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Dynamic Response of A G+10 RCC Building with Shear Walls Under Seismic and Wind Loading: A Comparative Analytical Study

*** K.SREE HARSHA[1], K. DILEEP CHOWDARY[2]**

[1]M.Tech Scholar (Structural Engineering), Department of Civil Engineering,

Sanketika Vidya Parishad Engineering College, P.M. Palem, Visakhapatnam – 530041, Andhra Pradesh, India

[2]Assistant Professor, Department of Civil Engineering, Sanketika Vidya Parishad Engineering College,

P.M. Palem, Visakhapatnam – 530041, Andhra Pradesh, India

Abstract

This study compares the lateral response of a G+10 reinforced-concrete residential building incorporating a central lift/staircase shear-wall core under earthquake and wind loading. The analytical configuration has a 24 m × 18 m plan, a total height of 33.6 m, M30 concrete and Fe500 reinforcement. The adopted numerical dataset gives a seismic base shear of 693 kN and an assumed wind base shear of 820 kN for a basic wind speed of 44 m/s. The maximum roof displacements are 72 mm under earthquake loading and 56 mm under wind loading; the corresponding reported maximum storey drifts are 13 mm and 9 mm. Wind produces larger reported beam and column bending moments, shear-wall shear and overturning moment, whereas earthquake loading governs roof displacement, drift and maximum column axial force. An illustrative frame-only comparison indicates reductions of 43.8% and 40.4% in earthquake- and wind-induced roof displacement, respectively, when shear walls are included. These values must be interpreted cautiously: the geometry and wind speed are assumed, several response quantities are manual analytical equivalents, and the available documentation records errors in the STAAD.Pro model. The results are therefore preliminary and are not presented as verified finite-element outputs. The study identifies the response trends indicated by the adopted dataset and the additional modelling and code checks required for reliable design conclusions.

Keywords—RCC building, shear wall, response spectrum analysis, wind loading, storey displacement, inter-storey drift, STAAD.Pro, lateral stiffness.

1. INTRODUCTION

Multistorey reinforced concrete buildings are subjected to gravity and lateral actions throughout their service life. Earthquake ground motion induces inertia forces that depend on the mass, stiffness, damping and dynamic characteristics of the structure. Wind loading, on the other hand, produces pressure and suction over exposed wall and roof surfaces, generating lateral forces, overturning effects and member bending demands. The relative severity of these actions varies with building geometry, location, exposure and structural configuration.

Shear walls are widely used to improve the lateral stiffness and strength of reinforced concrete buildings. When positioned around a lift or staircase core and continued to the foundation, they act as vertical cantilever elements and share lateral shear and overturning demand with the surrounding frame. Their contribution can reduce roof displacement and inter-storey drift, although force redistribution and wall boundary demands must also be considered.

The study evaluates the lateral response of a G+10 residential RCC building with a central shear-wall core under the specified seismic and wind actions. The comparison considers roof displacement, storey drift, base shear, member-force demands and shear-wall actions. A separate illustrative comparison is used to examine the potential contribution of the shear walls to deformation control. The discussion distinguishes the numerical values available for comparison from results that require confirmation through a complete and error-free structural analysis.

2. OBJECTIVES AND SCOPE

The objectives are to: (i) define the adopted three-dimensional G+10 RCC frame and central shear-wall configuration; (ii) present the seismic and wind loading assumptions used in the numerical illustration; (iii) compare roof displacement, storey-wise displacement, inter-storey drift, base shear and member-force demands; (iv) examine the indicative influence of the shear-wall core on lateral deformation; and (v) identify the modelling outputs and design checks needed to validate the response.

The investigation is restricted to one assumed building configuration and the loading parameters listed in this paper. The available dataset does not include validated modal properties, nonlinear time-history results, soil–structure interaction, explicit diaphragm-flexibility assessment, detailed wall boundary-element design or independent validation against measured structural response. The numerical comparisons should consequently be treated as preliminary.

