

Seismic Analysis of Multi Storey RCC Building in Different Seismic Zones Using STAAD Pro

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Abstract—The present study investigates and compare seismic-analysis framework for a ten-storey RCC building with a 24 m × 18 m plan and 30 m height. The proposed frame contains 300 × 450 mm beams, 450 × 450 mm columns and 150 mm slabs, with M30 concrete and Fe500 reinforcement. Zones II, III, IV and V are compared under the adopted IS 1893 (Part 1):2016 basis while maintaining constant geometry, mass and modelling assumptions. The methodology covers equivalent static checks and the intended response spectrum analysis in STAAD.Pro. Under the stated loading assumptions, seismic weight is 36,031.50 kN and calculated equivalent static base shear varies from 509.71 kN to 1,834.94 kN. Separate shear-building calculations illustrate displacement and inter-storey movement. The Zone V to Zone II action ratio is 3.60, representing a 260% increase when all other linear parameters remain unchanged.

Keywords—RCC building; seismic zones; STAAD.Pro; equivalent static analysis; response spectrum; storey drift.

I. INTRODUCTION

Earthquake excitation generates inertia forces that are transferred through floor diaphragms, beams, columns and foundations. The resulting response depends on the mass and stiffness distributions, damping, support conditions and seismic input. Assessment must therefore consider both global demand and deformation. Base shear indicates total horizontal action, while inter-storey movement describes relative deformation between adjacent levels.

This project examines the influence of seismic-zone coefficient on one fixed building configuration. Both principal horizontal directions are considered. The comparison is intended to isolate the effect of hazard scaling, rather than simultaneously changing the number of storeys, member sizes or mass source.

Earlier studies demonstrate the relevance of controlled seismic comparisons. Gupta and Baig [6] considered a G+21 RCC building using STAAD.Pro and compared designs across seismic zones. Tondon and Needhidasan [7] examined a G+8 building in Zones II and IV under the 2002 code framework. Their model heights and code bases differ from the present project; their numerical results cannot be transferred to this building.

Armo and Jha [8] describe a G+4 building in Zone II with base shear and drift as response measures. This illustrates a single-zone workflow but does not establish four-zone behaviour for the present configuration. The contribution here is a traceable case study linking the supplied geometry, explicit load assumptions, hand checks and a consistent procedure for subsequent solver evaluation.

The detailed project tables and elevation show ten storeys of 3 m each. Accordingly, the paper uses “ten-storey” and a height of 30 m throughout.

A. Objectives and comparison basis

The objectives are to document a consistent three-dimensional model; establish seismic weight; compare zone-dependent base shear; evaluate displacement and drift in X and Z; and define the member-force and verification records needed for final design assessment. The geometry, stiffness, mass source, damping, soil spectrum and structural-system assumptions are held constant between zones.

B. Status e available evidence

The supplied report includes geometry images and native STAAD.Pro model, analysis log or numerical output. The equivalent static benchmark follows the stated code basis; the displacement uses assumed storey springs.

II. METHODOLOGY AND MATERIAL CHARACTERISATION

A. Modelling and analysis sequence

The proposed workflow begins with geometry and connectivity checks, followed by materials, section properties, supports and diaphragms. Gravity loads and the seismic mass source are then defined. Static and spectrum cases are prepared for each zone and horizontal direction. Analysis warnings, mass, periods, participation and reactions must be verified before response comparisons and member design.

TABLE 1. BUILDING CONFIGURATION

Parameter	Project value
Plan dimensions	24 m × 18 m
Number of storeys	10
Storey / total height	3 m / 30 m
X bays	6 × 4 m
Z bays	3 × 6 m
Column positions	28 per level
Beam section	300 × 450 mm
Column section	450 × 450 mm
Slab thickness	150 mm
Materials	M30 / Fe500
Supports	Fixed

B. Model details

Use X and Z as horizontal axes and Y as vertical. The X coordinates are 0, 4, 8, 12, 16, 20 and 24 m; Z coordinates are 0, 6, 12 and 18 m. Eleven nodal levels, including the base, produce 308 baseline nodes. The model contains 280 column segments and 450 beams. Each elevated floor has 24 X beams and 21 Z beams, with a combined length of 222 m.

The preliminary concrete elastic modulus is $5000\sqrt{30} = 27,386$ MPa [2]. Density is assumed as 25 kN/m³ and Poisson's ratio as 0.20. Gross section properties must be distinguished from the effective flexural stiffness used in seismic analysis. Record the appropriate beam and column modifiers under the adopted code basis, including local member axes and any releases.

