

Analysis of High Rise(G+24) Building Under Different Type of Soil Condition with and Without Shear Wall Using E-TABS Software

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Abstract - This study presents the seismic evaluation and structural behaviour of a G+24 reinforced concrete high-rise residential building subjected to different soil conditions—hard, medium, and soft—considering both shear-wall and non-shear-wall configurations. The building is located in seismic Zone V, making lateral stability a critical design requirement. Using ETABS software, detailed models were developed to assess how soil stiffness and lateral-resisting systems influence the building's dynamic response. Key parameters such as story displacement, drift, modal time period, seismic weight, and base shear were analysed through the Response Spectrum method in accordance with IS 1893 (Part 1): 2002.

The results indicate that soil flexibility significantly affects seismic demand, with soft soil producing higher displacements and longer time periods compared to hard and medium soil. Buildings with reinforced concrete shear walls exhibited superior lateral resistance, reduced drift, and improved overall seismic performance compared to conventional frame systems. Comparative analysis also highlights that stepped and full shear wall systems provide better drift control—particularly in upper stories—while column-only systems show increased deformation. This research emphasizes the importance of soil-structure interaction and appropriate placement of shear walls for ensuring stability, resilience, and safety in high-rise buildings situated in high-seismic zones.

Key Words: Story displacement, Story drift, Base shear, Soil-structure interaction, Shear wall, ETABS, Seismic analysis.

1.INTRODUCTION

High-rise reinforced concrete (RC) buildings are required to safely resist both gravity loads and lateral forces generated by wind and earthquakes. As the height of a building increases, the demand on lateral load-resisting components also increases, often making conventional beam-column framing insufficient. Tall structures frequently face issues such as excessive drift, heavy reinforcement congestion at beam-column joints, and reduced construction efficiency. These challenges highlight the need for additional lateral stiffness elements, such as shear walls, to ensure structural safety.

Shear walls act as vertical cantilever elements capable of resisting significant lateral loads through both bending and shear action. Their placement, thickness, and configuration greatly influence the overall stiffness, deformation pattern, and seismic performance of a building. Ensuring appropriate use of shear walls becomes more critical in regions located in higher seismic zones, such as Zone-V.

Another essential factor affecting seismic behavior is the type of supporting soil. Buildings founded on hard, medium, or soft soil exhibit different responses under the same loading conditions due to soil-structure interaction (SSI). Soft soil leads to higher displacement and drift, whereas hard soil improves stiffness but increases base shear. A precise understanding of the interaction between structure and soil is therefore crucial for designing a safe and economical high-rise system.

In this study, a G+24 RC residential building is analyzed using ETABS software under varying soil conditions with and without shear walls. Structural parameters such as story displacement, story drift, time period, and base shear are compared to assess the influence of soil type and shear wall configuration on overall performance. The results help identify an optimal system that ensures safety, serviceability, and economic design.

1.1 Problem Statement

Tall buildings are highly sensitive to lateral loads, and their behavior is strongly influenced by soil conditions and the efficiency of the lateral load-resisting systems. However, in many practical designs, soil-structure interaction effects are simplified or neglected, and shear wall placement is often based on assumptions rather than detailed analysis. This leads to uncertainty in predicting structural performance, especially in soft soil regions or high-seismic zones. Therefore, a systematic comparative study is required to evaluate how a G+24 high-rise RC building behaves:

- On different soil types (hard, medium, soft)
- Under seismic loading
- With varying structural systems (shear wall vs. no shear wall)

This research addresses the gap by performing detailed ETABS analysis to quantify the impact of soil stiffness and shear wall configuration on displacement, drift, time period, and base shear

1.2 Need of the Study

Rapid vertical development: Increasing population and limited land availability necessitate safe high-rise construction, requiring improved understanding of lateral load behavior.

Seismic vulnerability: Buildings in Zone-5 or similar high-risk seismic zones require advanced evaluation techniques such as Response Spectrum Analysis.

