iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** XI **Month of publication:** November 2026

DOI: https://doi.org/10.22214/ijraset.2026.85789

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue XI Nov 2026- Available at www.ijraset.com

Seismic Response of RC Buildings with Vertical Stiffness Irregularity (Soft Storey) and Evaluation of Mitigation Measures

M Sankar Sree Prasad[1], Dr. M Madhuri[2]
Department of Civil Engineering, Sankethika Vidya Parishad College of Engineering, Visakhapatnam, Andhra Pradesh, India

Abstract: ***This study investigates the seismic response of a G+8 reinforced concrete (RC) building with vertical stiffness irregularity and compares four structural modification strategies. Five configurations are considered: the general building, building with shear walls, building with steel bracings, building with double-storey height, and building with modified member properties. The models are analysed in STAAD.Pro using the Response Spectrum Method under the seismic parameters reported in the project presentation. The response is compared using maximum storey displacement, ground-storey shear, maximum/reference bending moment, fundamental time period and fundamental frequency. The general model records a maximum displacement of 5.670 mm and ground-storey shear of 61.562 kN. Modified member properties produce the lowest reported maximum displacement of 3.487 mm, a reduction of 38.50% from the general model. The double-storey-height configuration records the lowest ground-storey shear of 49.250 kN, a reduction of approximately 20%. The braced configuration has the shortest fundamental time period of 0.590 s and the highest fundamental frequency of 1.695 Hz. The results demonstrate that the examined modifications influence both lateral response and dynamic characteristics. The findings are limited to the model properties, loading assumptions and analysis results documented in the source presentation.***

Keywords: RC building, vertical stiffness irregularity, soft storey, seismic analysis, Response Spectrum Method, STAAD.Pro, shear wall, steel bracing, storey displacement.

I. INTRODUCTION

Earthquake-induced structural damage is often associated with discontinuities in mass, stiffness or geometry. Buildings containing abrupt changes in these properties along their height are classified as vertically irregular structures. A soft storey is a form of vertical stiffness irregularity in which one level is substantially more flexible than the storeys above or below it. Such a configuration can concentrate lateral deformation and seismic demand at the flexible level.

Modern building layouts may include open ground floors and changes in storey height to satisfy functional and architectural requirements. Although these arrangements can be useful, they alter the dynamic characteristics and force distribution of reinforced concrete buildings. The present study examines a G+8 RC building and evaluates the response changes associated with shear walls, steel bracing, double-storey height and modified member properties.

II. PROBLEM STATEMENT AND OBJECTIVES

The study addresses how vertical stiffness irregularity affects the seismic response of a G+8 RC building and how selected structural modifications change that response. The objectives are to model the building in STAAD.Pro; conduct response-spectrum seismic analysis; compare five structural configurations; and assess storey displacement, storey shear, bending moment, fundamental time period and frequency.

III. LITERATURE REVIEW

The source presentation summarizes prior work on structural systems and soft-storey behaviour. Hussaini and Nasier (2020) reviewed bracing, diagrid and outrigger systems for improving seismic performance in high-rise buildings and reported that combined lateral-resisting systems can perform better than relying on a single technique. Rao and co-authors (2023) examined multi-storey buildings with soft-storey irregularities using STAAD.Pro and highlighted excessive displacement and vulnerability associated with abrupt lower-storey stiffness reduction. Harati et al. (2020) reviewed experimental and field observations relating to RC shear walls. Their summarized findings identify shear walls as effective elements for providing stiffness, strength and energy dissipation. The literature review in the source therefore motivates comparison of shear walls and bracing with other structural modifications.

©IJRASET: All Rights are Reserved

IV. BUILDING DESCRIPTION AND SEISMIC PARAMETERS

The investigated structure is a G+8 reinforced concrete building with an approximate plan area of 792 m² and a typical storey height of 3 m. The presentation reports M30 concrete, Fe600 reinforcement, beam dimensions of 690 × 460 mm, column dimensions of 460 × 300 mm and a 150 mm slab. The reported live load is 3.5 kN/m², dead load is 2 kN/m², concrete density is 25 kN/m³ and wind speed is 44 m/s.

