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Seismic Analysis and Designing of a Low, Medium and High Raised Buildings

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ABSTRACT:

The seismic analysis and design of buildings is a critical aspect of ensuring their safety and stability in earthquake-prone areas. High-rise building construction has become unavoidable due to population increase and land constraints. In terms of the in-built traditional practice of designs with the hand methods, it would consume more time as well as increasing the risks of human blunders. Therefore, software has to be employed to enhance such accuracy. In this research, an attempt is made to assess the seismic responses of different buildings using seismic analysis and design in STAAD Pro software. The effect of three soil types [soft, medium, and hard] and four seismic zones [zone II, III, IV, V] are deliberately consider to study their impact on the building responses. The critical responses like lateral displacement, shear force, bending moments, base shear, drift ratios, and quantity of steel and concrete materials are ascertained, based on Indian standard code provision IS 1893-2016 and IS 456-2000, respectively. It is concluded that, among the different building types, the low, medium, and high-rise building types exhibited identical result as well as most vulnerable against the seismic loading.

Keywords: Seismic Analysis, Structural Design, Earthquake Engineering, Low-Rise Building, Medium-Rise Building, High-Rise Building, Seismic Loading, Earthquake Resistance

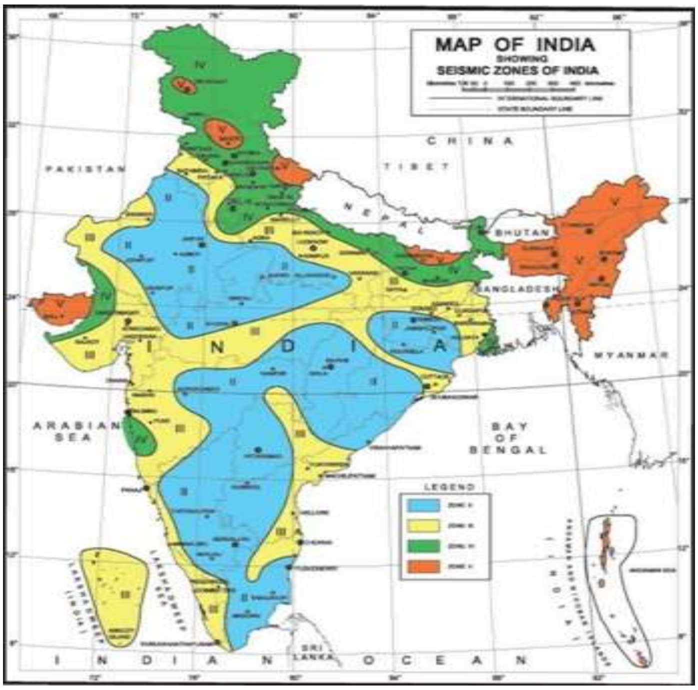
Introduction: -

General

The multi-story buildings are constructed to accommodate numerous residents in confined spaces due to the growing population and lack of available land. The population growth and industrial revolution caused a migration of people from rural to urban areas resulting in the need for the construction of multi-story buildings for both residential and commercial uses. The tall buildings, which are not adequately constructed to resist lateral stresses, result in the total collapse of the structure. To ensure safety against the seismic stresses of multi-story buildings, it is essential to understand seismic analysis in order to develop earthquake-resistant structures. The performance of asymmetric buildings under seismic excitation is very poor and its behavior is highly complex when compared to that of regular buildings.

Methods of seismic analysis

Effects of design earthquake loads applied on structures can be considered in two ways, namely: Equivalent static method, and Dynamic analysis method. In turn, dynamic analysis can be performed in three ways, namely: Response spectrum method, Modal time history method, and Time history method. In this study we used equivalent static method.



Seismic zones of India

Equivalent static method

Equivalent static analysis is also known as linear static analysis and can be used only for regular structures with a limited height. It is the simplest form of analysis as it assumes that the building responds in its fundamental mode following the respective code of practice. The design base shear is determined and is then distributed to the height of the building. The lateral forces at each story are also computed and then distributed to the force resisting elements.

Types of Buildings

In the field of seismic analysis and design, buildings are often classified according to their height. This classification is important because the height of a building directly influences how it responds to forces such as wind and earthquakes. Taller buildings tend to have more flexible behavior and longer vibration periods, while shorter buildings are usually stiffer and respond differently to ground motion. By categorizing buildings as low-rise, mid-rise, or high-rise, engineers can apply appropriate design strategies to ensure safety, stability, and performance during seismic events. Understanding these categories helps in selecting suitable materials, construction techniques, and analysis methods for each type of structure.