3. BUILDING CONFIGURATION AND MATERIAL PARAMETERS

The building considered is a G+10 residential RCC structure with six apartments on a typical floor and a shear-wall core enclosing the lift/staircase. In the absence of confirmed architectural drawings, a 24 m × 18 m rectangular plan and the associated member dimensions are adopted for the analytical illustration. The plan comprises four 6 m bays in one direction and three 6 m bays in the perpendicular direction. The ground storey is 3.6 m high, each of the ten upper storeys is 3.0 m high, and the overall structural height is 33.6 m.

Table 1. Adopted building geometry and material properties

Parameter	Value
Building configuration	G+10 residential RCC building
Plan dimensions	24 m × 18 m
Typical floor area	432 m²
Number of floor levels	11
Ground / typical storey height	3.6 m / 3.0 m
Total structural height	33.6 m
Apartments per typical floor	6
Beam size	300 × 500 mm
Column size	500 × 500 mm
Slab thickness	125 mm
Shear-wall thickness	250 mm
Shear-wall length (assumed)	4.0 m
Concrete / reinforcement	M30 / Fe500
Foundation support	Fixed (assumed)

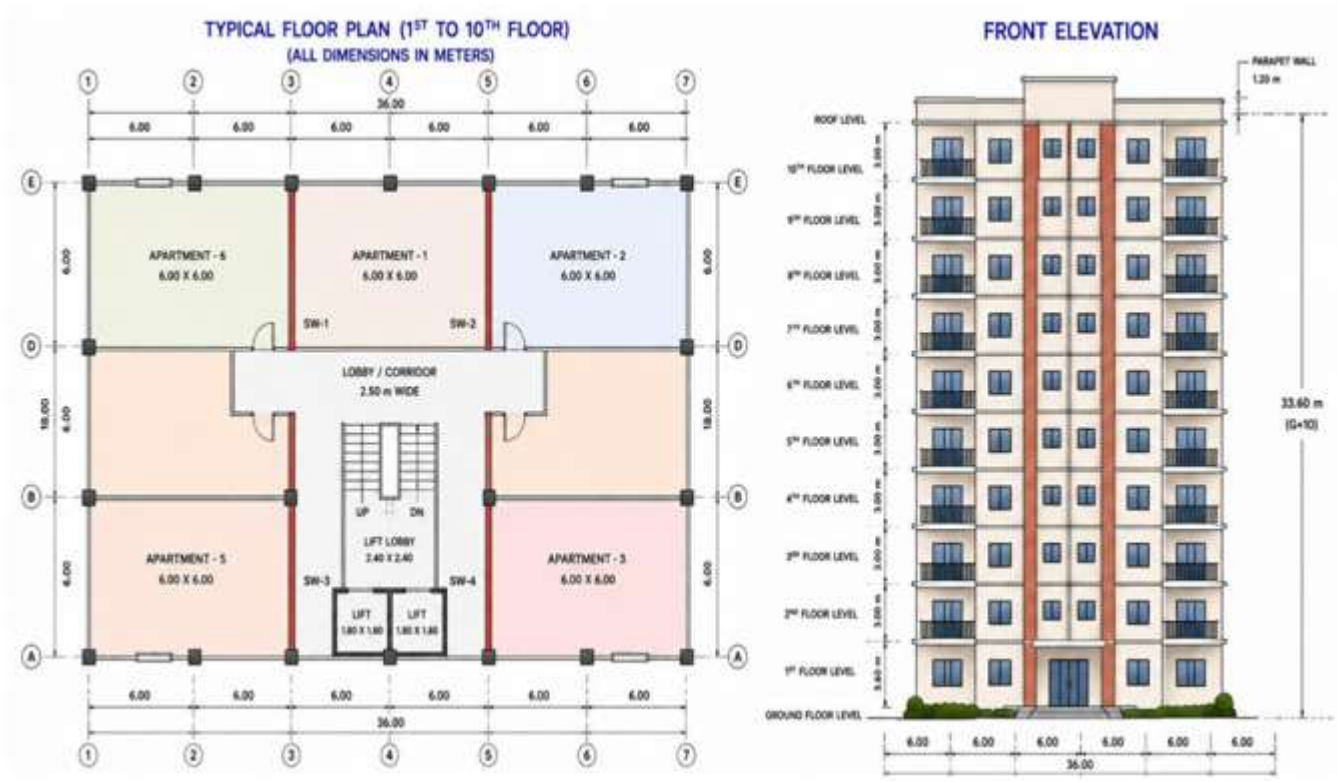


Fig. 1. Adopted typical floor plan and front elevation for the analytical building configuration.