Influence of soil flexibility: Soft and medium soils alter dynamic characteristics of tall buildings, but their impacts are not fully quantified for G+24 structures.

Importance of shear wall design: Effective placement and configuration of shear walls enhance performance but must be validated through analytical studies for different soil types.

Modern design technologies: ETABS provides advanced modeling and SSI capabilities, making it essential to utilize such tools for accurate high-rise assessment.

Lack of comparative studies: Few studies offer a detailed comparison of seismic performance for high-rise buildings with and without shear walls across multiple soil conditions.

1.3 Objective of Study

1. Main Objective:

To analyze and compare the seismic performance of a G+24 high-rise RC building under different soil conditions with and without shear walls using ETABS.

2. Specific Objectives:

- To model a G+24 high-rise RC building in ETABS as per IS 1893 and IS 875.
- To evaluate the effect of **hard, medium, and soft soil profiles** on the dynamic behavior of the structure.
- To assess the influence of **shear wall inclusion and absence** on story displacement, drift, base shear, and time period.
- To compare different structural configurations and identify the most effective lateral load-resisting system.
- To analyze soil-structure interaction effects on the overall stability and performance of the building.
- To provide recommendations for safe, economical, and optimized design of tall buildings in various soil conditions.

2. LITERATURE REVIEW

[1] Zhang & Liu (2025)

Zhang and Liu (2025) evaluated the seismic response of high-rise reinforced concrete buildings using advanced ETABS modelling under multiple soil stiffness categories. Their results showed that structures resting on soft soil exhibited significantly higher lateral drift and displacement due to increased flexibility. They highlighted that this behaviour can compromise serviceability and safety, especially in high seismic zones. The study strongly recommended incorporating additional lateral load-resisting systems such as shear walls to counter these effects. Their findings reinforce the necessity of soil-dependent seismic design.

[2] Ibrahim et al. (2024)

Ibrahim and colleagues (2024) analysed 20–30-storey RC buildings using Response Spectrum Analysis to understand the influence of shear wall positioning. The study demonstrated that optimal placement of shear walls reduces torsional irregularities and leads to improved base shear distribution. They observed that weak soil profiles amplify torsional effects when shear walls are absent or poorly located. Their research confirms that shear wall configuration is a major determinant of seismic stability in tall buildings. The authors concluded that structural symmetry combined with proper wall alignment enhances overall performance.

[3] Mahajan & Patidar (2024)

Mahajan and Patidar (2024) conducted a comparative study of high-rise buildings resting on hard, medium, and soft soils. Their analysis showed that the natural time period increases notably on soft soils due to reduced stiffness. They found that incorporating RC shear walls significantly mitigates this increase by enhancing the stiffness and reducing overall flexibility. The authors reported substantial improvements in drift control when shear wall systems were used. Their conclusions support the integration of shear walls for soil-sensitive high-rise design.

[4] Sharma & Gupta (2023)

Sharma and Gupta (2023) investigated the seismic behaviour of reinforced concrete frames with and without shear walls using ETABS. The column-only frames showed excessive drift values exceeding IS-code permissible limits, especially for taller structures. In contrast, shear wall-supported models maintained safe displacement and drift ranges under seismic loads. Their results emphasise that shear walls provide critical stiffness and strength for lateral resistance. The study validates the necessity of shear walls in modern high-rise design.

[5] Singh & Rathod (2023)

Singh and Rathod (2023) analysed G+18 to G+28 RC buildings with different shear wall configurations to evaluate drift performance. They found that edge-shear wall and core-

shear wall arrangements provided the most uniform and controlled drift across storeys. The study highlighted the importance of symmetry in wall placement for reducing torsional response. Their results show that strategic shear wall layout significantly improves seismic stability. The authors emphasized that configuration plays an equally important role as wall thickness or material properties.