Low-rise Building

A low-rise building is a structure that typically has 1-3 stories and a height of up to 12-15 meters. These buildings are often designed for residential, commercial, or mixed-use purposes. They often have a more straightforward design, with simpler structural systems. Low-rise buildings can be more cost-effective to build and maintain. The design process can be less complex, reducing design costs.

Medium-rise Building: -

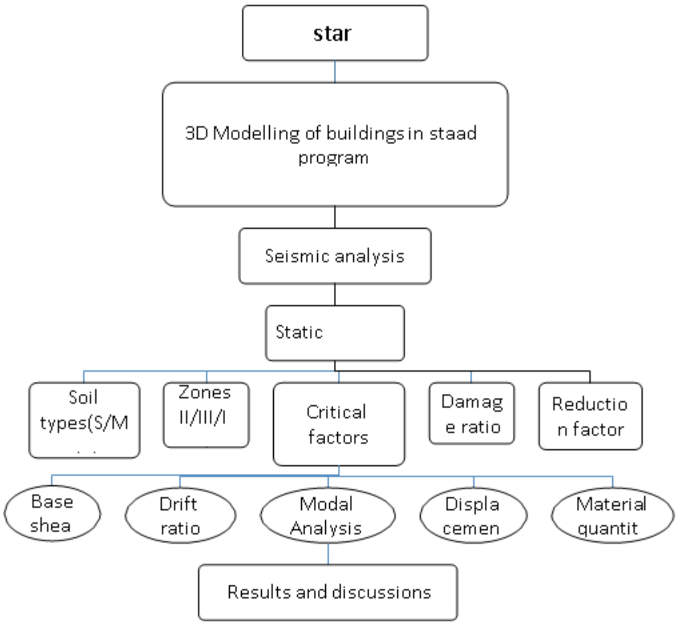
A medium-rise building, also known as a mid-rise building, is a structure that typically has a height of 15-30 meters. Medium-rise buildings often have a more complex design than low-rise buildings, requiring additional structural support. Medium-rise buildings offer a balance between the benefits of low-rise and high-rise buildings, making them a popular choice for various applications. Medium-rise buildings can be designed to be visually appealing and fit in with surrounding architecture.

High-rise Building: -

A high-rise building is a structure that typically has a height of 30-150 meters or more. High-rise buildings require advanced design and engineering techniques to withstand wind, seismic, and other loads. 4. High-rise buildings often use high-strength materials, such as reinforced concrete or steel, to support their structure. High-rise buildings can make efficient use of land, especially in urban areas. High-rise buildings offer a range of benefits and challenges, and their design and construction require careful planning and expertise.

Soil types and Seismic zones

As per code 1893-2016 code provisions, the soils are classified into three types: a) soil type I- (Rock or hard soil) b) soil type II (medium or stiff soils) and soil type III (soft soil). The Indian is classified into four categories of seismic zones, i.e., Zone-II, II, IV, V, in concern with the IS 1893- 2016 code. The seismic map of India showing the various seismic zones is represented in Fig. 1.



Flow chart of the study

The flowchart represents a process for analyzing and modelling the seismic behavior of a plan- irregular building using a specific software (STAAD program). It is the step-by-step method for understanding the structural response of a building to seismic forces.

Objective

- To develop the Staad pro model of different plan regular buildings such as low, medium and high-rise buildings and perform the Equivalent static method.
- To compare the seismic parameters such as base shear, drift ratio, lateral displacement, and material (steel & concrete) quantity for the various analysed building models.
- To conclude the most vulnerable building among all building shapes considered in this study under earth quake forces.

