 1). The use of advanced structural analysis software such as ETABS enables accurate modelling and dynamic analysis of complex building systems. This study focuses on analysing a 10-storey RCC building to evaluate its performance under wind and earthquake loading conditions and to determine the governing load case.

2. BUILDING DESCRIPTION AND MODELLING

2.1 Building Details

- Structure Type: RCC Moment Resisting Frame with Shear Walls

- Number of Storeys: G + 9 (10 Storeys)
- Total Height: 30 m
- Typical Storey Height: 3.0 m
- Plan Dimension: Approximately 20 m × 25 m
- Slab Thickness: 150 mm
- Concrete Grade: M30
- Steel Grade: Fe500

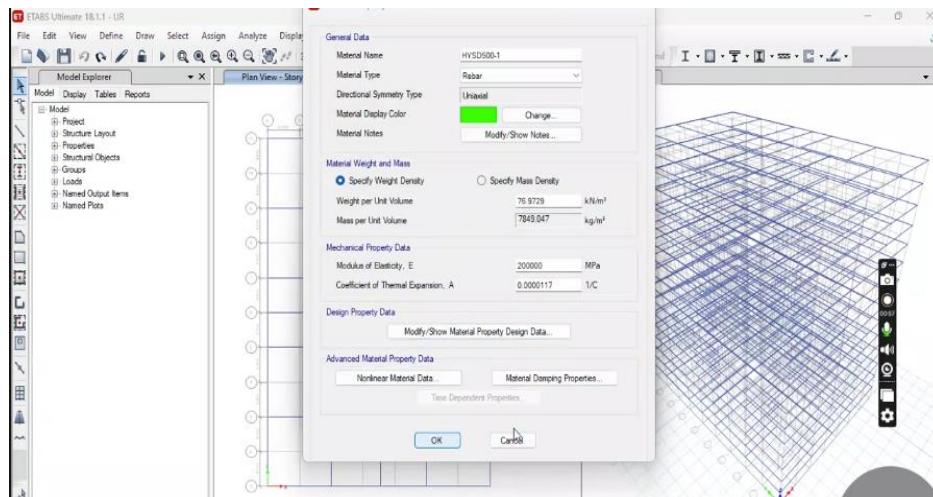


Fig.1: Geometric Details

2.2 Modelling in ETABS

The building was modelled as a three-dimensional space frame structure in ETABS. The following assumptions were adopted:

- Rigid diaphragm action at each floor
- Fixed base supports
- Linear elastic material behaviour
- 5% damping ratio for seismic analysis
- Mass source includes dead load and specified live load percentage

Beams and columns were modelled as frame elements, while slabs and shear walls were modelled as shell elements.

3. LOADING AND ANALYSIS METHODOLOGY

3.1 Dead Loads

Dead loads were calculated automatically by ETABS based on material density. Additional loads such as wall loads and floor finishes were applied manually. Live load of 2 kN/m² was considered as per IS 875 (Part 2).

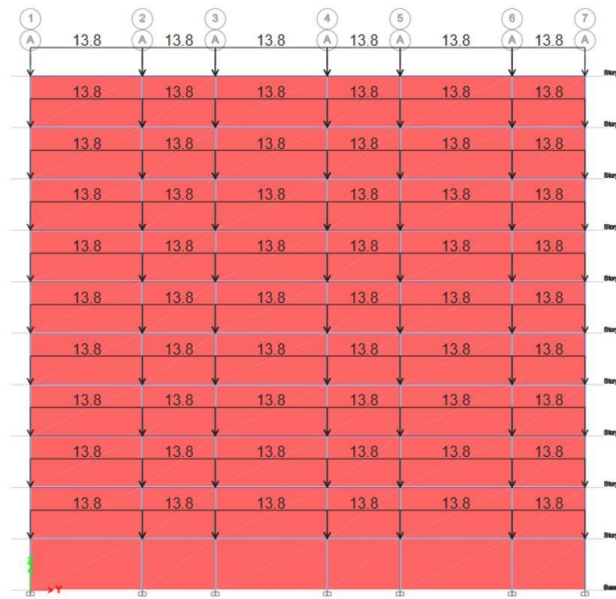


Fig.2: Dead Load

Live Load

Live load represents imposed load due to occupancy. For residential buildings, live load of 2 kN/m² is considered as per IS 875 Part 2. Roof live load is taken as per code recommendations.

