

Seismic Analysis Of High-Rise Building For Different Shapes Using E-Tabs

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ABSTRACT

This study evaluates the seismic response of a G+10 high-rise reinforced-concrete building with six plan configurations—Rectangular, T, L, C, I and O—using ETABS. All models were analysed under comparable geometric, material and loading assumptions so that the effect of plan shape could be assessed directly. The building has a total height of 37.7 m, a 3.5 m ground storey, 3.2 m typical storeys and a 2.2 m plinth level. Response-spectrum analysis was carried out for Pune in Seismic Zone III with medium soil conditions. Structural performance was compared using storey displacement, storey drift, storey shear/base shear and fundamental time period. The I-shaped model produced the largest top-storey displacement, reaching 17.890 mm in the X direction and 18.277 mm in the Y direction, and also the largest drift values of 0.000634 and 0.000646. The C-shaped building had the shortest fundamental period of 0.897 s, while the I-shaped building had the longest period of 1.107 s. Among the realistic base-shear values, the rectangular model recorded 6893.764 kN in X and 7021.649 kN in Y. The extremely small I-shaped shear values reported in the source require ETABS verification and are not treated as a performance advantage. Overall, the results show that plan configuration significantly affects seismic response, with the rectangular form providing the most balanced structural and constructional outcome in the reported study.

Keywords: ETABS, High-rise building, Plan configuration, Response spectrum, Storey displacement, Storey drift, Base shear.

I. Introduction

Increasing urban density has encouraged the use of high-rise residential and commercial buildings where land availability is limited. As structural height increases, lateral forces become more influential, and earthquake response becomes sensitive to mass distribution, stiffness, damping, ductility, foundation conditions and plan geometry.

Plan configuration affects the location of the centre of mass and centre of rigidity, the distribution of lateral stiffness and the potential for torsional response. Regular forms tend to distribute seismic forces more uniformly, whereas re-entrant corners and uneven geometry can create directional differences in displacement and inter-storey drift. For this reason, building shape should be considered at the preliminary design stage rather than treated only as an architectural decision.

The present study uses ETABS to compare six G+10 building forms—Rectangular, T, L, C, I and O—under the same general structural and loading framework. The comparison focuses on storey displacement, storey drift, storey shear/base shear and fundamental period in order to identify the influence of building geometry on overall seismic behaviour.

II. Literature Review

2.1 Seismic Response of Plan-Irregular Buildings

Previous studies reviewed in the report show that diaphragm discontinuity and plan irregularity can alter base shear, displacement, bending actions and force distribution. Sahu and Dwivedi (2017) reported differences between static and response-spectrum analyses for RC frames with diaphragm discontinuity, while Hallale and Sharada Bai (2016) observed that plan-irregular configurations can increase displacement, drift, time period and member forces.

2.2 Influence of Building Shape

Ullas and Nimisha (2017) analysed differently shaped buildings and found that lateral displacement and drift varied with plan form. Jitendra Choubisa (2020) similarly compared building shapes in ETABS and concluded that geometric symmetry generally improves seismic behaviour. These observations provide the basis for the present controlled comparison of six plan configurations.

III. Methodology

3.1 Building Configuration and Material Properties

Table 1. Principal modelling parameters

Parameter	Adopted value
Building type	G+10 RC high-rise building
Overall plan envelope	36 m × 48 m; nominal 6 m bays
Storey heights	Ground: 3.5 m; typical: 3.2 m; plinth: 2.2 m
Total building height	37.7 m
Slab thickness	150 mm
Column size	762 × 762 mm
Beam size	457 × 610 mm
Exterior / interior wall thickness	230 mm / 100 mm
Concrete grades	Columns: M35; beams and slabs: M30
Reinforcement	Fe550D
Support condition	Fixed