Table I. Building And Analysis Parameters Reported In The Presentation

Parameter	Reported value
Building configuration	G+8 RC building
Approximate plan area	792 m²
Storey height	3 m
Concrete grade	M30
Reinforcement grade	Fe600
Beam size	690 × 460 mm
Column size	460 × 300 mm
Slab thickness	150 mm
Live load	3.5 kN/m²
Dead load	2 kN/m²
Concrete density	25 kN/m³
Wind speed	44 m/s
Seismic zone	V
Site type	II
Importance factor	1.5
Response reduction factor	5
Damping	5%

The seismic code framework listed in the source includes IS 1893:2002 (Part 1), IS 456:2000, IS 875:1987 Part 3 and IS 800:2007. The source presentation also cites IS 1893 (Part 1):2016 in its reference list. The applicable code edition should be confirmed against the original analysis file and project requirements before publication.

V. STRUCTURAL CONFIGURATIONS AND MODELLING

Five structural configurations were considered. Model 1 is the general G+8 building and serves as the reference configuration. Model 2 incorporates shear walls as stiff vertical lateral-load-resisting elements. Model 3 incorporates steel bracings to provide additional lateral stiffness and load paths. Model 4 introduces a double-storey-height condition, modifying vertical geometry and flexibility. Model 5 changes member properties to alter the stiffness and strength characteristics of the structural members.

Table II. Five Structural Configurations

Model	Configuration	Modification
1	General G+8	Reference model
2	G+8 with shear walls	Additional shear walls
3	G+8 with bracings	Steel bracing system
4	G+8 with double-storey height	Modified storey geometry
5	G+8 with modified member properties	Changed member properties

The STAAD.Pro workflow described in the presentation includes creating nodes and beams using the modelling grid, assigning concrete material, specifying beam and column cross-sections, generating the three-dimensional model, checking member connectivity, assigning supports and defining load cases. Fixed supports are assigned at the lowermost nodes. Dead load represents self-weight and permanent gravity effects, while live load is assigned as imposed floor loading. Seismic actions are considered in the principal X and Z directions, and wind load cases are also included. The presentation states that Indian-code load combinations are generated and linear static analysis is specified before the model analysis.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

The comparative seismic response is evaluated using the Response Spectrum Method. The exact response-spectrum ordinates, modal mass participation ratios, number of modes, scale factors and detailed load-combination expressions are not fully specified in the presentation and should be added from the STAAD.Pro input and output files for a reproducible journal submission.

VI. RESULTS AND DISCUSSION

The following values reproduce the comparative performance summary reported in the presentation. Displacement is reported in millimetres, storey shear in kilonewtons, bending moment in kN-m, time period in seconds and frequency in hertz.

Table III. Comparative Seismic Response Of The Five Models

Configuration	Disp. (mm)	Shear (kN)	B.M. (kN-m)	T (s)	f (Hz)
General	5.670	61.562	27.323	1.384	0.723
Shear wall	3.941	56.637	29.120	0.715	1.399
Bracing	3.631	52.943	29.207	0.590	1.695
Double storey	5.630	49.250	26.468	0.658	1.519
Modified members	3.487	55.406	29.458	0.614	1.628

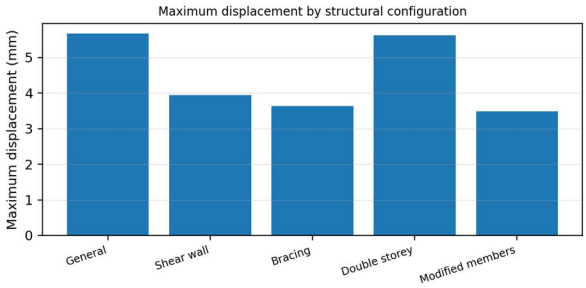


Fig. 1. Maximum displacement for the five structural configurations.

The general model records the maximum displacement of 5.670 mm. The modified-member configuration gives the lowest value of 3.487 mm, corresponding to the 38.50% reduction reported in the source presentation. The bracing and shear-wall configurations record 3.631 mm and 3.941 mm, respectively. The double-storey-height model records 5.630 mm, which is close to the general model value.

