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Analysis Of Multistorey Building Using ETABS

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ABSTRACT: The structural safety and performance of multistorey buildings are highly dependent on accurate analysis and design methods. This study focuses on the analysis of a multistorey building using ETABS software. The building, comprising G+10, is analyzed using the linear method to understand its behavior under dead, live, wind, and earthquake load. This study evaluates storey displacement and Storey drift to check safety and serviceability as per IS codes. Linear analysis provides a clear understanding of the structure's performance under normal conditions, ensuring stability and strength. The research highlights the role of ETABS in modern structural design and demonstrates how linear analysis serves as an essential step in achieving safe and economical buildings.

KEYWORDS: Multistorey Building, Structural Analysis, ETABS Software, Linear Analysis, Storey Displacement & Storey Drift.

1. INTRODUCTION

The design and analysis of multistorey buildings is a vital part of structural engineering, as it ensures stability, strength, and serviceability under different loading conditions. Among the various analytical approaches**, linear analysis** is one of the most commonly used methods for evaluating building performance. It is based on the assumption that material properties remain elastic and that the structural response is directly proportional to the applied loads.

In linear analysis, forces and deformations are calculated without considering inelastic effects such as cracking or yielding, making it a simplified yet efficient method for preliminary design and codal verification. This approach allows engineers to assess structural behaviour under **dead loads, live loads, wind loads, and seismic forces,** ensuring that displacements and drifts remain within the permissible codal limits. Although it does not capture nonlinear behaviour, linear analysis provides a reliable foundation for the safe and economical design of multistorey buildings.

1.1 Linear Analysis

Linear analysis assumes elastic structural behaviour, where deformations are proportional to applied loads and material properties remain constant. In ETABS, it is categorized into **linear static** and **linear dynamic** analysis.

- **Linear Static Analysis (Equivalent Static Method):** Earthquake loading is represented by lateral forces, with base shear estimated as per IS 1893:2016 and distributed along the height. It is simple, computationally efficient, and suitable for regular, low-rise buildings, but less accurate for tall or irregular structures.
- **Linear Dynamic Analysis (Response Spectrum Method):** Captures vibration characteristics through modal analysis and combines responses using SRSS or CQC procedures. It provides realistic estimation of displacements, drifts, and base shear, especially for tall and irregular buildings. This method is codally mandatory for buildings above 40 m in seismic zones III–V (IS 1893:2016).

Dynamic Analysis in Structural Engineering

Dynamic analysis evaluates structural response to time-varying loads such as earthquakes and wind, accounting for inertia forces and energy transmission. It is essential for tall/irregular buildings with multiple natural frequencies.

- **Linear Dynamic Analysis:** Includes Response Spectrum Analysis (RSA) and Linear Time History, assuming elastic behaviour.
- **Nonlinear Dynamic Analysis:** Considers material nonlinearity and plastic hinges, usually through Nonlinear Time History, but requires higher computational effort.

Response Spectrum Method (RSA): Widely used due to its efficiency, RSA estimates seismic demand based on codal response spectra. It captures multiple vibration modes, ensures better lateral force distribution, and is more reliable than static methods. However, it is limited to linear elastic behaviour and does not represent inelastic performance.

1.2 Etabs

Linear analysis assumes elastic structural behaviour, where deformations are proportional to applied loads and material properties remain constant. In ETABS, it is classified into linear static and linear dynamic analysis.

- Linear Static Analysis (Equivalent Static Method): Earthquake loading is represented by lateral forces, with base shear estimated as per IS 1893:2016 and distributed across the building height. This method is computationally simple and suitable for regular, low-rise buildings but less accurate for tall or irregular structures.
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1.3 Storey drift

Storey drift is the relative displacement between two consecutive floors, expressed as a drift ratio (Δ/h). It governs local deformation and damage in structural and non-structural elements.

Codal Requirement (IS 1893:2016):
Maximum drift = 0.004 × storey height (i.e., 0.4% of storey height).