Important Considerations:

- Reduced live load participation in seismic weight
- Uniform distribution over floor area
- Consideration of load reduction factors if applicable

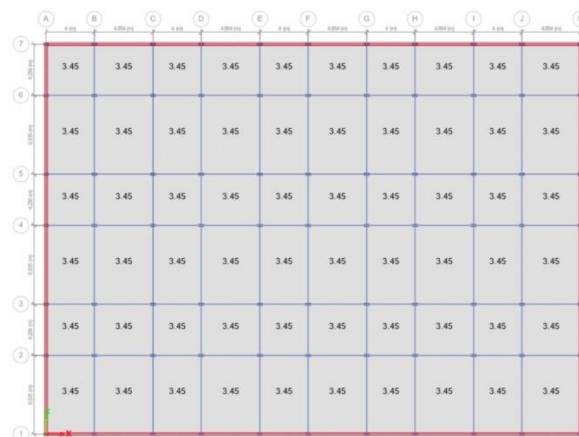


Fig.3: Live Load

3.2 Wind Load Analysis

Wind loads were applied in both X and Y directions using the equivalent static method. Storey-wise lateral forces were generated automatically in ETABS.

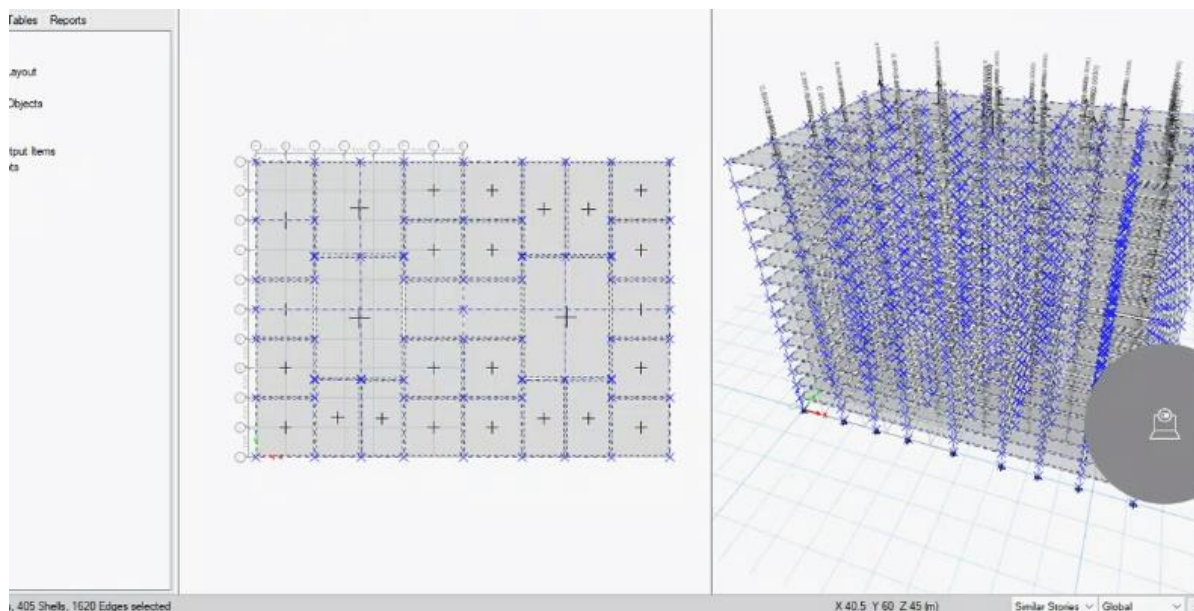


Fig.4: Wind Load Analysis

Table 1: Wind Parameters Adopted

Parameter	Symbol	Adopted Value	Description
Basic Wind Speed	V _b	44 m/s	As per wind map
Risk Coefficient	k ₁	1.0	Standard building
Terrain Category	—	Category II	Urban terrain
Terrain & Height Factor	k ₂	0.98–1.12	Varies with height
Topography Factor	k ₃	1.0	Flat terrain
Importance Factor	—	1.0	Ordinary building

These parameters ensure realistic representation of local wind conditions.