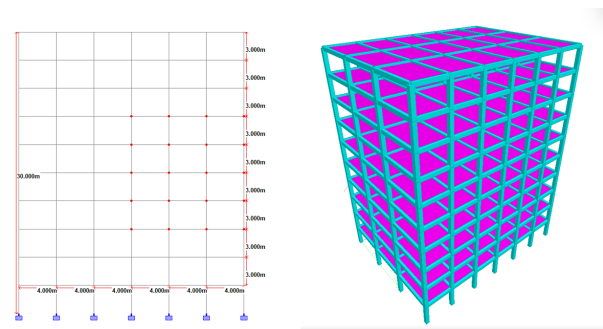


Fig. 1. Elevation and isometric views of a ten-storey frame.

C. Seismic details

TABLE 2. SEISMIC INPUT ASSUMPTIONS

Parameter	Value
Zones	II, III, IV, V
Zone coefficients	0.10, 0.16, 0.24, 0.36
Importance factor I	1.0 assumed
Reduction factor R	5.0 conditional
Soil spectrum	Medium soil assumed
Damping	5%
Analysis basis	IS 1893 Part 1:2016

The use of $R = 5$ assumes an eligible special moment-resisting frame; material grades alone do not establish that eligibility. Strength, proportions, joints and ductile detailing require verification [2, 3]. The soil spectrum is an assumption because no geotechnical report was provided.

A rigid in-plane diaphragm is proposed at each floor, with floor-load transfer to frame members. A floor load does not itself create diaphragm rigidity. If slabs are represented by plates, use appropriate connectivity and mesh refinement, and avoid counting slab self-weight twice. Fixed bases exclude soil flexibility. Infill stiffness, stairs and foundation interaction are outside the baseline and require separate review when relevant.

D. Controlled zone cases

Prepare zone variants from a verified master model. Preserve mass, stiffness, restraints and analysis settings, changing only Z. Include the required positive and negative horizontal actions, eccentricity variants and orthogonal combinations. Symmetry in plan is not a reason to omit accidental torsion or edge-drift checks.

E. Gravity loading and seismic ma

For the given model, floor finish and distributed partitions are each assumed as 1.0 kN/m². Occupied-floor imposed load is 2.0 kN/m², with 25% included in seismic weight. Roof imposed load is excluded from seismic mass. Actual wall layouts, parapets, equipment and stairs must replace the allowances where applicable [1, 4, 5].

TABLE 3. LEVEL WEIGHT

Component	Weight kN
Slab: 432 × 0.15 × 25	1,620.00
Beam downstand: 222 × 0.3 × 0.3 × 25	499.50
Columns: 28 × 0.45 ² × 3 × 25	425.25
Finish allowance	432.00
Partition allowance	432.00
Permanent subtotal	3,408.75
Seismic imposed load per occupied floor	216.00
Occupied floor total	3,624.75
Roof total	3,408.75

Beam down stand weight avoids slab–beam duplication in the hand benchmark. Full storey-column weight is assigned to the level above. Small joint overlaps are not corrected. The roof partition allowance is retained only for this schedule and must be replaced by the actual roof take-off. Reconcile the software mass source with its own volume and nodal-allocation conventions.

$$W = 9(3624.75) + 3408.75 = 36,031.50 \text{ kN.}$$

F. Equivalent static benchmar

For the adopted bare-frame idealisation, $T_a = 0.075H^{0.75} = 0.9614 \text{ s}$. On the applicable medium-soil branch, $S_a/g = 1.36/T_a = 1.4146$. The design coefficient is $A_h = (Z/2)(I/R)(S_a/g)$, and base shear is $V^B = A_h W$ [1]. Floor force is $Q_i = V^B W_i h_i^2 / \sum (W_j h_j^2)$. Storey shear is the sum of forces at and above that level. Verify $\sum Q_i = V^B$ before comparing with software.

G. Dynamic analysis and verificati

Define a consistent mass source and spectrum in STAAD.Pro. Check whether the software expects normalised spectral ordinates or acceleration values so that gravity and reduction factors are applied once. Select enough modes to satisfy the adopted participation requirement. Use the appropriate modal combination, including CQC where closely spaced modes require it. Record raw dynamic base shear and any code-required adjustment separately.

Representative strength families include 1.5(DL + LL), 1.2(DL + LL ± E), 1.5(DL ± E) and 0.9DL ± 1.5E, with E representing the required directional and eccentricity action. Drift and service checks require their specified load levels. Independently combined modal peak floor displacements must not simply be subtracted to obtain drift; combine modal relative movements appropriately.

III. R TS AND DISCUSSION

A. Equivalent static base she

Table 4 and Fig. 2 are independent calculations using Table 3 and the adopted parameters. The same mass and spectral ordinate produce proportional scaling with the zone coefficient.