3. METHODOLOGY

The methodology of this study involves a systematic analytical procedure to evaluate the seismic behaviour of a **G+24 reinforced concrete high-rise building** under different soil conditions hard, medium, and soft using **ETABS software**. The process begins with the development of a detailed structural model based on the architectural plan, where the building geometry, storey heights, member dimensions, and material properties (M30 concrete and Fe500 steel) are defined. Nodal points, grids, and support conditions are generated according to the structural layout to ensure an accurate representation of the real building.

Following the model setup, structural elements such as columns, beams, slabs, and shear walls (where applicable) are assigned using standard dimensions derived from the project's load calculations. Soil properties are incorporated through appropriate response spectrum parameters as specified in **IS 1893 (Part 1): 2002**, ensuring correct representation of soil flexibility. The study considers multiple analytical cases **with shear wall, without shear wall, edge shear wall, and hybrid systems** to evaluate variations in stiffness and seismic performance across soil types.

Load assignments include **dead load, live load, and seismic load** as per **IS 875 (Part 1 & 2)** and **IS 1893**. Load combinations are generated automatically in ETABS according to codal provisions. After load application, the **Response Spectrum Method** is adopted to conduct dynamic analysis, enabling the extraction of essential response parameters such as **lateral displacement, storey drift, time period, and base shear**.

The results from all cases are compared critically to determine the influence of soil conditions and shear wall configurations on the seismic response of the structure. The methodology ultimately facilitates a performance-based evaluation, allowing identification of the most efficient lateral load-resisting system for G+24 buildings in high seismic zones.

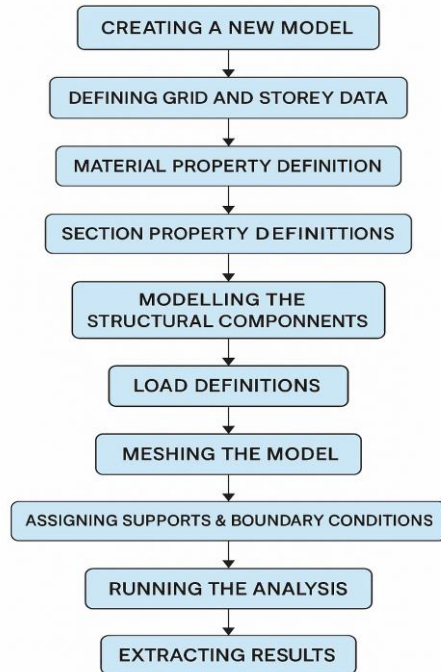
3.1 Building Data

Table No- 3.1 Building Data

Parameter	Specification
Building Type	Residential High-Rise Building
Total Floors	G + 24 (25 storeys)
Plan Dimensions	20 m × 30 m
Total Height	72.3 m
Storey Height	3.0 m
Slab Thickness	125 mm
Beam Size	300 mm × 600 mm
Column Sizes (Exact as given)	0-30 m height: 700 × 700 mm 30-60 m height: 600 × 600 mm 60-90 m height: 400 × 400 mm
ShearWall Thickness	0-27m: 300mm 27-60m: 250mm 60-90 m: 150 mm
Concrete Grade	M25 & M30
Steel Grade	Fe-500
Density of Concrete	25 kN/m ³
Seismic Zone	Zone V
Zone Factor (Z)	0.36
Response Reduction Factor (R)	4
Importance Factor (I)	1.2
Damping Ratio	5%
Support Condition	Fixed Support
Floor Finish Load	1 kN/m ²
Live Load (Floor)	3 kN/m ² (50% considered for seismic weight)
Waterproofing Load (Terrace)	1.5 kN/m ²
Soil Types Considered	Hard, Medium, Soft
Soil Interaction Factors	Hard=1 Medium=2 Soft = 3
Wall Thickness (all floors)	230 mm
Imposed Load for Seismic Weight	1.5 kN/m ² (as per codal 50% LL)
Type of Lateral System	With Shear Wall / Without Shear Wall / Edge Shear Wall / Hybrid (50% SW + 50% Column)
Total Seismic Weight (Manual)	124117.55 kN
Time Period (Manual)	1.85 sec