Literature review:

- **Dilkhush et al. (2024),** This study analyzes the seismic behavior of low-rise (G+4) and high- rise (G+15) buildings using ETABS and SAFE software in seismic zones II and III. It emphasizes the critical role of foundation-soil interaction, often overlooked in design. Findings recommend a minimum 1000 mm raft for low-rise structures on soils with 165 kN/m² bearing capacity, while high-rise buildings require piled rafts due to inadequate performance of standard rafts.
- **Kiran et al. (2023),** Focusing on G+8 buildings, this research compares seismic responses across zones III, IV, and V using ETABS. It reveals a rise in base shear and reinforcement needs with increasing seismic intensity. The study stresses improved design practices for enhanced structural safety in higher-risk areas and informs potential updates to building codes.
- **Abd et al. (2021),** This paper examines the seismic vulnerability of RC buildings with soft storeys through finite element analysis. Key factors like soft storey height and geometry affect stability, with mid-height soft storeys showing the poorest performance. Retrofitting with shear walls and bracing is shown to significantly enhance seismic resistance.
- **Rachana et al. (2023),** Using nonlinear and finite element analysis, this research assesses both elastic and inelastic responses of RC frames under seismic loads. It highlights the need for ductile detailing and advanced materials, proposing a performance-based design approach to improve structural reliability in seismic zones.
- **Pandimani et al. (2024),** The study integrates BIM to enhance both seismic resilience and energy efficiency in RC educational buildings. It reports up to 36.84% lifecycle energy savings through optimized design strategies such as orientation, passive elements, and shading. BIM is presented as a key tool for sustainable and resilient construction.
- **Samir et al. (2019),** This study compares the seismic performance of RC frame buildings designed using gross and cracked section properties, based on Indian seismic codes. It evaluates structures through nonlinear static pushover and time history analyses. Overstrength and ductility were assessed, highlighting serviceability concerns in older IS 1893:2002-based designs. Overall, updating designs to IS 1893:2016 cracked section provisions enhance seismic safety.

- **Brahim et at. (2023),** Seismic performance of buildings with vertical mass and stiffness irregularities has been a major concern, as such irregularities can significantly weaken structures during earthquakes. Research shows that mass irregularities moderately affect seismic demand, while stiffness irregularities have a pronounced Building on this, the present study employs adaptive pushover analysis to evaluate how vertical irregularities influence RC frame performance under seismic loads.
- **Kishalay et al. (2018),** Floating columns are commonly used in multi-story buildings to accommodate architectural needs, especially open ground floors. However, their presence introduces vertical irregularity, affecting seismic performance. Asymmetrical placement of floating columns often leads to torsional irregularities. Increasing column dimensions can improve stiffness and reduce structural vulnerabilities. Overall, careful design is crucial when incorporating floating columns in seismic zones.
- **Ashikur et al. (2023),** Shear walls play a vital role in improving lateral load resistance in RC buildings. Their efficiency is influenced by proper placement and orientation. Research shows that well-positioned shear walls minimize story drift and displacement. Poor placement may cause torsional effects due to structural eccentricity. Analytical studies using ETABS highlight that peripheral placement offers the best control over deflection. Overall, strategic shear wall location enhances seismic performance and stability.
- **Avinash et al. (2022),** Floating columns are used in high-rise buildings for space and architectural flexibility. However, they disrupt load paths and weaken seismic performance. Studies show increased displacement and drift in structures with floating columns. Conventional frames offer better resistance to seismic forces. Response spectrum analysis reveals that column placement affects story shear and stability. Proper positioning of floating columns is essential for earthquake-resistant design.
- **Meena et al. (2024),** Seismic analysis is vital for structural safety in earthquake zones, with soil-structure interaction playing a key role in building response. Studies show that piled raft foundations improve seismic load distribution and minimize settlement. Updated IS codes indicate increased base shear demands. Dynamic techniques like response spectrum analysis effectively assess structural parameters such as drift and time period. Tools like ETABS and SAFE are widely used for accurate seismic modeling and foundation design.
- **Kumar et al. (2022),** Floating columns are widely adopted in multi-storey structures but introduce vertical irregularities that increase seismic vulnerability. Studies show that such buildings experience higher storey drift, lateral displacement, and lower base shear during earthquakes. The seismic risk intensifies when floating columns are positioned at corners or lower levels. Retrofitting strategies like shear walls and bracings are essential to enhance stability. Proper design is critical to ensure safety in seismic zones, especially Zone V.
- **Bosh et al. (2023),** Floating columns are used in modern buildings to provide more open space, but they create vertical irregularities that weaken seismic performance. They interrupt the load transfer mechanism, leading to higher story drift, displacement, base shear, and overturning moments during earthquakes. Studies reveal that asymmetrical placement of floating columns increases structural vulnerability. Research emphasizes limiting their use in seismic zones. Proper reinforcements are necessary when floating columns are unavoidable.
- **Islam et al. (2017),** Soft-story RC buildings are prone to seismic failures due to stiffness irregularities. Strengthening strategies like shear walls, lateral buttresses, and bracings improve their performance. Research shows shear walls offer the best enhancement in strength and ductility. Pushover analysis confirms these methods effectively increase earthquake resistance.
- **Ahmed et al. (2007),** Concrete cracking reduces the lateral stiffness and increases deformations in RCC buildings during seismic events. Researchers like Branson and Ghali proposed models to capture stiffness degradation. Building codes such as ACI and Eurocode 8 suggest modification factors for cracked sections. Neglecting cracking effects leads to significant underestimation of drifts and deflections. Accurate modeling of cracking is essential for reliable seismic performance assessment.