Formula:

Storey Drift=Δ2−Δ1/h

1.4. Storey Displacement

Storey displacement is the total lateral movement of a floor level relative to its original position, caused by loads such as wind and earthquakes. It is influenced by building flexibility, applied lateral forces, and structural stiffness. Excessive displacement can damage structural and non-structural elements and cause discomfort to occupants.

Codal Requirement (IS 1893:2016):
Though IS 1893 specifies drift limits, displacement is also checked to ensure serviceability and prevent P–Δ effects.

2. METHODOLOGY

The analysis of the G+10 including terrace and head room multistorey building were carried out using ETABS software. The following steps were followed

1. **Planning and Data Collection**
   - The project involved collecting architectural plans, selecting relevant IS codes (IS 456, IS 875, IS 1893),
   - Defining the grid, storey heights, and materials, and modelling structural elements including beams, columns, slabs and shear walls.
2. **Load Application**
   - Applied dead, live, wind and seismic loads as per IS standards.
   - Created load combinations for design.
3. **Linear Analysis**
   - Performed static and dynamic (response spectrum) analysis.
   - Checked displacements, drifts, base shear, and mode shapes.
4. **Design and Checks**
   - Designed members using ETABS auto design as per IS 456.
5. **Result Comparison**
   - Compared results of linear analysis for structural response.
   - Evaluated performance level and member safety.
6. **Conclusion**
   - Summarized findings and confirmed code compliance.

2.1 Building details - This project involves the analysis of a G+10 including terrace and head room multistorey reinforced concrete building using ETABS, located in seismic Zone II. The building is intended for residential/commercial use and includes vertical and lateral load-resisting systems to ensure stability and safety under gravity and earthquake loads.

- Grade of Concrete: M35, M40
- Grade of Steel: Fe 550
- Seismic Zone: II
- Location: Hyderabad
- Importance Factor (I): 1
- Response Reduction Factor (R): 5 (SMRF)
- Damping Ratio: 5%
- Storey Height: 3 m
- Number of Storeys: Sub cellar + Cellar + Stilt + 10 typical floors + Terrace + Head room
- Beam Sizes: 203 × 610 mm,
  305 × 610 mm
- Column Sizes: 230 × 750 mm,
  300 × 750 mm,
  380 × 750 mm
- Slab Thickness: 152.4 mm
- Density of Concrete: 25 kN/m³
- Total Height of Building: 48 m

Fig 2.1- floor plan

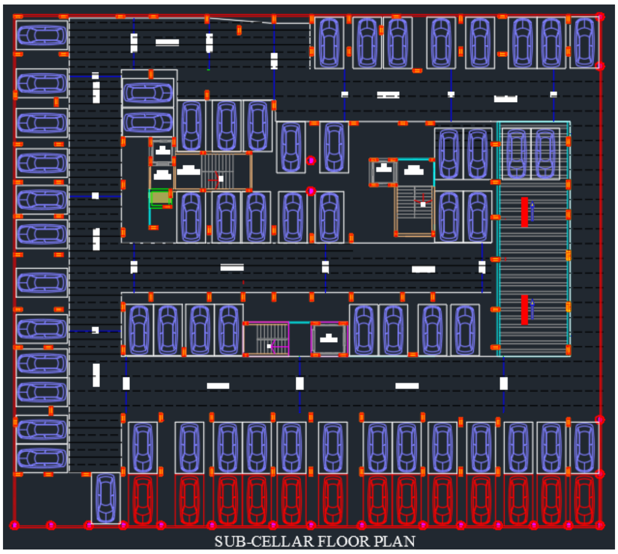


Fig 2.2 - Sub-cellar, cellar and stilt floor plan (Parking)

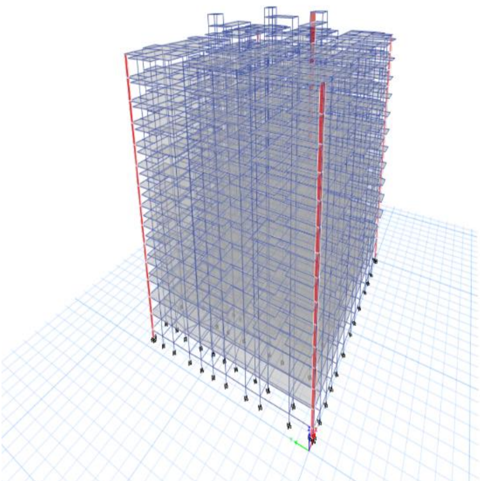


Fig 2.3- 3D view of the building

2.2 Bending moment diagram

A Moment Force Diagram, also called a Bending Moment Diagram (BMD), is a graphical representation of the bending moment along the length of a structural member such as a beam. It shows how the internal bending moment varies at different points under applied loads.