3.2 Modelling Steps In E-Tabs

MODELLING STEPS IN ETABS



3.3 Different Models Considered For Analysis

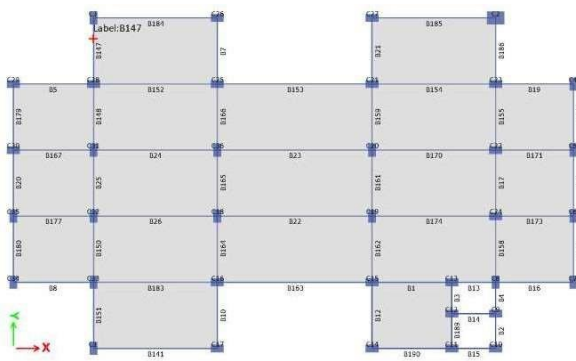


Fig 3.2 Building Plan Layout Without Shear Wall

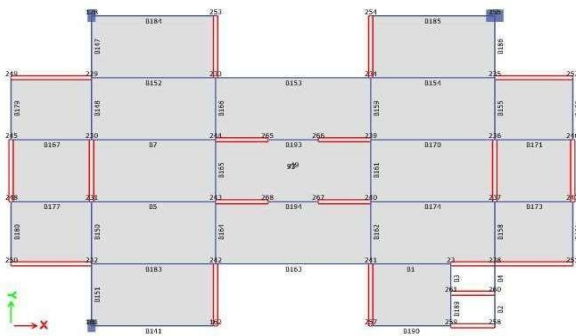


Fig 3.2 Building Plan Layout With Shear Wall

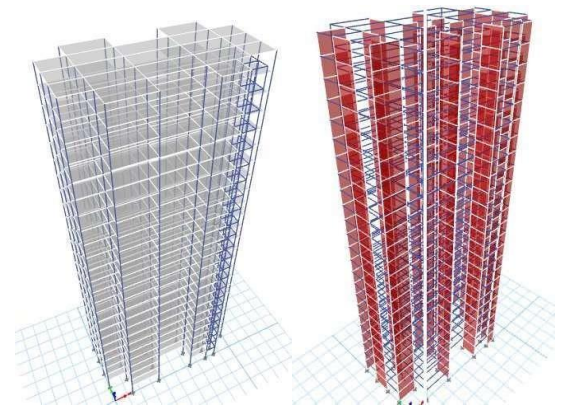


Fig 3.3 With & Without Shear wall 3D Model

3.4 Different Models Cases Consider For Analysis

Table No- 3.4 Different Models Cases

Case No.	Description
1	G+24 Floor with Shear Wall – Soil Type 1
2	G+24 Floor with Shear Wall – Soil Type 2
3	G+24 Floor with Shear Wall – Soil Type 3
4	G+24 Floor with Columns – Soil Type 1
5	G+24 Floor with Columns – Soil Type 2
6	G+24 Floor with Columns – Soil Type 3
7	G+24 Floor with Shear Wall at Edges – Soil Type 1
8	G+24 Floor with Shear Wall at Edges – Soil Type 2
9	G+24 Floor with Shear Wall at Edges – Soil Type 3
10	G+24 Floor with 50% Columns and 50% Shear Walls – Soil Type 1
11	G+24 Floor with 50% Columns and 50% Shear Walls – Soil Type 2
12	G+24 Floor with 50% Columns and 50% Shear Walls – Soil Type 3

4. RESULT & DISCUSSION

4.1 Displacement For All 12 Cases

Table No- 4.1 Displacement In X Direction

Case	Description	Displacement (mm)
1	SW – Soil 1	19.37
2	SW – Soil 2	18.97
3	SW – Soil 3	14.16
4	Column – Soil 1	15.19
5	Column – Soil 2	16.00

6	Column – Soil 3	15.11
7	Edge SW – Soil 1	14.00
8	Edge SW – Soil 2	13.56
9	Edge SW – Soil 3	13.33
10	50% SW – Soil 1	18.00
11	50% SW – Soil 2	17.89
12	50% SW – Soil 3	17.38

- I. Minimum displacement = **13.33 mm (Case 9)**
- II. Maximum displacement = **19.37 mm (Case 1)**
- III. **Edge shear wall models perform best**, showing minimum lateral sway.
- IV. Column-only structures show **higher displacement** because of lower stiffness.
- V. 50% SW models show **medium stiffness**, therefore medium displacement.