Table 2: Design Wind Speed at Various Storey Levels

Storey	Height (m)	k2 Factor	Design Wind Speed Vz (m/s)
1	3	0.98	43.12
5	15	1.02	44.88
10	30	1.08	47.52

The increase in wind speed with height results in higher wind pressure at upper storeys.

Table 3: Wind Pressure at Various Heights

Storey	Height (m)	Wind Speed (m/s)	Wind Pressure Pz (N/m ²)
1	3	43.12	1116
5	15	44.88	1208
10	30	47.52	1356

The maximum wind pressure occurs at the roof level.

3.3 Seismic Analysis

Seismic forces were evaluated as per IS 1893 (Part 1): 2016 using the Response Spectrum Method.

Design horizontal seismic coefficient:

$$A_h = \frac{Z}{2} \cdot \frac{I}{R} \cdot \frac{S_a}{g}$$

Where:

- Z = Zone factor
- I = Importance factor
- R = Response reduction factor
- Sa/g = Spectral acceleration coefficient

Modal analysis was performed to obtain natural time periods and mode shapes. More than 90% mass participation was ensured.

Table 4: Seismic Parameters Adopted

Parameter	Symbol	Adopted Value
Seismic Zone	—	Zone III
Zone Factor	Z	0.16
Importance Factor	I	1.0
Response Reduction Factor	R	5.0
Soil Type	—	Medium Soil
Damping Ratio	—	5%

Table 5: Model Time Periods

Mode No.	Time Period (sec)	Mass Participation (%)	Mode Type
1	1.85	62	Translational (X)
2	1.72	58	Translational (Y)
3	1.48	12	Torsional
4	0.95	6	Higher Mode

More than 90% mass participation was achieved in the first few modes.

Table 6: Base Shear Comparison

Direction	Base Shear (kN)
X-Direction	1850
Y-Direction	1785

Maximum base shear occurs at the foundation level and reduces upward.

4. RESULTS AND DISCUSSION

RESULTS OF WIND LOAD ANALYSIS

After analysis, storey displacement, drift, and shear were obtained.

1. Storey Displacement

Displacement increased progressively with height.

Table 7: Storey Displacement under Wind Load (X-Direction)

Storey	Height (m)	Displacement (mm)
1	3	2.4
5	15	10.8
10	30	21.6

2. Storey Drift

Storey drift was calculated as relative displacement between adjacent floors divided by storey height. The maximum drift observed was within allowable limits (less than H/500).

3. Storey Shear

Storey shear values were maximum at the base and reduced toward the top. The shear walls significantly contributed to resisting lateral loads.

Table 8: Storey Shear under Wind Load

Storey	Shear Force (kN)
10	540
5	820
Base	1150

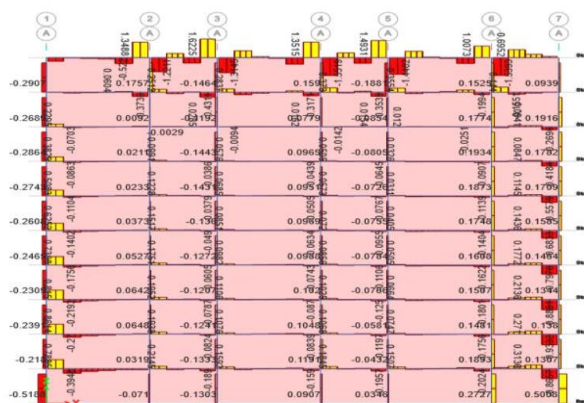


Fig.5: Shear Force

RESULTS OF SEISMIC ANALYSIS

After analysis, the following results were obtained:

1. Storey Displacement

Displacement increased gradually from base to roof level. Maximum displacement occurred at the top storey. Seismic displacement was higher than wind displacement in the considered seismic zone.

Displacement increased gradually with height.