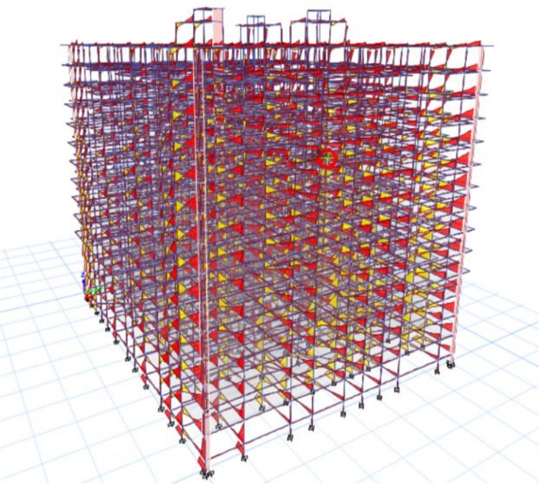


Fig 2.4- Bending moment diagram.

2.3 Shear force diagram

A Shear Force Diagram is a graphical representation showing how the shear force varies along the length of a beam or structural member under applied loads. Shear force is the internal force that acts perpendicular to the member's axis, causing one part of the section to slide relative to the other.

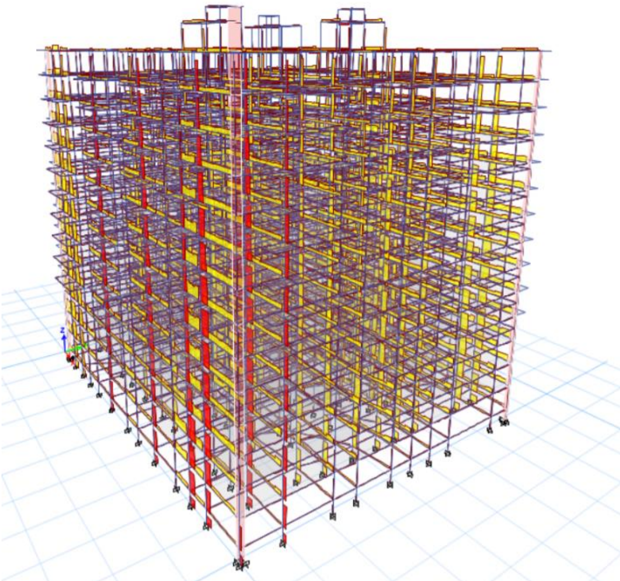


Fig 2.5 – Shear force diagram

2.4. Storey Drift of Dead Load In X And Y Direction (Linear Analysis)

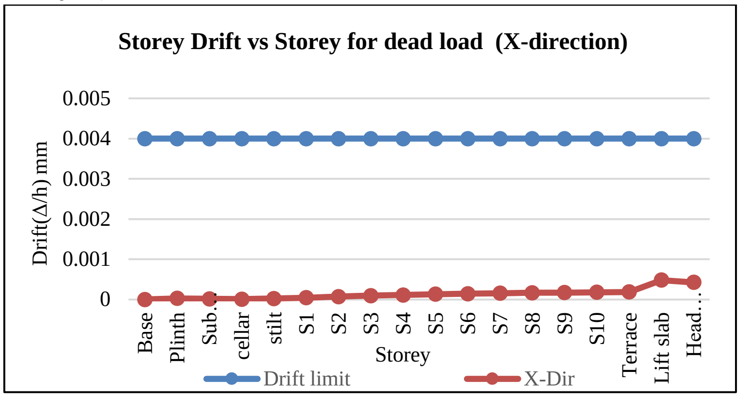


Fig 2.6 -Storey drift of dead load X-direction (Linear Analysis)