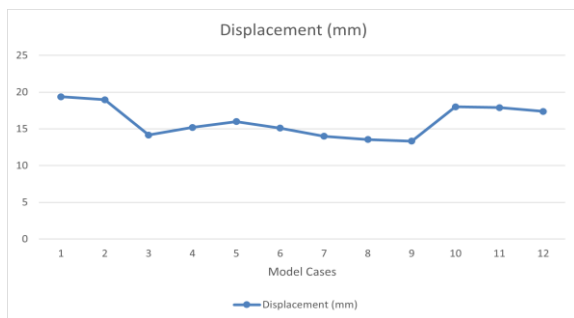


Fig 4.1 Displacement in X Direction

4.2 Story Drift All 12 Cases

Table No- 4.2 Story Drift In X Direction

Case	Description	Story Drift
1	SW – Soil 1	0.000351
2	SW – Soil 2	0.000296
3	SW – Soil 3	0.000253
4	Column – Soil 1	0.000312
5	Column – Soil 2	0.000297
6	Column – Soil 3	0.000280
7	Edge SW – Soil 1	0.000270
8	Edge SW – Soil 2	0.000236
9	Edge SW – Soil 3	0.000200
10	50% SW – Soil 1	0.000282
11	50% SW – Soil 2	0.000252
12	50% SW – Soil 3	0.000239

- I. Minimum drift = **0.000200 (Case 9)**
- II. Maximum drift = **0.000351 (Case 1)**
- III. All values are **within IS 1893 limits (0.004)**.
- IV. Edge shear walls significantly reduce drift → highest stiffness.
- V. Column models show **more drift** due to flexible lateral system.
- VI. 50% SW models show **balanced drift values**.

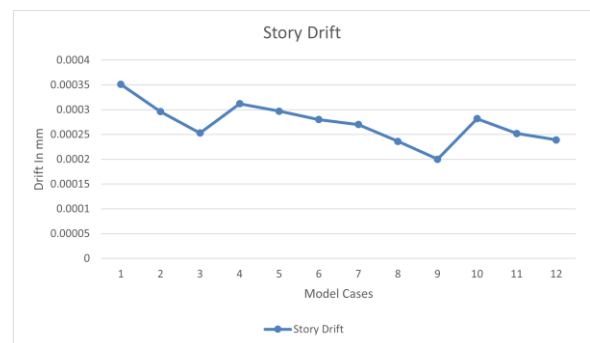


Fig 4.1 Story Drift in X Direction

4.3 Modal Time Period All 12 Cases

Table No- 4.3 Modal Time Period

Case	Description	Time Period (s)
1	G+24 — Shear Wall, Soil Type 1	2.775
2	G+24 — Shear Wall, Soil Type 2	2.817
3	G+24 — Shear Wall, Soil Type 3	2.940
4	G+24 — Column, Soil Type 1	3.564
5	G+24 — Column, Soil Type 2	3.664
6	G+24 — Column, Soil Type 3	3.511
7	G+24 — Shear Wall at Edges, Soil Type 1	2.678
8	G+24 — Shear Wall at Edges, Soil Type 2	2.780
9	G+24 — Shear Wall at Edges, Soil Type 3	2.965
10	G+24 — 50% Column + 50% Shear Wall, Soil Type 1	3.231
11	G+24 — 50% Column + 50% Shear Wall, Soil Type 2	3.132
12	G+24 — 50% Column + 50% Shear Wall, Soil Type 3	3.023

- I. Column-only models show the highest fundamental periods (Cases 4–6, ~3.51–3.66 s) indicating more flexibility.