Table 9: Storey Displacement under Seismic Load (X-Direction)

Storey	Height (m)	Displacement (mm)
1	3	3.5
5	15	14.8
10	30	29.6

Maximum displacement occurred at roof level.

2. Storey Drift

Storey drift was checked against the permissible limit of 0.004 times storey height. All drift values were within allowable limits, indicating adequate lateral stiffness.

Drift values were checked against $0.004 \times$ storey height limit.

Table 10: Maximum Storey Drift

Storey	Drift Value	Allowable Drift	Status
5	0.0028	0.004	Safe
10	0.0035	0.004	Safe

All values are within permissible limits.

3. Storey Shear

Maximum storey shear occurred at the base and reduced progressively upward. The shear walls played a significant role in resisting seismic forces.

Table 11: Storey Shear under Seismic Load

Storey	Shear Force (kN)
10	950
5	1450
Base	1850

Maximum shear occurred at base level.

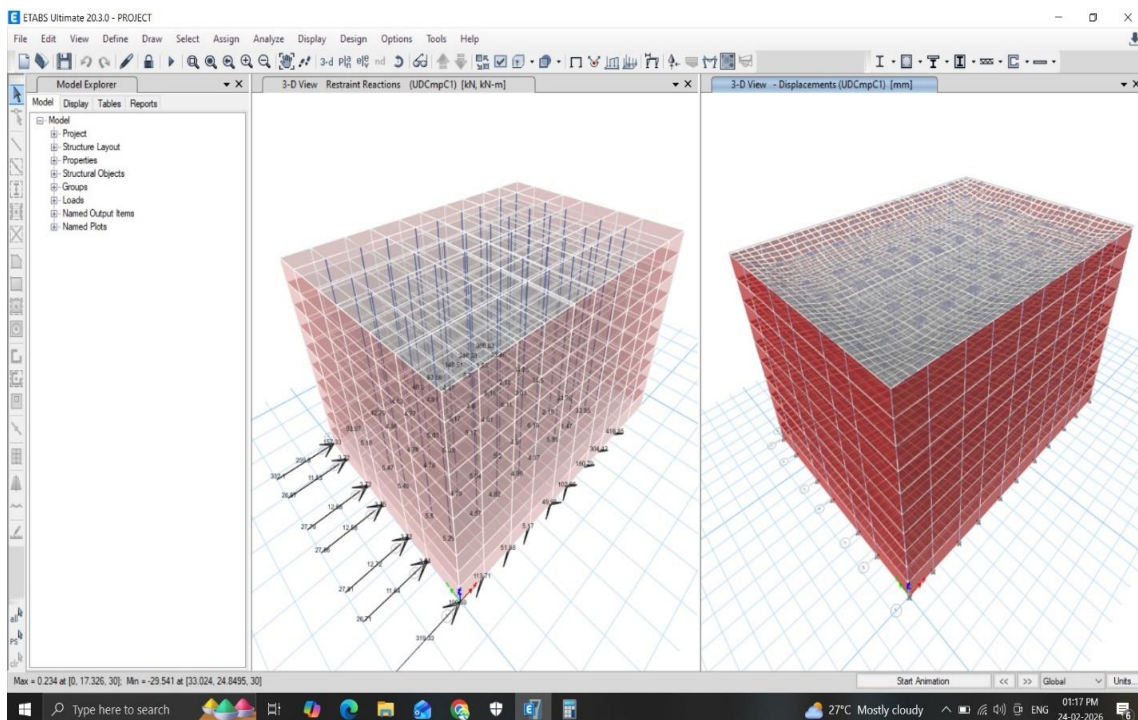


Fig.6: Max. Story Displacement

Table 13: Material Properties Adopted

Parameter	Value Adopted
Grade of Concrete	M30
Characteristic Compressive Strength (fck)	30 MPa
Grade of Reinforcement Steel	Fe500
Yield Strength of Steel (fy)	500 MPa
Density of Concrete	25 kN/m ³
Exposure Condition	Moderate