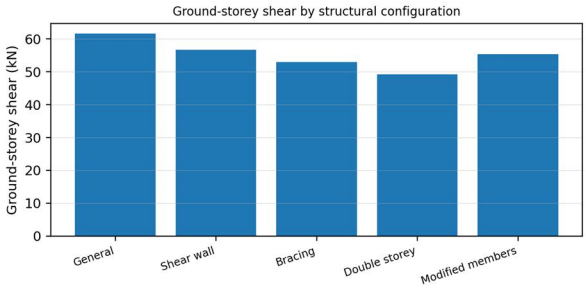


Fig. 2. Ground-storey shear for the five structural configurations.

The general model has a reported ground-storey shear of 61.562 kN. The double-storey-height configuration records the lowest value, 49.250 kN, corresponding to an approximately 20% reduction. Bracing records 52.943 kN, modified member properties 55.406 kN and shear walls 56.637 kN.

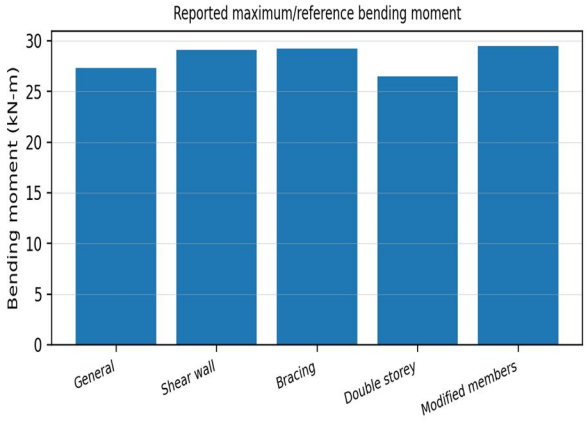


Fig. 3. Maximum/reference bending moment for the five configurations

The reported bending-moment values vary from 26.468 kN-m for the double-storey-height configuration to 29.458 kN-m for modified member properties. Compared with the general model value of 27.323 kN-m, the shear-wall, bracing and modified-member configurations show higher reported values. This indicates that a reduction in displacement does not necessarily correspond to a reduction in bending moment, because lateral forces may be redistributed among members.

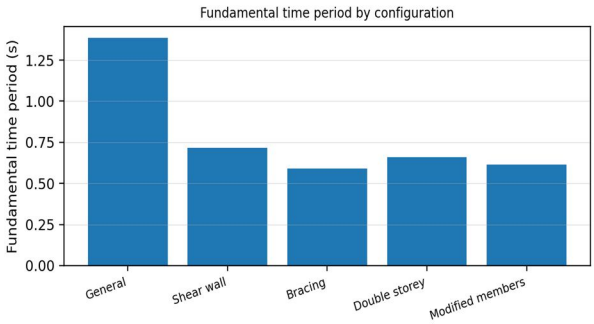


Fig. 4. Fundamental time period for the five configurations

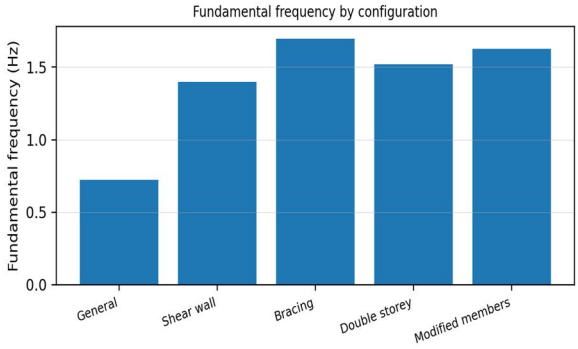


Fig. 5. Fundamental frequency for the five configurations

The general model has a fundamental time period of 1.384 s and frequency of 0.723 Hz. The bracing configuration has the shortest reported period, 0.590 s, and highest reported frequency, 1.695 Hz. The modified-member and double-storey-height configurations have periods of 0.614 s and 0.658 s, respectively. The shear-wall model has a period of 0.715 s. The reported trend is consistent with the inverse relationship between natural period and frequency.