TABLE 4. CALCULATED BASE SHEAR

Zone	Z	V ^B kN	Ratio
II	0.10	509.71	1.00
III	0.16	815.53	1.60
IV	0.24	1223.29	2.40
V	0.36	1834.94	3.60

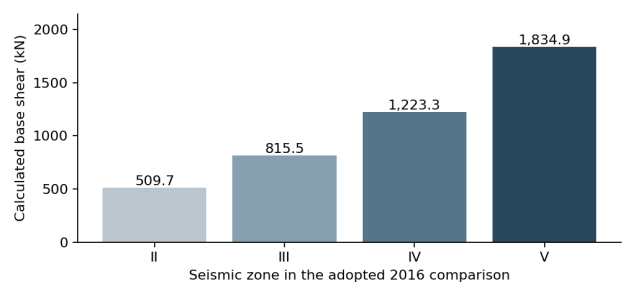


Fig. 2. Equivalent static base shear for the four zone cases.

Zone III, IV and V demands are respectively 60%, 140% and 260% above Zone II. The 3.60 ratio for Zone V means 360% of the Zone II value, not a 360% increase. These values describe design action, not damage probability or reinforcement demand.

B. Storey displacement

Displacement tables are populated using an independent ten-level shear-building example. Uniform springs $kX = 250,000$ kN/m and $kZ = 180,000$ kN/m are assumed; they have not been derived from the proposed frame sections. With static storey shear V_i , relative movement is $\delta_i = V_i/k$ and floor translation is $u_i = \sum \delta_j$ from the base. The model excludes joint rotations and torsion.

TABLE 5. ROOF DISPLACEMENT

Zone	X mm	Z mm
II	15.95	22.15
III	25.52	35.45
IV	38.28	53.17
V	57.42	79.75

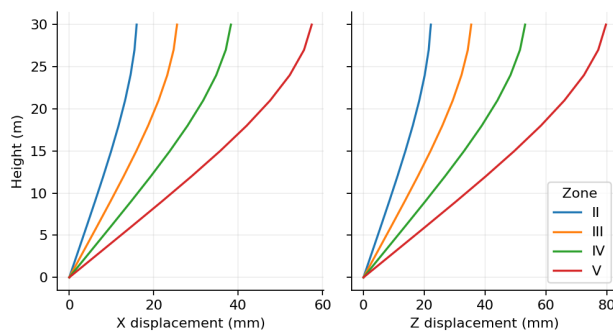


Fig. 3. Static displacement profiles.

TABLE 6. ZONE V FLOOR TRANSLATION

Height m	X mm	Z mm
3	7.34	10.19
6	14.66	20.36
9	21.90	30.42
12	28.97	40.24
15	35.73	49.63
18	42.01	58.34
21	47.58	66.09
24	52.21	72.52
27	55.60	77.22
30	57.42	79.75

The greater Z response is imposed by the assumed stiffness ratio, $kX/kZ = 1.389$. Maximum floor translation occurs at the roof in this static example.

C. Inter storey movement

Inter storey movement is the difference between adjacent level translations within the same static case. It must be distinguished from absolute floor displacement. For a 3 m storey, the adopted 0.004-height reference gives 12 mm at the specified design action [1].

TABLE 7. MAXIMUM MOVEMENT

Zone	δX mm	δZ mm
II	2.04	2.83
III	3.26	4.53
IV	4.89	6.80
V	7.34	10.19

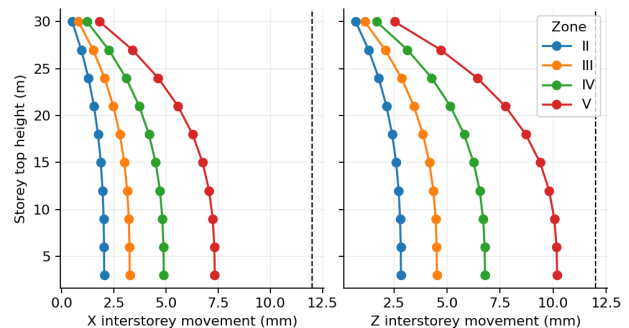


Fig. 4. Inter storey movement

The first storey has the largest movement in the constant-stiffness because shear accumulates downward. All values are below 12 mm.

D. Interpolation and missing solver evidence

Linear static forces and displacements scale with Z when mass and stiffness are unchanged. Modal periods do not change solely because Z changes. Unexpected period differences between zone variants should first trigger a check of modelling inputs and settings.

IV. C NCLUSION

1. The project geometry is consistently defined as a 24 m × 18 m ten-storey RCC frame of 30 m height, with 28 column positions per level. The baseline consists of 308 nodes and 730 frame members before any additional mesh or secondary framing.
2. Under the explicit load, the seismic weight is 36,031.50 kN. Equivalent static base shear increases from 509.71 kN in Zone II to 1,834.94 kN in Zone V. The ratio is 3.60, corresponding to a 260% increase.
3. The shear-building demonstrates displacement and drift reporting and predict the actual frame response. The assumed directional springs determine the relative X and Z responses. Their values can establish member adequacy or a need for shear walls.

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Data availability and manuscript status

The source material consists of the author's project manuscript and geometry views. Tables 3–7 and Figs. 2–4 contain independent calculations. Native STAAD.Pro input and output files were available.

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