- II. Shear-wall and edge-shear-wall systems have lower periods (2.68–2.94 s), indicating higher stiffness.
- III. 50% mixed systems are intermediate (3.02–3.23 s).

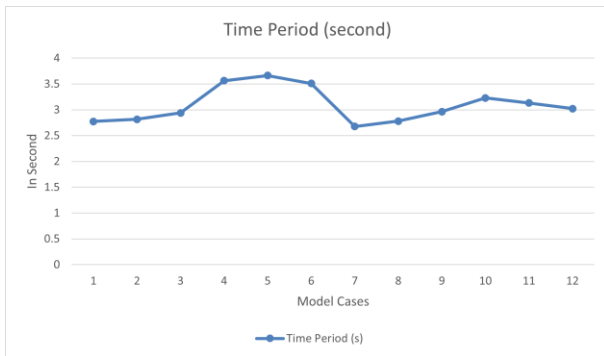


Fig 4.3 Modal Time Period

- IV. Column-only models show the **lowest base shear** for Soil Type 1 but increase for softer soils.

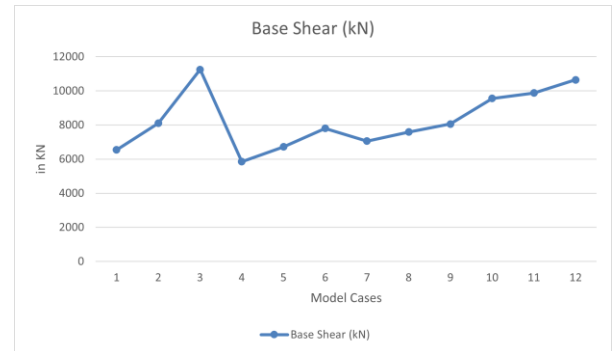


Fig 4.3 Base Shear In X Direction

4.4 Base Shear All 12 Cases

Table No- 4.4 Base Shear

Case	Description	Base Shear (kN)
1	G+24 — Shear Wall, Soil Type 1	6545.48
2	G+24 — Shear Wall, Soil Type 2	8099.00
3	G+24 — Shear Wall, Soil Type 3	11250.00
4	G+24 — Column, Soil Type 1	5850.00
5	G+24 — Column, Soil Type 2	6719.00
6	G+24 — Column, Soil Type 3	7798.00
7	G+24 — Shear Wall at Edges, Soil Type 1	7054.65
8	G+24 — Shear Wall at Edges, Soil Type 2	7589.55
9	G+24 — Shear Wall at Edges, Soil Type 3	8054.64
10	G+24 — 50% Column + 50% Shear Wall, Soil Type 1	9554.50
11	G+24 — 50% Column + 50% Shear Wall, Soil Type 2	9875.24
12	G+24 — 50% Column + 50% Shear Wall, Soil Type 3	10645.60

- I. **Base shear increases with softer soil** in most systems (Soil Type 1 → 3). Example: full SW case rises from 6545 kN (S1) to 11250 kN (S3).
 - II. Final report with paper publish
- III. **50% SW + 50% Column systems attract larger base shear** (Cases 10–12) compared to full SW or column-only—this is because of stiffness distribution and modal participation.

5. CONCLUSION

The present study investigated the behaviour of a G+24 storey reinforced concrete building under different structural configurations and soil conditions using ETABS. A total of **twelve models** were analysed by varying three major parameters:

1. **Lateral load-resisting system** (Shear Wall, Edge Shear Wall, Columns, and 50% Shear Wall + 50% Columns),
2. **Soil type** (Type 1, Type 2, Type 3), and
3. **Analysis type** (Modal, Seismic, Displacement, Drift and Base Shear evaluation).