VII. PERCENTAGE CHANGES AND ENGINEERING INTERPRETATION

Table IV. Percentage Changes Reported In The Source Presentation

Response measure	Reported result
Maximum displacement	Modified members: 38.50% reduction; bracing: 35.96%; shear wall: 30.49%; double storey: 0.71%
Storey shear	Double storey: 20.00% reduction; bracing: 14.00%; modified members: 10.00%; shear wall: 8.00%
Bending moment	Double storey: 0.50% reduction; shear wall: +6.58%; bracing: +6.90%; modified members: +7.81%
Time period	Bracing: 57.37% reduction; modified members: 55.64%; double storey: 52.46%; shear wall: 48.34%

The source presentation reports that displacement increases with height in all configurations, with the maximum response at the eighth storey. Storey shear is highest near the base and decreases upward. The double-storey-height configuration gives the lowest reported storey-shear values. Bending-moment differences are comparatively modest and reflect redistribution of seismic forces. Shorter time periods and higher frequencies indicate a stiffer dynamic response relative to the general building.

VIII. CONCLUSIONS

1) The G+8 RC building was evaluated using the Response Spectrum Method in STAAD.Pro under the seismic parameters reported in the project presentation.
2) The general building recorded a maximum displacement of 5.670 mm and ground-storey shear of 61.562 kN.
3) Modified member properties produced the lowest reported maximum displacement of 3.487 mm, corresponding to a 38.50% reduction relative to the general model.
4) The double-storey-height configuration produced the lowest reported ground-storey shear of 49.250 kN, corresponding to an approximately 20% reduction.
5) The bracing configuration produced the shortest fundamental time period of 0.590 s and the highest reported fundamental frequency of 1.695 Hz.
6) Bending-moment changes were comparatively modest and varied with the redistribution of lateral forces among the structural members.
7) The results show that changes to the lateral-load-resisting system, building geometry and member properties influence both lateral response measures and dynamic characteristics.

IX. LIMITATIONS AND FURTHER WORK

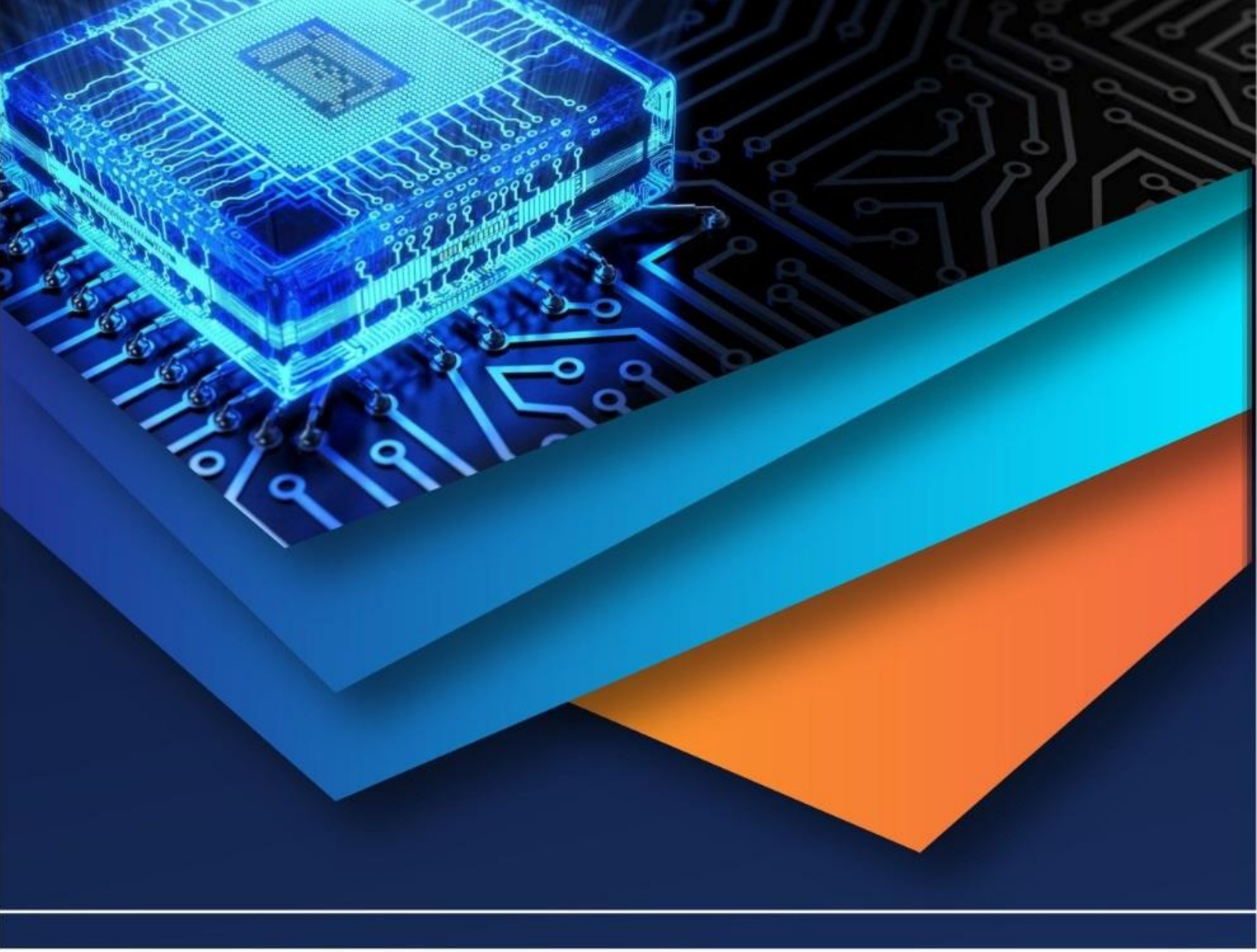
This paper is based on the analysis summary and plots documented in the supplied presentation. The presentation does not provide the complete STAAD.Pro input file, full storey-by-storey numerical result tables, response-spectrum data, modal mass participation ratios, detailed member-property changes, or all load-combination definitions. The plotted storey-response curves are therefore not digitized into additional numerical tables. Before journal submission, the model should be checked against the original STAAD.Pro files, the applicable IS 1893 edition should be confirmed, and full model assumptions and output data should be reported. Further work may include drift checks against the applicable code limits, torsional response assessment, P–Delta effects, ductility and member-design checks, and sensitivity analysis of the soft-storey stiffness ratio.