The shear walls are idealised as 250 mm thick plate elements arranged around the central core and extending from the foundation level to the roof. The base supports are assumed to be fixed. The plan and elevation in Fig. 1 define the adopted analytical arrangement; they should not be treated as approved architectural or construction drawings.

4. LOADING AND ANALYSIS METHODOLOGY

4.1 Gravity loading

The slab self-weight is evaluated using a thickness of 125 mm and a reinforced-concrete unit weight of 25 kN/m³, giving 3.125 kN/m². A floor-finish load of 1.0 kN/m² is added, producing 4.125 kN/m² before allowances for beams, columns and walls. An equivalent dead-load intensity of approximately 5.9 kN/m² and a residential live-load intensity of 2.0 kN/m² are adopted. For the seismic-weight calculation, 25% of the live load is included, giving an adopted seismic load intensity of 6.4 kN/m².

Table 2. Reported gravity and seismic-weight assumptions

Parameter	Adopted value
Slab self-weight	3.125 kN/m²
Floor finish	1.0 kN/m²
Equivalent dead load incl. structural allowance	5.9 kN/m²
Residential live load	2.0 kN/m²
Live-load fraction in seismic weight	25%
Seismic weight intensity	6.4 kN/m²
Typical floor seismic weight	2,765 kN
Roof seismic weight	2,550 kN
Total building seismic weight	≈30,200 kN

4.2 Seismic loading

The seismic illustration uses Zone IV with zone factor Z = 0.24, importance factor I = 1.0, response reduction factor R = 5.0, medium soil and 5% damping. The approximate fundamental period is taken as 1.05 s. Using an assumed spectral acceleration ratio of approximately 0.95, the horizontal seismic coefficient is estimated as 0.0228, giving a base shear of approximately 689 kN; 693 kN is adopted in the response dataset. The lateral force is distributed vertically using the conventional height- and seismic-weight-based distribution expression. The period, spectral ordinate and coefficient require confirmation using the applicable code provisions and the final structural model.

Table 3. Reported seismic force distribution

Floor	Height (m)	Seismic force (kN)
Ground	3.6	1.9
1	6.6	6.4
2	9.6	13.6
3	12.6	23.4
4	15.6	35.8
5	18.6	50.9
6	21.6	68.7
7	24.6	89.1
8	27.6	112.1
9	30.6	137.8
10/Roof	33.6	153.2
Total	—	693

4.3 Wind loading

A basic wind speed of 44 m/s is assumed for the numerical illustration. The simplified basic wind pressure is calculated from $p = 0.6V^2$, giving 1.162 kN/m². An equivalent total horizontal wind force of 820 kN is adopted. This value is not a complete code-derived design wind force: the final pressure calculation must incorporate the applicable risk, terrain, height, topography, directionality and other factors specified in IS 875 (Part 3), together with the exposed areas and pressure coefficients.

Table 4. Reported wind-force distribution

Floor	Height (m)	Wind force (kN)
Ground	3.6	14.5
1	6.6	24.2
2	9.6	33.9
3	12.6	46.0
4	15.6	58.1
5	18.6	70.1
6	21.6	82.2
7	24.6	96.8
8	27.6	111.3
9	30.6	130.6
10/Roof	33.6	152.4

Total	—	820

4.4 Modelling and load combinations

The analytical idealisation comprises a three-dimensional space frame of beams and columns with plate elements representing the shear-wall core. The listed actions include self-weight, slab and floor-finish loads, masonry walls, parapets, staircase/service loads and imposed floor loads, together with seismic and wind actions in both principal directions and their reversals. The combinations reported include 1.5(DL + LL), 1.2(DL + LL ± EQ/WL), 1.5DL ± 1.5EQ and 0.9DL ± 1.5EQ/WL. The available documentation records errors in the STAAD.Pro model and describes the response values as manual or analytical equivalents. Accordingly, the results below are not attributed to a successfully converged or independently verified STAAD.Pro analysis.