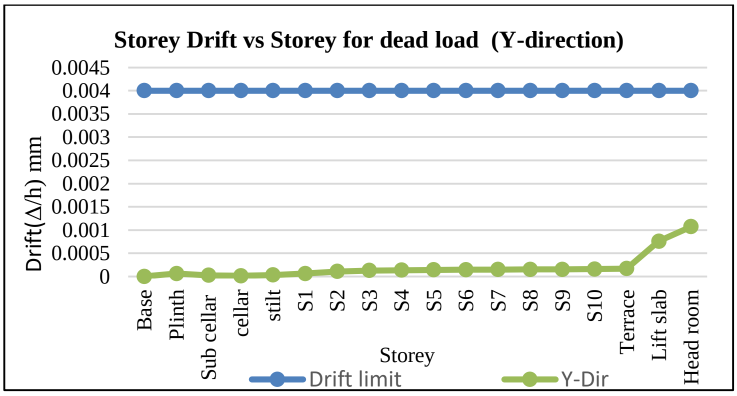


Fig 2.7-Storey drift of Dead load in Y-direction (Linear Analysis)

Storey Drift of Live Load In X And Y Direction (Linear Analysis)

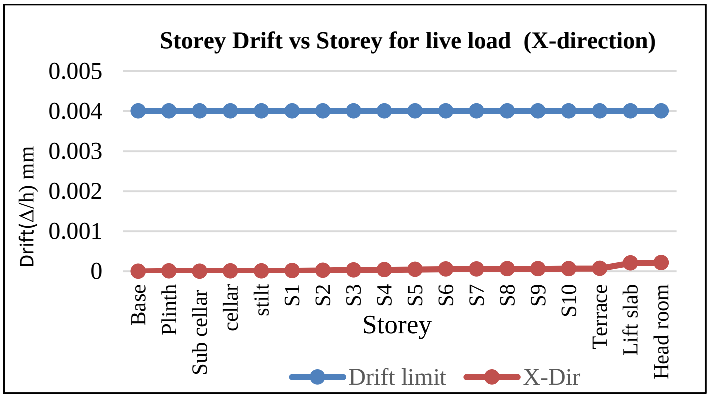


Fig 2.8- Storey drift of Live load in X-direction (Linear Analysis)

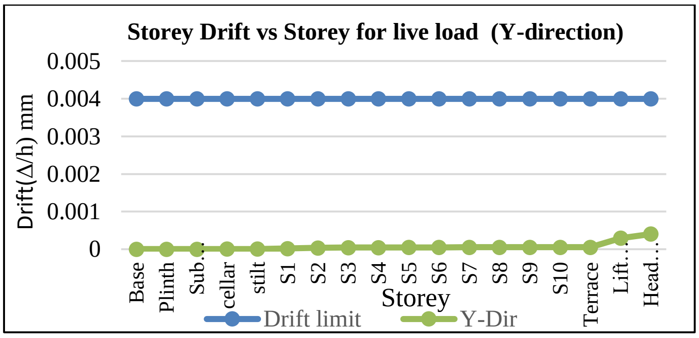


Fig 2.9-Storey drift of Live load in Y-direction (Linear Analysis)

Storey Drift of Earthquake load in X and Y Direction (Linear Analysis)

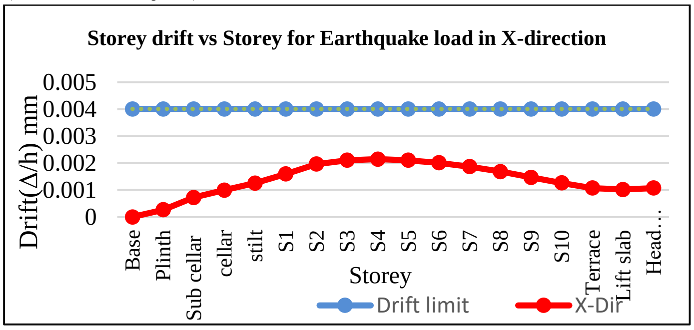


Fig 2.10 Storey drift of Earthquake load in X-direction (Linear Analysis)