Methodology: -

Introduction

The building adopted in this study are of different plan buildings, such as low, medium, and high rise respectively. All the building are analyzed under seismic zone and soil types to investigate their potential impact on the building responses. The length, breadth of the building are 22.5m,

22.5m respectively. The heights of buildings are 15.5m, 30.5m, and 45.5m respectively. The beam and column cross-section dimension are:

Dimensions of buildings

Buildings	low rise	medium	high rise
Foundation columns	450*500	600*600	900*900
Other columns	450*500	600*600	800*800
Main beams	325*425	300*600	400*600
Secondary beams	250*325	200*500	300*400

The isometric view and plan view dimensions of the building are modeled in one of the robust structural analysis software, the Staad Program connect edition, as displayed in Fig. 3.5 to and 3.11. respectively**.** The material properties such as concrete and masonry modulus of elasticity (25 kN/m²), damping ratio = 5% are assumed. The employed concrete has 25MPa strength and steel has a yield capacity of 415MPa. The thickness of the inner and outer walls is assumed as 230mm. The self-weight is assigned to all the beam and column elements. Live load intensity (including floor finish) of 4kN/m² is adopted for floor load, equally distributed to all the beams, except the top floor which is taken as 1.5kN/m². The software-generated gravity loading diagrams are presented in Figs. 3.2(a). 3.2 (b). The zone factor equal to 0.16, is considered for zone III, in concern with IS 1893-2016 code. Response factor of 5, Importance factor, I = 1, and acceleration coefficient (s/g) = 1.402 (for time-period, T 0.97s) for medium soil type are employed in the building model. The seismic method adopts IS: 1893-2016 code provisions. The design procedure for beam and column elements is adopted based on the IS: 456-2000 code. The bases of the columns are assumed fully constrained (fixed) and the RC frame is modeled as a special moment resisting (SMRF) type. In this study, a STAAD Program connect edition tool is used to analyzed the buildings, which is a civil engineering analysis software used by various industrialists, educationalists, and research scholars to model and design concrete and steel structures.

Load calculations

In this study gravity loads such as dead loads, live loads, Earthquake loads in lateral direction (SLX and SLZ) are assigned to all the case studied building the manually calculated magnitudes of these values are presented in subsequent sections Fig.3.

Dead load (D.L)

i. External wall load (w1)

= height of wall * thickness of wall * masonry density

= 5m * 0.21m * 20kN/m^3 = 21.6kN/m

ii. Internal wall load (w2)

= height of wall * thickness of wall * masonry density

= 5m * 0.17m * 20kN/(m^3) = 17.2kN/m

iii. Parapet wall load (w3)

= thickness * height * masonry density

= 0.125m *1.1m * 20kN/(m^3) = 4.9kN/m

Live load (L.L)

iv. Live load on floors including floor finish (w4), except top floor

= 4kN/m^2 (as per IS: 875-1987 (Part-2))

v. Live load on the top floor including floor finish (w5)

= 1.5kN/m^2 (as per IS: 875-1987 (Part-2))