Table 12: Load Combinations Considered

Load Combination No.	Load Case
LC1	1.5 (DL + LL)
LC2	1.2 (DL + LL + EQx)
LC3	1.2 (DL + LL – EQx)
LC4	1.5 (DL + EQx)
LC5	1.5 (DL – EQx)
LC6	0.9 DL ± 1.5 EQx
LC7	Wind Load Combinations

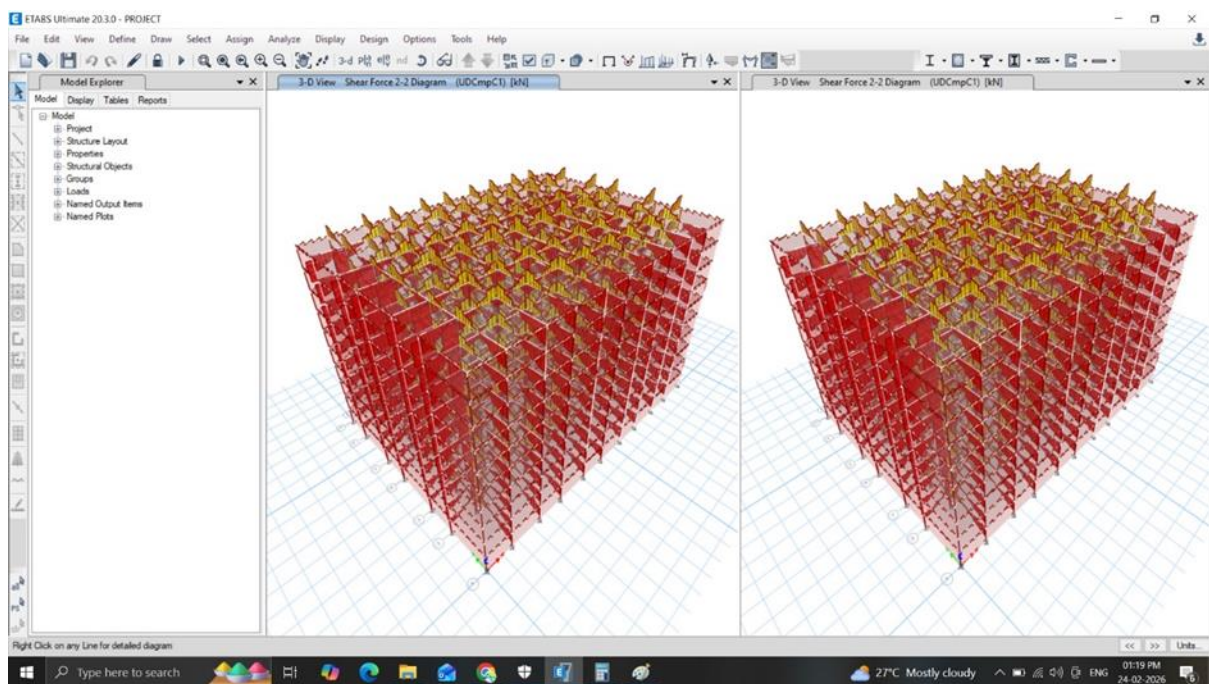


Fig.7: Shear Force

The structural elements were proportioned to satisfy these combinations, ensuring adequate strength and stability.

5. COMPARATIVE STUDY OF WIND AND SEISMIC EFFECTS

The comparison between wind and seismic loads showed:

- Wind loads primarily influence displacement and drift.
- Seismic forces generate higher base shear.
- Shear walls improve lateral stiffness and reduce displacement.

- Structural symmetry reduces torsional response.

In moderate seismic regions, earthquake load governs ultimate design, while wind controls serviceability criteria.