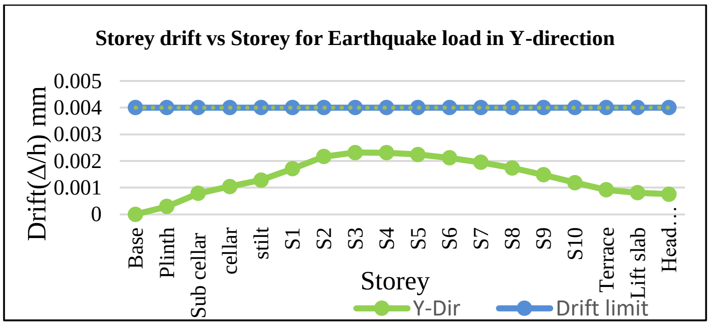


Fig 2.11-Storey drift of Earthquake load in Y-direction (Linear Analysis)

2.5. Storey Displacement of Dead Load in X and Y direction(Linear Analysis)

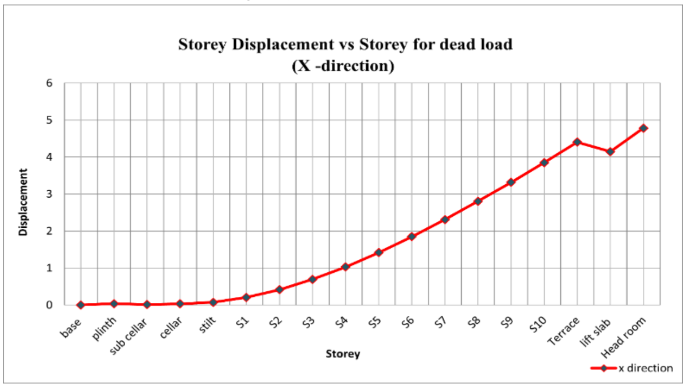


Fig 2.12- Storey displacement of Dead load in X-direction (Linear Analysis)

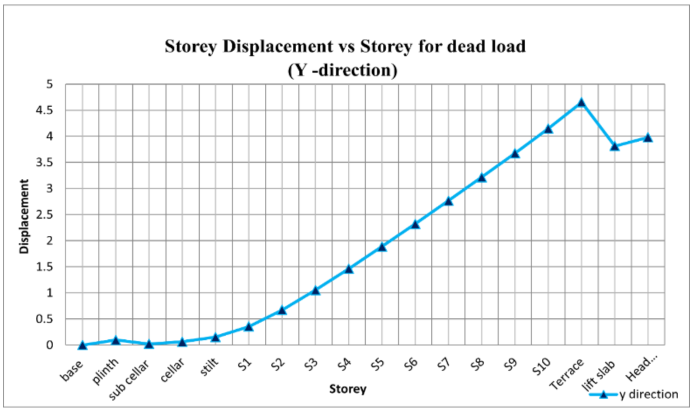


Fig 2.13- Storey displacement of Dead load in Y-direction (Linear Analysis)

Storey Displacement of Live load in X and Y direction (Linear Analysis)

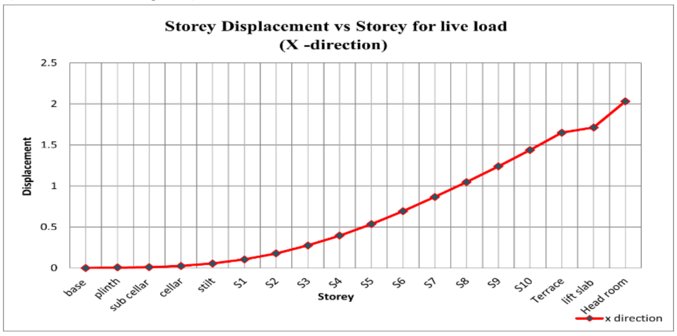


Fig 2.14- Storey displacement of Live load in X-direction (Linear Analysis)

