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Analysis of Multi-Storey Building based on Different Shear Wall Locations

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Abstract:

This research provides a comprehensive analysis of shear wall locations in multi-storey buildings for seismic resistance. The seismic analysis is carried out using STAAD PRO. V8i software, utilizing the Response Spectrum Analysis method. A G+10 multi-storey structure situated in Seismic Zone V is designed according to IS 1893:2002, with three different models incorporating shear walls at various locations. The performance of these models is evaluated in terms of important parameters such as lateral displacement, torsion, bending moment, and axial force. By synthesizing the findings from the reviewed papers and the analysis of different shear wall locations, this study provides valuable insights for engineers and researchers in optimizing the seismic performance of multi-storey buildings.

Key Words: Seismic Analysis, Shear wall, Axial Force, Tension

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1. Introduction:

This research focuses on the study of shear wall frame structures in multi-storey buildings, aiming to identify the most efficient shear wall locations for optimal load resistance against earthquakes. Shear walls are crucial elements designed to resist horizontal forces induced by wind, earthquakes, and other factors. By incorporating shear walls in high-rise buildings, the overall structural integrity can be enhanced, preventing collapse under seismic forces. This study aims to analyze different types of shear wall locations and propose the most effective configuration for load resistance. Additionally, the report explores the impact of lateral loads on structures and suggests future research directions, such as investigating braced frame systems for reducing the effects of lateral loads.

2. Building description and process flow:

The lateral displacement and storey drift of a G+10 bare frame structure with different configurations of shear walls are analyzed and compared using STAAD Pro software. The STAAD Pro analysis is based on the Limit State of Design as per Indian Code of Practices. The multi-story RCC frame structure in the Y direction is considered, and the concrete material properties, beam and column cross sections, and fixed base supports are specified. Seismic load calculations are performed according to IS1893:2002. The analysis includes dead load, live load, wind load, and seismic load combinations. Table 1 shows the building description.

Table 1 Building description

S.NO	PARTICULARS	RCC STRUCTURE
1	Grade of Concrete	M30
2	Grade of Steel	Fe415
3	Density of Reinforced concrete	25 KN/m3
4	No. of Storey	G+10
5	Beam size	300*400 mm
6	Column size	450*600 mm
7	Shear wall thickness	0.3 m
8	Height of ground floor	3.5 m
9	Height of above all storey	3 m
10	Seismic zone	V
11	Soil type	Medium soil
12	Live load	3 KN/m2
13	Imposed factor	1
14	Damping ratio	5 %

Properties of Member

Designing & assigning properties to the members were done as per IS 456 Building design code. Table 2 shows the properties of members used in building and figure 1 shows the process flow.

Element	Dimension	Material type	Unit weight (KN/m^3)	Modulus of elasticity (N/mm^2)	Poisson's Ratio	Compressive strength (N/mm^2)
Beam	300x 450 mm	Concrete (M25)	25	25000	0.17	25
Column	450x 600 mm	Concrete (M25)	25	25000	0.17	25
Reinforcement		Rebar (Fe415)	78.5	200000	0.3	--