5. RESULTS AND DISCUSSION

5.1 Consolidated seismic and wind response

Table 5. Consolidated reported structural response

Response parameter	Earthquake	Wind	Governing case
Maximum roof displacement	72 mm	56 mm	Earthquake
Maximum storey drift	13 mm	9 mm	Earthquake
Maximum drift ratio	0.433%	0.300%	Earthquake
Base shear	693 kN	820 kN	Wind
Maximum beam moment	165 kN·m	190 kN·m	Wind
Maximum column moment	245 kN·m	280 kN·m	Wind
Maximum column axial force	1,850 kN	1,600 kN	Earthquake
Maximum shear-wall shear	620 kN	710 kN	Wind
Wall overturning moment	18,500 kN·m	21,000 kN·m	Wind

The adopted dataset indicates that the governing action varies with the response quantity. Earthquake loading produces the larger roof displacement, maximum storey drift and maximum column axial compression. Wind loading produces the larger total base shear, beam and column bending moments, shear-wall shear and wall overturning moment. The adopted wind base shear of 820 kN is approximately 18.3% greater than the seismic value of 693 kN, whereas the earthquake roof displacement of 72 mm is approximately 28.6% greater than the wind displacement of 56 mm. These comparisons describe the supplied numerical dataset and should not be interpreted as validated design envelopes.

5.2 Storey displacement profiles

Table 6. Storey-wise lateral displacement values adopted for the comparison

Storey elevation (m)	Earthquake (mm)	Wind (mm)
3.6	0	0
6.6	2	1.5
9.6	5	4
12.6	9	7

15.6	14	11
18.6	20	16
21.6	28	22
24.6	37	29
27.6	47	37
30.6	59	46
33.6	72	56

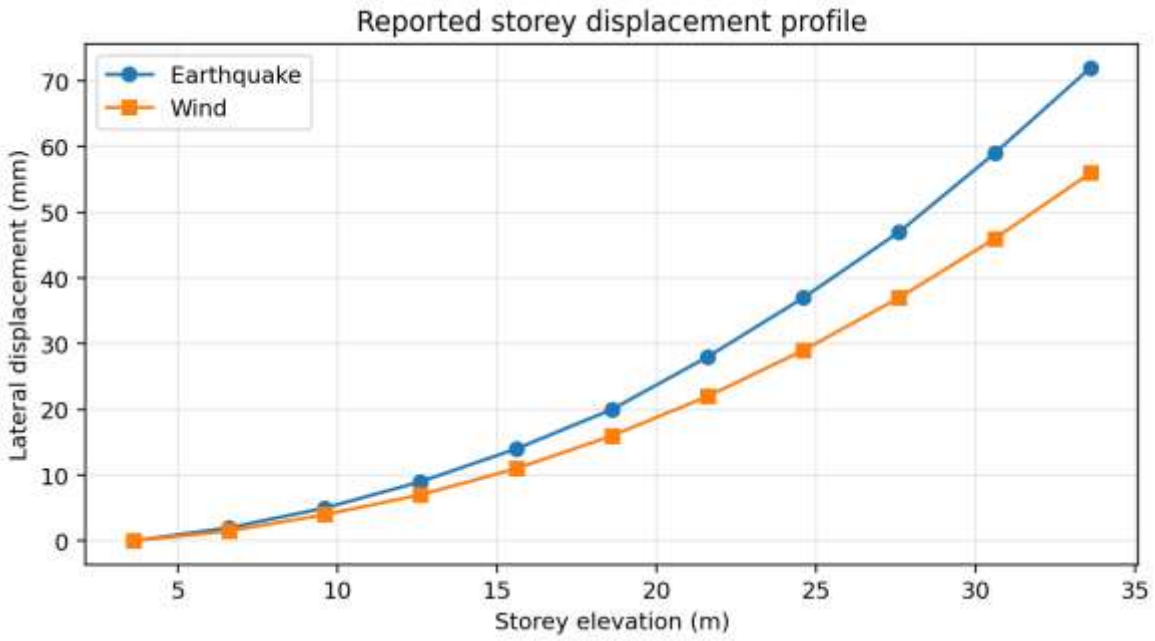


Fig. 2. Storey displacement profiles under the adopted earthquake and wind loading cases.