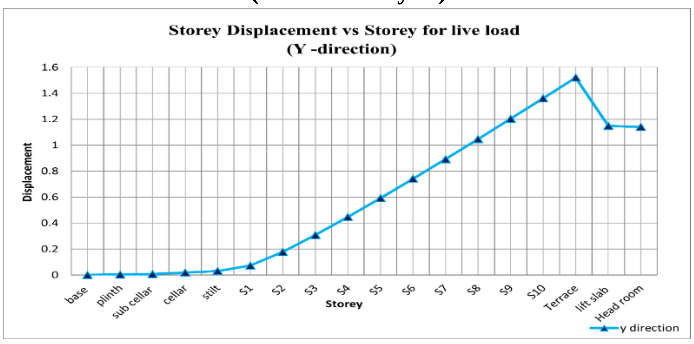


Fig 2.15 Storey displacement of Live load in Y-direction (Linear Analysis)

Storey Displacement of Earthquake in X and Y direction (Linear Analysis)

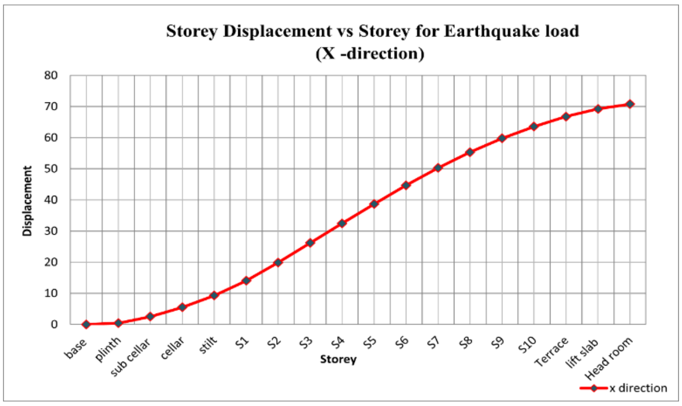


Fig 2.16- Storey displacement of Earthquake load in X-direction (Linear Analysis)

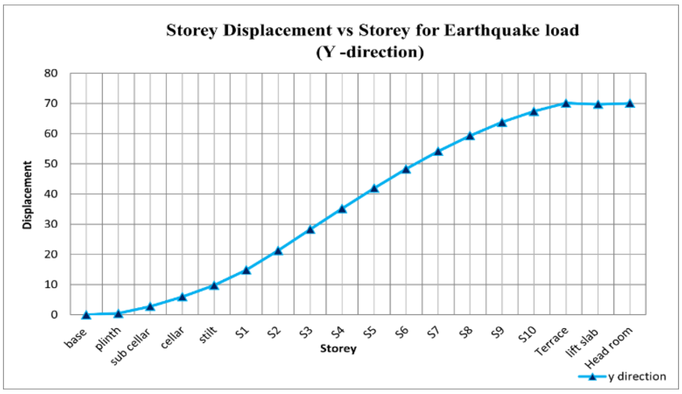


Fig 2.17- Storey displacement of Earthquake load in Y-direction (Linear Analysis)

3. Results and Discussion

3.1 Comparision of Storey drift (X-Direction)

Table 3.1 – Comparison of Storey drift of Dead load, Live load and Earthquake load in X-direction (Linear Analysis)

Storey	Dead load mm	Live load mm	EQ load mm
Base	0	0	0
plinth	0.000025	0.000005	0.000268
sub cellar	0.000013	0.000003	0.000721
cellar	0.000007	0.000006	0.000994
stilt	0.000022	0.00001	0.001256
S10	0.000177	0.000066	0.001261
terrace	0.000184	0.00007	0.001069
lift slab	0.00048	0.000207	0.00102
Head room	0.000423	0.000213	0.001072