Table 2 Properties of members

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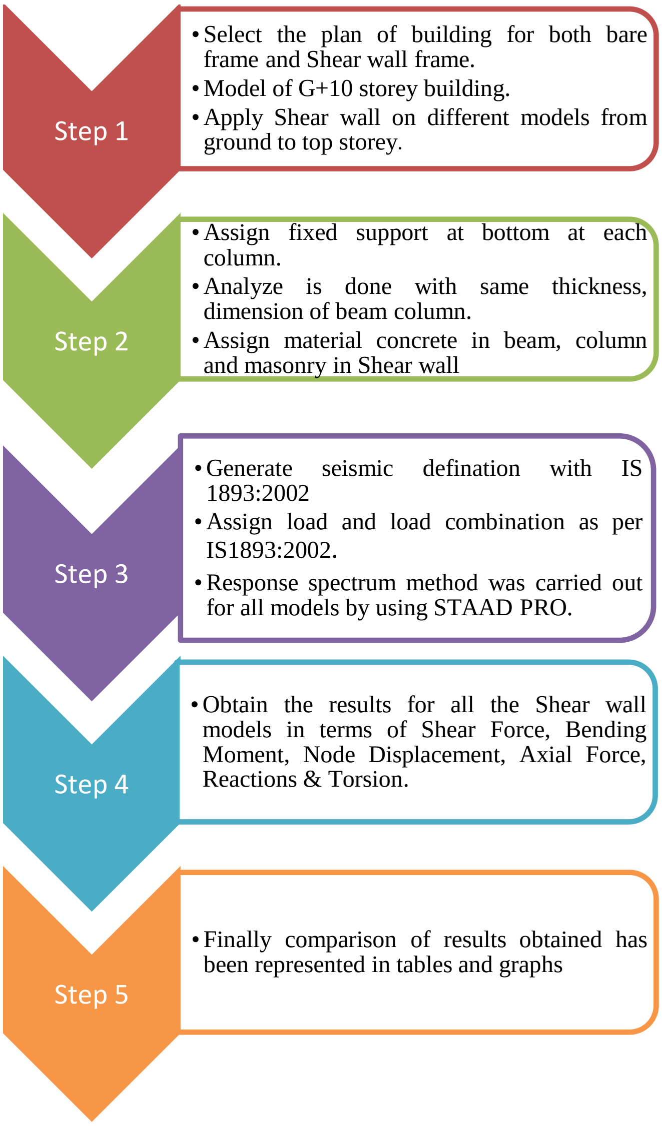


Figure 1: Process Flow

2.1 Applied earthquake load

Seismic parameter has been generated as per IS: 1893-2002 for seismic zone V with zone factor 0.36 in medium soil. The importance factor of the RC frame building structure was taken 1.0 and 5% damping ratio as per IS code 1893-2002. Load combinations used are shown in table 3.

Table 3 Load combination

S.no.	Load combination
1	1.5 (DL+LL)
2	1.5 (DL+ELX)
3	1.5 (DL+LL+ELX)
4	1.5 (DL+ELZ)
5	1.5 (DL+LL+ELZ)

2.2 Design of Shear wall models

Total 3 models were analyzed in this study. They are as follows:

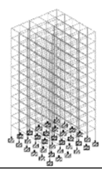
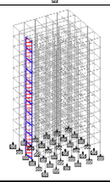
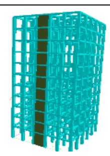
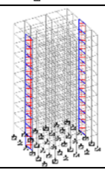
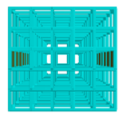
Model 1: Bare frame model.

Model 2: Building with single side shear wall (-X direction).

Model 3: Building with double side shear wall (-X and +X direction).

Table 4 shows the isometric model view and 3-D model view of the shear wall models.

Table 4 Model descriptions

	Name of Model	Isometric model view	3-D model view
Model 1	Bare frame model		
Model 2	Single side (-X direction) shear wall		
Model 3	Double side (-X & +X direction) shear wall		

3. Comparison of Results

Results were equated for all the 5 Shear wall models in terms of Shear Force, bending moment, node displacement, reactions, axial force & torsion against bare frame model to rank the different models in terms of their efficiency. Table 5.54 -5.62 expressions the efficiency comparison of different models against bare frame model in percentage.

- Maximum Shear force along X, Y & Z direction
- Maximum Bending moment along X, Y & Z direction
- Maximum Node displacement along X, Y & Z direction
- Maximum Reaction along X, Y & Z direction
- Maximum Axial force
- Maximum Torsion

3.1 Maximum Shear force & Bending moment value along X, Y & Z direction

Table 5 shows the comparison of Maximum Shear Force & Bending Moment values of all the analyzed models, while efficiency in percentage of different models to resist Shear Force & Bending Moment against Bare Frame is displayed in table 6.

Table 5: Comparison of Maximum S.F & B.M values

Models	Fx	Fy	Fz	Mx	My	Mz
Model 1	6781.469	723.381	19.872	7.472	21348.11	17486.23
Model 2	6695.495	272.311	30.66	12.954	447.7	468.683
Model 3	5575.274	141.264	29.017	7.946	463.885	226.329

Table 6: Efficiency in % to resist Shear Force & Bending Moment

	Fx	Fy	Fz	Mx	My	Mz
Model 2	1.26%	6.23%	53.99%	73.37%	97.90%	97.31%
Model 3	17.79%	80.48%	46.02%	6.35%	97.83%	98.71%

Fig.2 shows the variation in Maximum Shear force and Fig.3shows the variation in Maximum Bending Moment along X, Y & Z direction for different models.