REFERENCES

[1] Bureau of Indian Standards, IS 875 (Part 1):1987, Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures—Dead Loads, New Delhi, 1987.
[2] Bureau of Indian Standards, IS 875 (Part 2):1987, Code of Practice for Design Loads—Imposed Loads, New Delhi, 1987.
[3] Bureau of Indian Standards, IS 875 (Part 3):1987, Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures—Wind Loads, New Delhi, 1987.
[4] Bureau of Indian Standards, IS 456:2000, Plain and Reinforced Concrete—Code of Practice, New Delhi, 2000.
[5] I. H. Cagatay, C. Beklen and K. M. Mosalam, “Investigation of short column effect of RC buildings: Failure and prevention,” Computers and Concrete, vol. 7, no. 6, pp. 523–532, 2010.

[6] K. Gowda and S. Tajoddeen, “Seismic analysis of multistorey building with floating columns,” 2014. [Publication details to be completed from the original source.]
[7] H. Bansal and Gagandeep, “Seismic analysis and design of vertically irregular RC building frames,” International Journal of Science and Research, vol. 3, no. 8, 2012. [Page details to be verified.]
[8] Federal Emergency Management Agency, NEHRP Recommended Seismic Provisions for New Buildings and Other Structures, FEMA P-1050-1, 2015.
[9] A. S. Bhosale, R. Davis and P. Sarkar, “Seismic safety of vertically irregular buildings: Performance of existing indicators,” Journal of Architectural Engineering, vol. 24, no. 3, art. 04018013, 2018.
[10] Bureau of Indian Standards, IS 1893 (Part 1):2016, Criteria for Earthquake Resistant Design of Structures—General Provisions and Buildings, New Delhi, 2016.
[11] Bureau of Indian Standards, IS 875 (Part 3):2015, Design Loads (Other than Earthquake) for Buildings and Structures—Wind Loads, New Delhi, 2015.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)