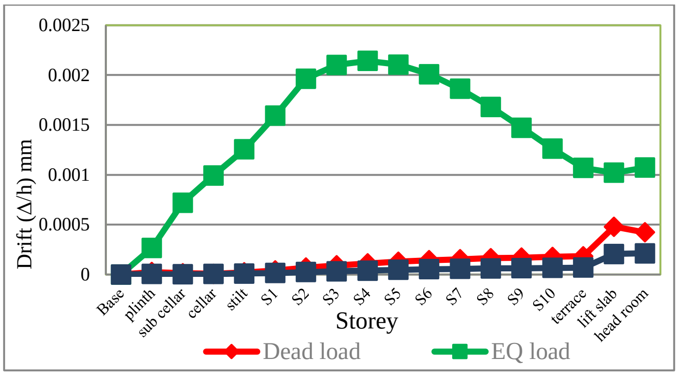


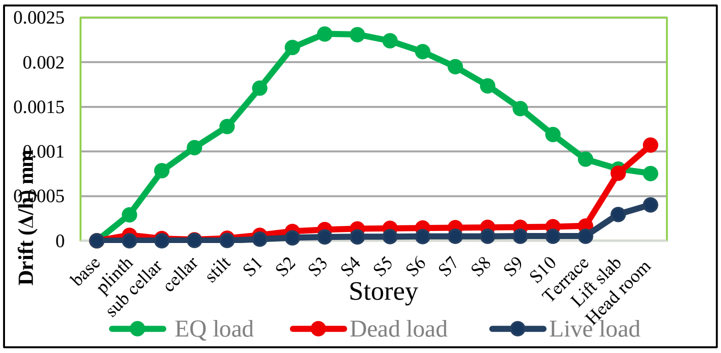
Fig-3.1 Comparison of Storey drift of Dead load, live load and Earthquake load in X-direction (Linear Analysis)

- Storey drift in the X-direction at the plinth level due to Earthquake load is 53.6 times higher and 0.72 times that under Dead load in comparison to live load.
- Storey drift in the X-direction at the terrace level due to Earthquake load is 15.27 times higher and 5.8 times that under Dead load in comparison to live load.

3.2 Comparison of Storey drift (Y-Direction)

Table – 3.2 – Comparison of Storey drift of Dead load, Live load and Earthquake load in Y-direction (Linear Analysis)

Storey	Dead load mm	Live load mm	EQ load mm
base	0	0	0
plinth	0.000064	0.000002	0.000293
sub cellar	0.000026	0.000003	0.000786
cellar	0.000014	0.000004	0.001045
stilt	0.00003	0.000004	0.001281
S10	0.000158	0.000053	0.001191
Terrace	0.000168	0.000053	0.000915
Lift slab	0.000757	0.000297	0.000806
Head room	0.001072	0.000404	0.000755



- Storey drift in the Y-direction at the plinth level due to Earthquake load is 146.5 times higher and 4.57 times that under Dead load in comparison with live load.
- Storey drift in the Y-direction at the terrace level due to Earthquake load is 17.26 times higher and 5.44 times that under Dead load in comparison with live load.

3.3 Comparision of Storey displacement (X-Direction)

Table – 3.3 – Comparison of Storey displacement of Dead load, Live load and Earthquake load in X-direction (Linear Analysis)

Storey	Dead load mm	Live load mm	Earthquake load mm
base	0	0	0
plinth	0.037	0.007	0.402
sub cellar	0.011	0.009	2.509
cellar	0.033	0.025	5.491
stilt	0.072	0.055	9.26
S10	3.847	1.438	63.543
Terrace	4.401	1.649	66.769
Lift slab	4.146	1.712	69.224
Head room	4.78	2.031	70.764

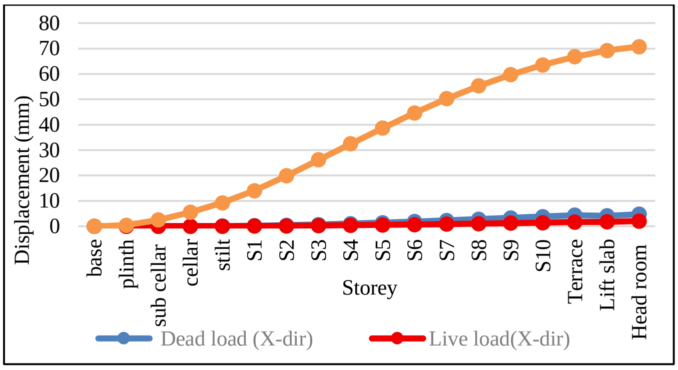


Fig-3.3 Comparison of Storey displacement of Dead load, live load Earthquake load in X-direction (Linear Analysis)