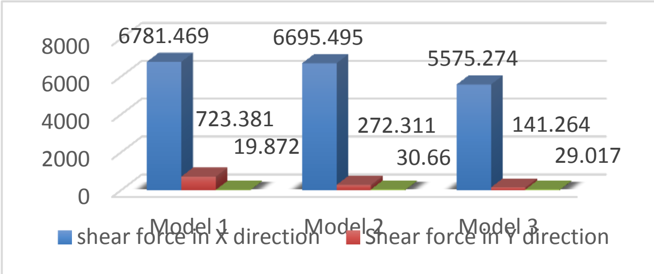


Fig 2 Comparison of Maximum Shear Force in X, Y & Z direction

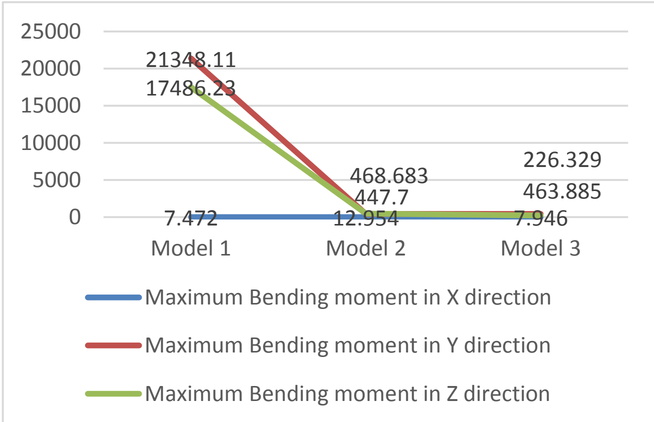


Fig 3 Comparison of Maximum Bending Moment in X, Y & Z direction

3.2 Maximum Node displacement & rotation Value along X, Y & Z direction

Table 7 shows the comparison of Maximum Node Displacement values of all the analyzed models, while efficiency in percentage of different models to resist Node Displacement against Bare Frame is displayed in table 8.

Table 7: Comparison of Maximum Node displacement values

Models	X	Y	Z	Max Rst	rX	rY	rZ
Model 1	150.617	4.294	148.78	152.679	0.03	0	-0.032
Model 2	145.924	3.513	140.103	147.584	0.005	0.003	0
Model 3	91.626	3.655	144.499	144.5	0.006	0	0

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Table 8: Efficiency in % to resist Maximum Node displacement

	Fx	**Fy**	**Fz**
Model 2	3.17%	20.01%	6.01%
Model 3	48.71%	16.08%	2.92%

Fig 4 displays the variation in Maximum Node Displacement along X, Y & Z direction which need

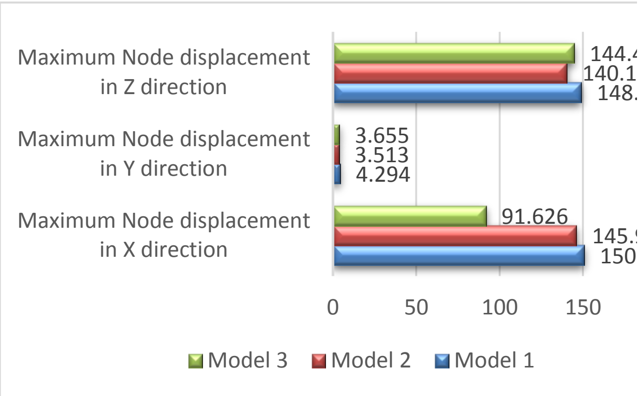


Fig 4: Comparison of Maximum Node Displacement

3.3 Maximum Support Reaction values along X, Y & Z direction

Table 9 shows the comparison of Maximum Reaction values of all the analyzed models, while efficiency in percentage of different models to resist Reactions against Bare Frame is displayed in table 10.