The displacement values increase with elevation and reach their maximum at the roof in both loading cases. The roof displacement is 72 mm for earthquake loading and 56 mm for wind loading, making the earthquake value approximately 28.6% higher. This trend is consistent with the overall flexural response expected from a tall lateral-load-resisting system. The displacement profiles nevertheless require confirmation from the final three-dimensional model, including diaphragm constraints and the actual distribution of lateral loads.

5.3 Storey drift

Table 7. Reported storey drift values

Storey	Earthquake drift (mm)	Wind drift (mm)
1	2	1.5
2	3	2.5
3	4	3
4	5	4
5	6	5
6	8	6
7	9	7
8	10	8
9	12	9

10	13	9

The maximum tabulated storey drift is 13 mm for earthquake loading and 9 mm for wind loading. For a 3.0 m typical storey, these values correspond to drift ratios of 0.433% and 0.300%, respectively. The displacement data contain an arithmetic inconsistency in the final wind storey: the roof displacement of 56 mm minus the displacement at 30.6 m of 46 mm gives 10 mm, not the tabulated 9 mm. The 9 mm value is retained as originally tabulated but must be recalculated from consecutive floor displacements before any code-compliance statement is made. The applicable drift limit and the precise definition of the displacement quantity must also be checked against the governing code.

5.4 Member forces and shear-wall demand

The adopted values show higher beam bending moment under wind loading (190 kN·m) than under earthquake loading (165 kN·m), and the corresponding column moments are 280 and 245 kN·m. Earthquake loading produces the larger column axial force (1,850 kN, compared with 1,600 kN under wind). The maximum shear-wall shear is 710 kN under wind and 620 kN under earthquake, while the corresponding wall overturning moments are 21,000 and 18,500 kN·m. The results indicate that frame and wall components must be checked for the full set of governing load combinations rather than for a single global load case.

Table 8. Reported beam, column and shear-wall actions

Parameter	Earthquake	Wind
Beam bending moment	165 kN·m	190 kN·m
Beam shear	125 kN	145 kN
Column bending moment	245 kN·m	280 kN·m
Column axial compression	1,850 kN	1,600 kN
Column shear	105 kN	120 kN
Shear-wall shear	620 kN	710 kN
Shear-wall overturning moment	18,500 kN·m	21,000 kN·m