Lateral load (SL)

vi. Seismic load in the x-direction

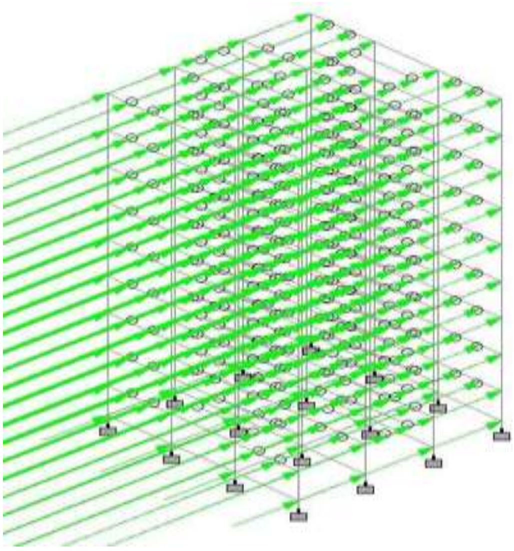
= 100% D.L+50%L.L (excluding top floor load)

vii. Seismic load in the z-direction

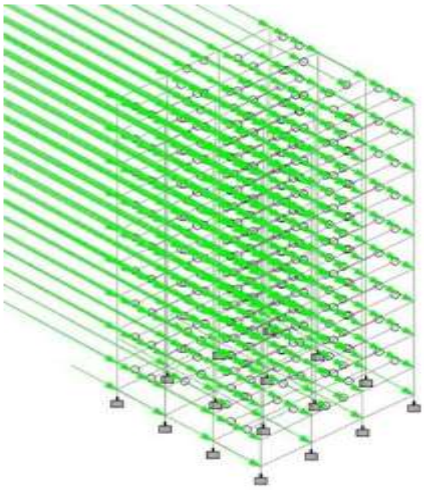
= 100% D.L+50%L.L (excluding top floor load)

viii. Critical load combination (seismic coefficient method)

=1.5(D.L+SLZ)