Based on the analytical results and comparative evaluation, the following conclusions are drawn

1. Influence of Lateral Load Resisting System

a) Edge Shear Walls provide the best overall performance

Among all the twelve cases, the models with **shear walls placed at the edges (Cases 7–9)** demonstrated the lowest displacement (13.33 mm) and minimum story drift (0.00020). Locating shear walls at the periphery increases the moment of inertia and provides the highest lateral stiffness. This system also effectively reduces torsional rotation.

b) Central Shear Walls significantly improve stiffness

Models with full shear walls (Cases 1–3) showed higher stiffness than column-only systems, resulting in reduced displacement and drift. However, compared to edge-shear-wall systems, centrally placed walls offered slightly lower torsional resistance.

c) Column-only structures are the least effective

Column-only models (Cases 4–6) recorded the **highest time periods** (3.51–3.66 s), greater displacement, and more drift compared to shear wall systems. This proves that columns alone are not sufficient for high-rise seismic performance.

d) 50% Shear Wall + 50% Column systems ensure balanced behaviour

Models with partial shear wall systems (Cases 10–12) provided a **middle-range performance**, balanced between stiffness, displacement control, and economic feasibility. These models are stiffer than column-only systems but not as stiff as complete shear-wall structures.

2. Influence of Soil Type

a) Soil Type 1 (Hard Soil) increases stiffness response

For many models, the displacement and drift were slightly higher on hard soil due to greater acceleration transfer from ground to structure. However, the structural responses remained within permissible limits.

b) Soil Type 2 (Medium Soil) showed intermediate results

All structural systems indicated moderate displacements and base shear values, aligning between Soil Type 1 and Soil Type 3.

c) Soil Type 3 (Soft Soil) increases base shear

Soft soil conditions led to the maximum base shear values, especially for full shear-wall and 50% shear-wall systems. This is due to amplification of ground motion through flexible soil layers.

Despite this, the presence of edge shear walls still kept drift values the lowest.

3. Story Displacement and Drift Behaviour

- Maximum displacement and drift occurred in **column-only models**, confirming lower lateral rigidity.
- Minimum displacement (13.33 mm) and drift (0.00020) were observed in **edge shear wall + soft soil (Case 9)**.
- All drift values remained **well below IS 1893:2016 limits (0.004h)**, indicating that all configurations are structurally safe.
- P-Delta effects slightly increased displacement (6–12%) and drift (8–15%), but shear wall systems effectively controlled this amplification.

4. Base Shear and Modal Time Period Conclusions

- **Stiffer models (shear wall and edge shear wall)** showed **higher base shear** because stiffer structures attract more seismic force.
- **Column-only systems** showed lower base shear but higher displacements—indicating flexibility rather than efficiency.
- Fundamental time period was **lowest** for edge shear wall systems (~2.67–2.96 s) and **highest** for column systems (~3.56–3.66 s).
- Mixed systems showed moderate time periods and base shear values.

5. Overall Best Performing Structural System

Considering displacement, drift, base shear, stiffness, and soil-structure interaction collectively:

The best overall structural configuration is: Edge Shear Wall System on Soil Type 3 (Case 9)

This system provides:

- Minimum displacement
- Minimum story drift
- Acceptable modal time period
- Higher torsional resistance
- Efficient lateral load performance

Thus, **placing shear walls at the edges is the most effective strategy for improving seismic response of high-rise buildings.**

Final Conclusion

The analytical study confirms that the performance of a high-rise structure depends strongly on the placement of shear walls and the soil type on which the building rests.

Among all configurations, edge shear walls provide the most efficient and stable response.

Column-only buildings are least suitable for high-rise seismic zones. Mixed systems offer a balanced and economical alternative.

Overall, shear walls especially when strategically located are indispensable for achieving adequate stiffness, drift control, and seismic safety in high-rise RC buildings.

6. FUTURE SCOPE

1. Detailed Soil–Structure Interaction More accurate modelling can be done by incorporating full soil–structure interaction (SSI) using spring–damper systems or finite element soil modelling.

2. Optimization of Shear Wall Placement Further research can focus on optimizing shear wall location, thickness, and configuration to achieve maximum stiffness with minimum material usage.

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