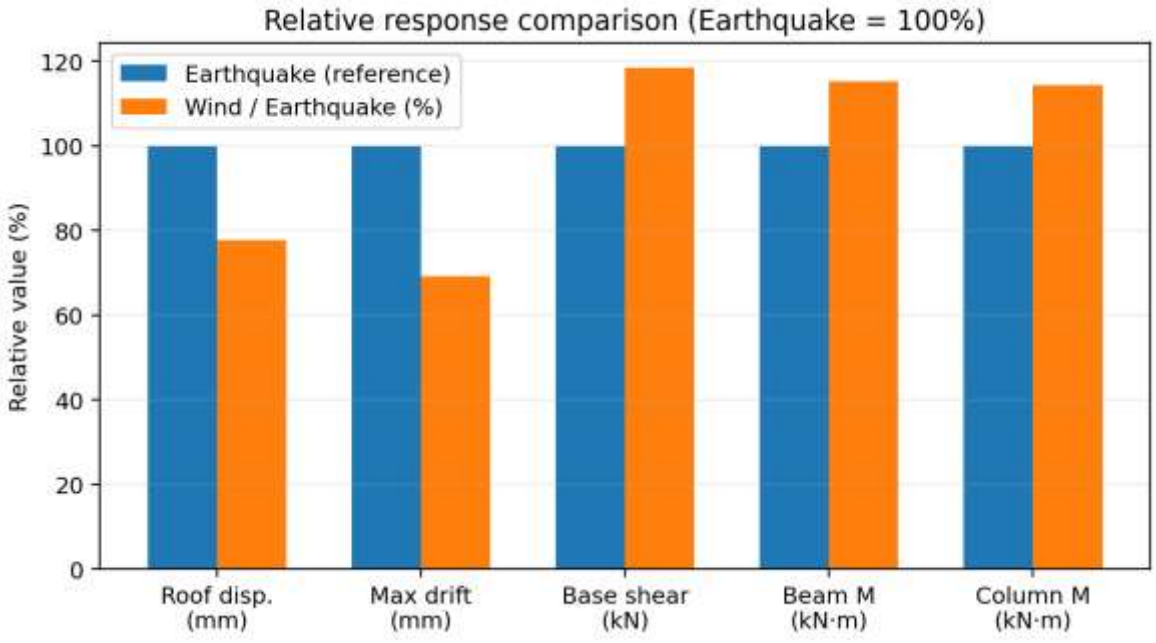


Fig. 3. Relative comparison of selected response parameters, with earthquake values normalised to 100%.

5.5 Reported contribution of shear walls

Table 9. Illustrative frame-only and frame-plus-shear-wall comparison

Response parameter	Frame only	Frame + wall	Reported reduction
Earthquake roof displacement	128 mm	72 mm	43.8%
Earthquake maximum drift	22 mm	13 mm	40.9%
Wind roof displacement	94 mm	56 mm	40.4%
Wind maximum drift	15 mm	9 mm	40.0%

The frame-only and frame-plus-wall values indicate reductions of 43.8% in earthquake roof displacement and 40.4% in wind roof displacement when the shear-wall system is included. The corresponding reported reductions in maximum drift are 40.9% and 40.0%. These percentages are indicative only because complete paired model files, consistent mass and stiffness assumptions, and full response output for the frame-only configuration are not available. They should not be presented as independently verified shear-wall effectiveness factors.

6. DISCUSSION

The results illustrate why lateral-load performance should be assessed using several response measures. A larger base shear under wind does not necessarily produce a larger roof displacement, since displacement also depends on the vertical distribution of lateral force, stiffness, mass and dynamic characteristics. In the adopted dataset, earthquake loading governs roof displacement, drift and column axial force, while wind governs several bending and shear-wall force measures. The central core is intended to provide additional lateral stiffness and resistance to overturning, thereby sharing lateral demand with the surrounding moment-resisting frame. The magnitude of this contribution, however, can only be quantified through matched and validated analytical models.For design, governing combinations should be established independently for beams, columns, shear walls, diaphragms, foundations and serviceability checks. Wall boundary zones, coupling beams, wall–foundation force transfer, torsional response, accidental eccentricity, diaphragm action and load reversal require explicit evaluation. The simplified equivalent-static calculations presented here cannot substitute for a complete code-compliant seismic and wind analysis, including response-spectrum scaling where applicable.

7. CONCLUSIONS

For the assumed G+10 building, the adopted seismic base shear is 693 kN and the assumed wind base shear is 820 kN; the wind value is approximately 18.3% higher.

The adopted roof displacements are 72 mm under earthquake loading and 56 mm under wind loading. The tabulated maximum storey drifts are 13 mm and 9 mm, respectively, although the final wind-storey drift requires correction because the displacement difference is 10 mm.

Wind loading produces the larger reported beam moment, column moment, shear-wall shear and wall overturning moment, whereas earthquake loading produces the larger reported column axial force.

The illustrative frame-only comparison indicates potential reductions of approximately 40–44% in roof displacement and 40–41% in maximum storey drift when the shear-wall core is included. These percentages remain unverified because the paired model outputs are not available.

No single load case governs every response quantity in the adopted dataset. Both seismic and wind actions must therefore be considered when identifying member design forces and serviceability demands.

The numerical results are preliminary. The building dimensions and basic wind speed are assumed, and the available record states that the STAAD.Pro model was producing errors. The response values must not be represented as verified software outputs until the analytical model and code checks are completed.

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