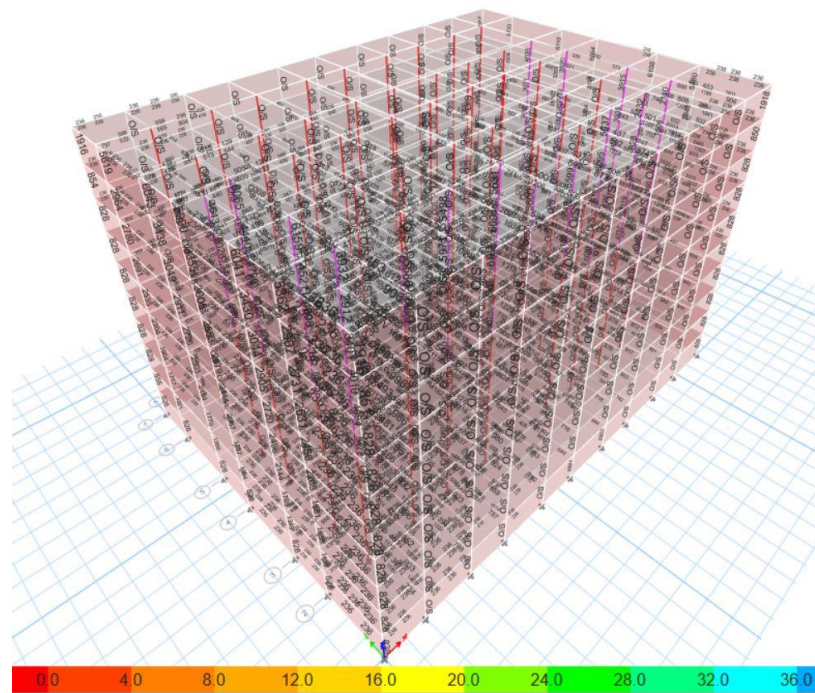


Fig.8: Design of structure

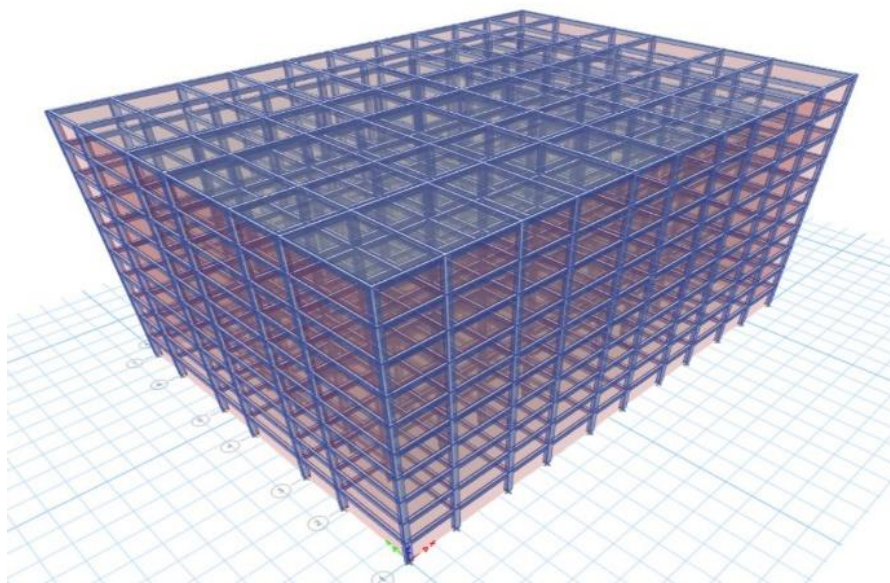


Fig.9: 3D View

6. CONCLUSIONS

The investigation confirms that the combination of moment-resisting frames and shear walls provides an efficient lateral load-resisting system for mid-to-high-rise buildings. The structural analysis and design were carried out using ETABS, ensuring that all member forces, deflections, and drift values were evaluated under realistic load conditions. General conclusions include:

- The building demonstrates adequate strength and stability under gravity, wind, and seismic loading, with all structural elements meeting ultimate and serviceability limit state requirements.
- Shear walls effectively reduce lateral deflections and inter-storey drifts, improving overall stiffness and controlling sway.

The following conclusions are drawn from the study:

1. The 10-storey RCC building satisfies codal limits for displacement and drift under both wind and seismic loads.
2. Seismic base shear is higher than wind base shear in moderate seismic zones.
3. Wind load primarily governs serviceability requirements.
4. Shear walls significantly enhance lateral stiffness and reduce displacement.
5. Response spectrum analysis provides realistic seismic response for medium-rise buildings.
6. ETABS proves to be an efficient and reliable tool for structural modelling and dynamic analysis.

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