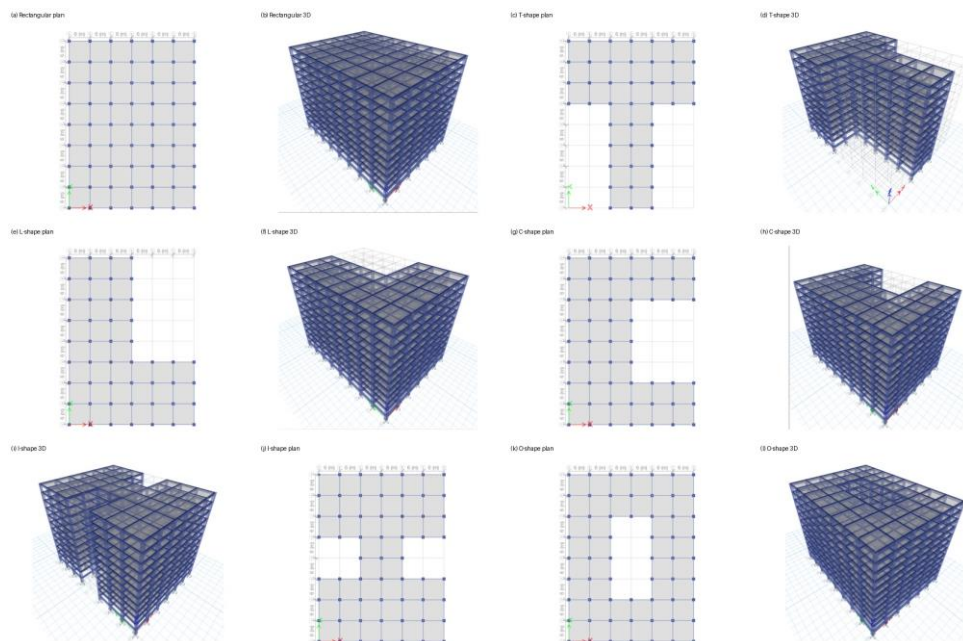


Figure 1. ETABS plan and three-dimensional views of the Rectangular, T, L, C, I and O building configurations.

3.2 Loads and Seismic Parameters

Table 2. Loads and lateral-analysis parameters

Parameter	Adopted value / basis
Floor live load	3 kN/m ²
Roof live load	1 kN/m ²
Floor finish	1 kN/m ²
Wind speed / terrain category	39 m/s / Category 2
Wind region	Pune
Seismic zone / zone factor	Zone III / 0.16
Soil type	Type II (medium soil)
Importance factor	1.0
Response reduction factor	3.0
Damping ratio	0.05
Seismic analysis	Response Spectrum Method; IS 1893 (Part 1):2016 as stated in the report

3.3 ETABS Modelling and Analysis Procedure

For each plan form, grids and storeys were defined, material and section properties were assigned, beams, columns and slabs were placed, fixed support conditions were applied, and dead, live, wind and seismic load cases were defined. Floor diaphragms were assigned and the models were checked before analysis. Response-spectrum analysis was then executed for the six configurations under comparable assumptions, and the resulting storey responses were extracted for comparison.

IV. Results and Discussion

4.1 Storey Displacement

Table 3. Maximum 10th-floor displacement for each building shape

Shape	X direction (mm)	Y direction (mm)
Rectangle	12.551	12.270
T	13.970	12.226
L	15.746	14.875
C	12.347	13.109
I	17.890	18.277
O	12.703	12.070

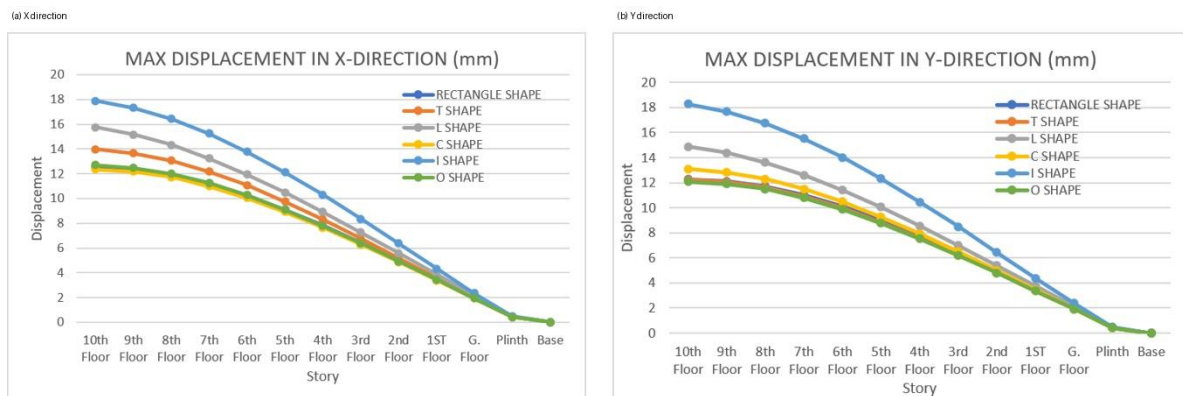


Figure 2. Storey-displacement profiles in (a) X and (b) Y directions.

Displacement increased progressively with building height in both directions. The I-shaped configuration produced the largest 10th-floor displacement at 17.890 mm in X and 18.277 mm in Y. The C-shaped model had the lowest reported X-direction top displacement of 12.347 mm, while the O-shaped model had the lowest Y-direction value of 12.070 mm. The L-shaped model also showed comparatively high displacement, indicating the influence of plan irregularity and stiffness distribution.

4.2 Storey Drift

Table 4. Maximum storey drift by building shape

Shape	Maximum drift in X	Maximum drift in Y
Rectangle	0.000468	0.000462
T	0.000502	0.000454
L	0.000534	0.000510
C	0.000458	0.000475
I	0.000634	0.000646
O	0.000466	0.000452

The maximum drift values occurred mainly in the lower to intermediate storeys. The I-shaped building recorded the highest drift in both directions, reaching 0.000634 in X and 0.000646 in Y at the second floor. The rectangular, C-shaped and O-shaped forms showed lower peak drift values, indicating comparatively better inter-storey deformation control within the investigated models.