- Storey displacement in the X-direction at the plinth level due to Earthquake load is 57.42 times higher and 10.86 times that under Dead load in comparison with live load.
- Storey displacement in the X-direction at the terrace level due to Earthquake load is 40.49 times higher and 15.85 times that under Dead load in comparison with live load.

3.4 Comparision of Storey displacement (Y-Direction)

Table – 5.4 – Comparison of Storey displacement of Dead load, Live load and Earthquake load in Y-direction

Storey	Dead load mm	Live load mm	EQ load mm
base	0	0	0
plinth	0.097	0.003	0.44
sub cellar	0.021	0.007	2.775
cellar	0.062	0.018	5.911
stilt	0.152	0.031	9.753
S10	4.147	1.361	67.357
Terrace	4.652	1.521	70.102
Lift slab	3.812	1.149	69.68
Headroom	3.978	1.141	70.044

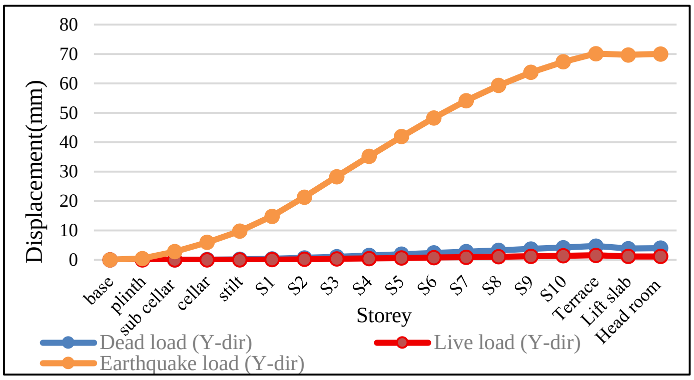


Fig-3.4 Comparison of Storey displacement of Dead load, live load Earthquake load in -direction (Linear Analysis)

- Storey displacement in the Y-direction at the plinth level due to Earthquake load is 146.66 times higher and 4.53 times that under Dead load in comparison with live load
- Storey displacement in the Y-direction at the terrace level due to Earthquake load is 46.09 times higher and 15.07 times that under Dead load in comparison with live load.

CONCLUSION

- Storey drift in the X-direction at the plinth level under earthquake load is 53.6 times higher than live load and 0.72 times that under dead load, while in the X-direction at the terrace level it is 15.27 times higher than live load and 5.8 times that under dead load. These results confirm that earthquake loads govern the design, with drifts remaining within IS 1893 limits, ensuring structural safety.
- Storey drift in the Y-direction at the plinth level under earthquake load is 146.5 times higher than live load and 4.57 times that under dead load, while at the terrace level it is 17.26 times higher than live load and 5.44 times that under dead load. These values highlight that earthquake load is the most critical factor influencing drift and the analysis confirms the necessity of seismic design considerations to ensure safety and compliance with IS 1893 limits.
- Storey displacement in the X-direction at the plinth level under earthquake load is 57.42 times higher than live load and 10.86 times that under dead load, while at the terrace level it is 40.49 times higher than live load and 15.85 times that under dead load. These results clearly indicate that earthquake load governs the displacement response, emphasizing the need for adequate seismic design provisions to maintain structural stability and serviceability.
- Storey drift in the Y-direction at the plinth level under earthquake load is 146.66 times higher than live load and 4.53 times that under dead load, while at the terrace level it is 46.09 times higher than live load and 15.07 times that under dead load. These results highlight that earthquake load is the most critical factor influencing storey drift, necessitating careful seismic design measures to ensure safety and serviceability of the structure.

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