Table 9: Comparison of Maximum Reaction values

Models	**Fx**	**Fy**	**Fz**	**Mx**	**My**	**Mz**
Model 1	1.999	6781.5	2.226	24.392	1.444	17486.2
Model 2	2.546	6695.5	24.011	83.324	0.738	468.683
Model 3	629.95	8370.7	7.5	8.624	6.691	151.364

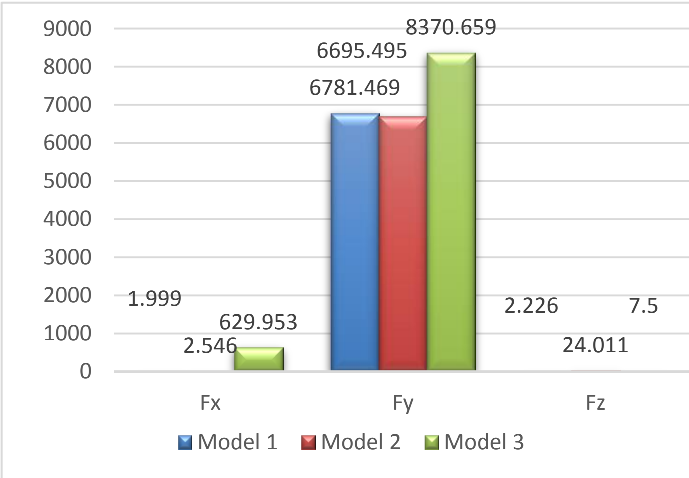
Table 10: Efficiency in % of Structural Reaction

Models	**X**	**Y**	**Z**
Model 2	28.26%	1.27%	166.03%

Model 3	198.74%	27.86%	236.93%

Fig 5 shows the variation in Maximum Support Reaction along X, Y & Z direction for different models

Fig 5 Comparison of Maximum Reaction



3.4 Maximum Axial force & Torsion value

Table 11 shows the comparison of Maximum Axial Force & Torsion values of all the analyzed models, while efficiency in percentage of different models checked against Bare Frame is displayed in table 12

Table 11: Comparison of Maximum Axial Force & Torsion values

	Axial force	**Torsion**
Models	**Max Fx KN**	**Max Mx KN/m**
Model 1	207.254	3.257
Model 2	121.683	4.651
Model 3	123.707	4.866

Table 12: Efficiency in % for Axial Force & Torsion

Models	**Axial force**	**Torsion**
Model 2	52.03%	35.26%
Model 3	50.49%	39.62%

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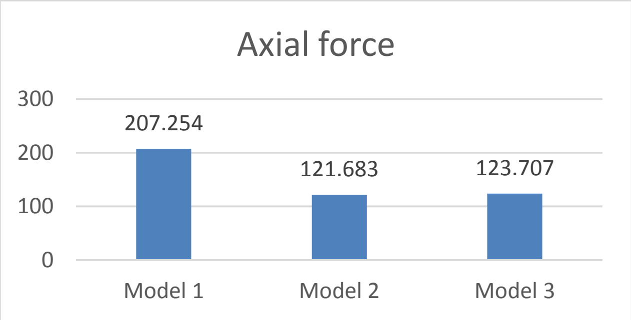
Fig 6 shows the variation in Maximum Axial Force and Maximum Torsion for different models



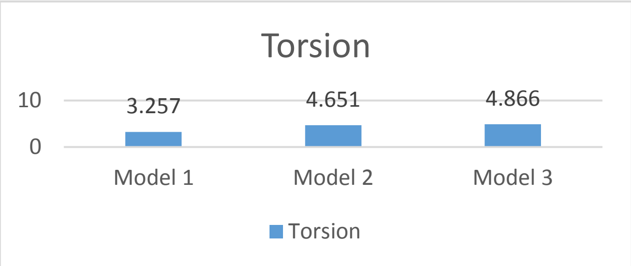


Fig 6: Comparison of Maximum Axial force and maximum Torsion

4 Conclusion:

The main objective was to design a high-rise building and determine the optimal location of shear walls. The performance of reinforced concrete frames with and without shear walls was evaluated using the Response Spectrum Analysis method in STAAD Pro V8i software. An 11-story G+10 regular structure situated in a high seismic zone (seismic zone V) was considered for analysis. The structures were subjected to seismic load combinations along both the major and minor axes, and various parameters such as shear force, bending moment, node displacement, support reactions, axial force, torsion, and structural weight were analyzed. The effectiveness of different shear wall models was compared to bare frame models in terms of strength and stiffness.

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