4.3 Storey Shear and Base Shear

Table 5. Base shear reported for the six configurations

Shape	Base shear X (kN)	Base shear Y (kN)
Rectangle	6893.764	7021.649
T	4265.136	4446.678
L	5359.985	5507.951
C	5609.535	5514.994
I	2.114e-08	2.155e-08
O	6121.519	6376.582

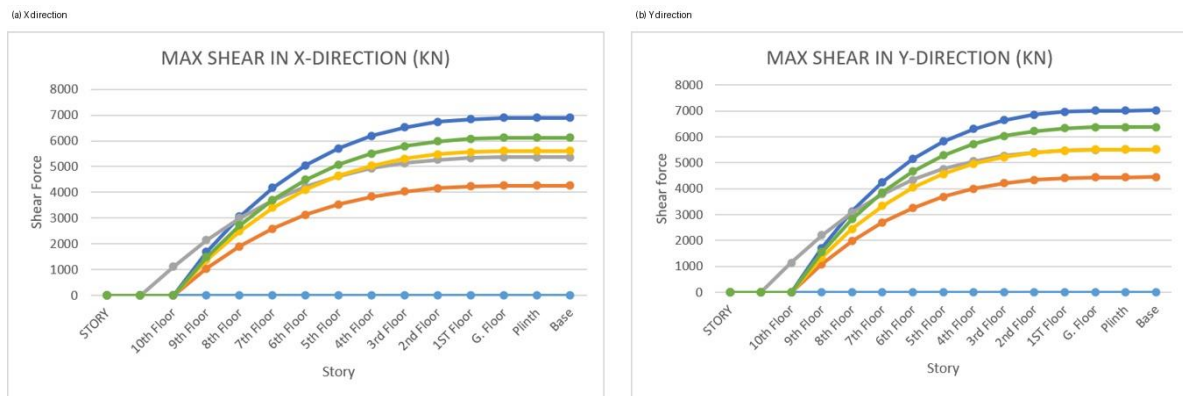


Figure 3. Storey-shear profiles in (a) X and (b) Y directions.

For the realistic values reported, the rectangular model developed the largest base shear: 6893.764 kN in X and 7021.649 kN in Y. The T-shaped model had the lowest realistic base-shear values, followed by the L- and C-shaped configurations. The I-shaped table values are of the order of 10^{-8} kN, which is several orders of magnitude below the other models. The thesis explicitly identifies these values as requiring verification in the ETABS model and output settings; therefore, they are reported here as an anomaly rather than interpreted as superior seismic performance.

4.4 Fundamental Time Period

Table 6. Fundamental time period

Building shape	Time period (s)
Rectangle	0.902
T	0.910
L	0.904
C	0.897
I	1.107
O	0.902

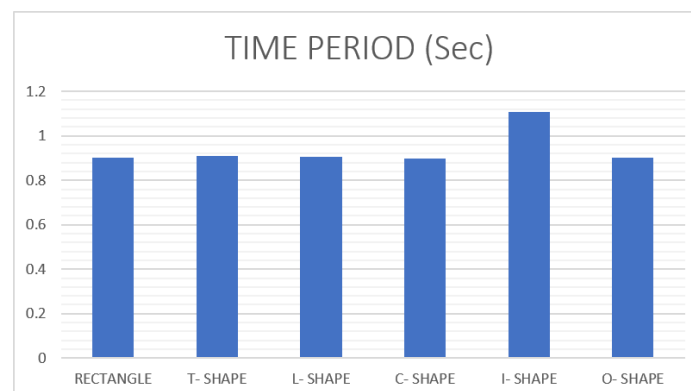


Figure 4. Fundamental time period for the six building configurations.

The C-shaped building had the shortest reported period of 0.897 s, indicating the stiffest dynamic response among the studied shapes, while the I-shaped building had the longest period of 1.107 s and the largest deformation demand. The remaining configurations had closely grouped periods between 0.902 and 0.910 s.

4.5 Overall Comparative Assessment

The results demonstrate that no single parameter should be used in isolation to select a building form. The I-shaped model showed the highest displacement, drift and time period, while the rectangular model attracted the highest realistic base shear. Considering the thesis conclusions together with structural regularity, deformation control, constructional simplicity and economy, the rectangular configuration was identified as the most suitable overall option among the six investigated forms.

V. Conclusion

- Building plan configuration had a measurable influence on displacement, drift, shear distribution and fundamental time period under the adopted response-spectrum analysis.
- The I-shaped building produced the maximum 10th-floor displacement of 17.890 mm in X and 18.277 mm in Y and the maximum drift of 0.000634 and 0.000646.
- The C-shaped model had the minimum time period of 0.897 s, while the I-shaped model had the maximum period of 1.107 s.
- Among the realistic values, the rectangular configuration developed the largest base shear, with 6893.764 kN in X and 7021.649 kN in Y.
- The near-zero I-shaped shear results should be verified in ETABS before they are used for design or comparative conclusions.
- Based on the reported analytical results together with regularity, ease of construction and economy, the rectangular-shaped building was identified as the most suitable configuration in this study.

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