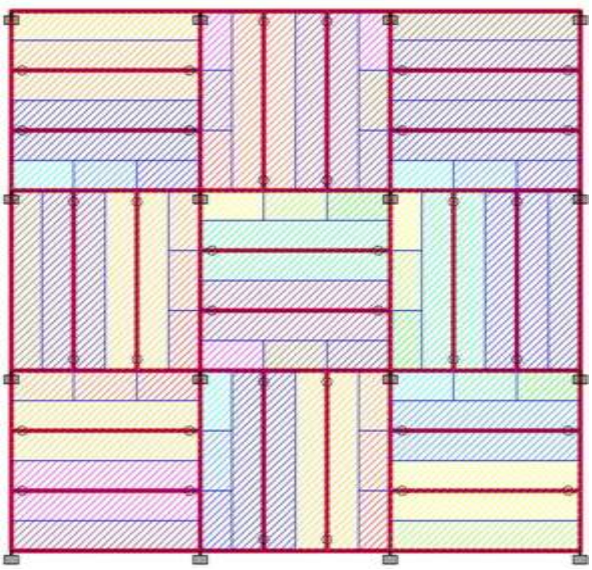


a) SLX

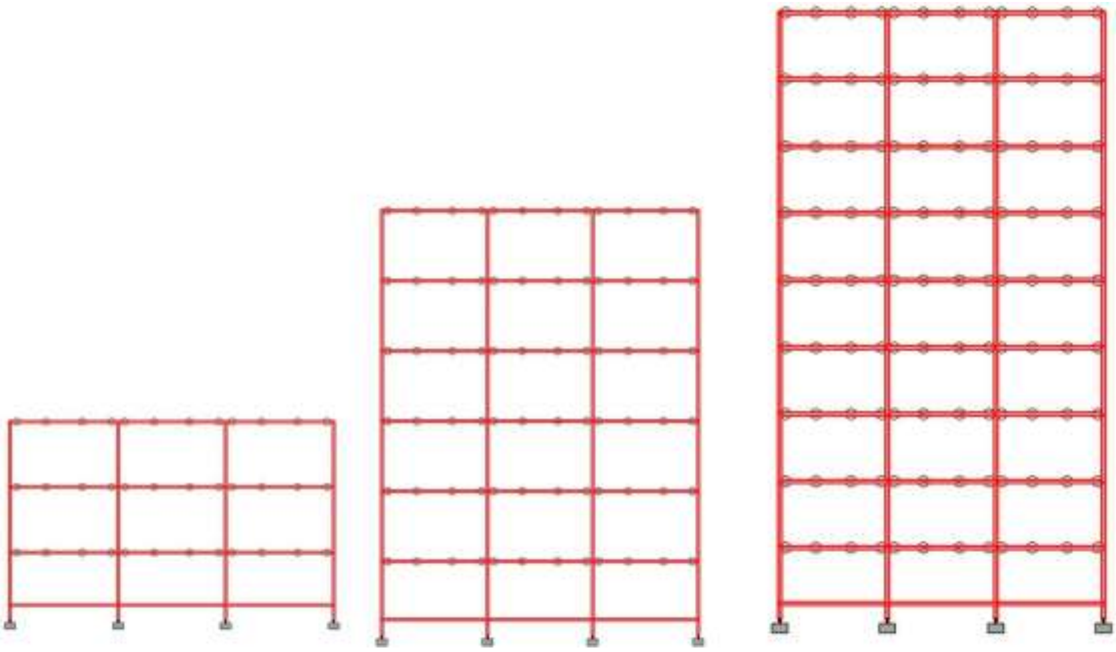


b) SLZ

High-rise building



Plan of the buildings



Low, Medium, High-rise building elevations

Plan and elevations of a low, medium, high-rise buildings as in the figure 4 and figure 5. The height of the low-rise building is 15.5m, medium-rise building is 30.5 and high-rise building is

45.5m. Length and width of all buildings are 22.5m.

Validation of STAAD model

To verify the analysis procedure of earthquake loading using the seismic coefficient method, a four-story reference framed building is modeled in STAAD Pro. Connect Edition. Each floor has a 506.25 square meter area with 30.2m. The zone factor (Z) = 0.16 time-period (Ta) = 0.97s, sa/g

= 1.402, I= 1 design acceleration coefficient Ah = 0.03, R = 5 and soil-type = medium are assumed for the reference model. The theoretic results are evaluated using the IS 1893-2016 code provisions using the expression given in equations (1) to (5).

Dead loads of 21.6,17.2 and 4.9 kilo-Newton per square meter and live loads of 4 and 1.5 kilo- Newton per square meter are assumed for all floors and roof levels, respectively. Therefore, the total magnitude of loads at the roof is 100%DL +0% and for all floors is 100% DL +50% LL respectively. The reference frame model is then simulated for gravity and SL load types and the resulting base shear and story shear at each floor elevation are extracted. The extracted results are validated with the manual expressions related to the Indian code IS: 1893-2016. The STAAD program generated story-shear and base-shear results are identical to that of the results evaluated using Indian code provision, as shown in Table 2. Therefore, the same procedure is adopted to model and perform the EQ performance of all irregular shaped building. The expressions given in Eqs. (1) to (5) is used to evaluate the theoretical results as per IS: 1893-2016 code.

Table 2 Verification of STAAD program and IS 1893-2016 results

S.no	Storey	W(kN)	h(m)	Wh^2	Vb (kN)	Base shear (kN)	
						Manual	Staad
1	7	5597	30.2	5105	1320	480	472.442
2	6	6381	25.2	4052	1320	380	390.306
3	5	6381	20.2	2604	1320	244	242.705
4	4	6381	15.2	1474	1320	138	137.424
5	3	6381	10.2	664	1320	62	61.884
6	2	6138	5.2	166	1320	16	15.961
7	1	2027	1.1	3	1320	0	0.308
	Total	39286		14068		1320	1321.03

Conclusion:

Introduction

In this study, the seismic response of three different structures a low-rise (G+2), medium-rise (G+5), and high-rise (G+8) building was analyzed. The parameters evaluated include lateral displacement, base shear, bending moments, and drift ratios (for the 9-storey building). The key findings are summarized below.

Low rise Building (G+2 floors):

Lateral Displacement:

The maximum lateral displacement was observed at the top floor with a displacement of 146.353

mm. The critical load combination for this building for displacement is 1.5(DL+SLZ). The minimum displacement is obtained in the ground floor (4.679 mm) for the load combination DL+SLZ. The displacement increased gradually from the base to the top, confirming the expected flexural behavior under seismic loads.

Displacements of low-rise building

Sno	Floors	1.5(DL+LL)	1.5(DL+SLZ)	1.2(DL+LL+SLZ)	0.9DL+1.5SLZ	DL+SLZ	DL+0.8(LL+SLZ)
1	4	93.211	146.353	124.57	134.091	97.568	89.107
2	3	98.045	101.035	104.264	91.813	67.357	74.822
3	2	97.5	64.834	85.25	47.026	43.222	63.63
4	1	6.243	7.018	5.618	4.917	4.679	4.508

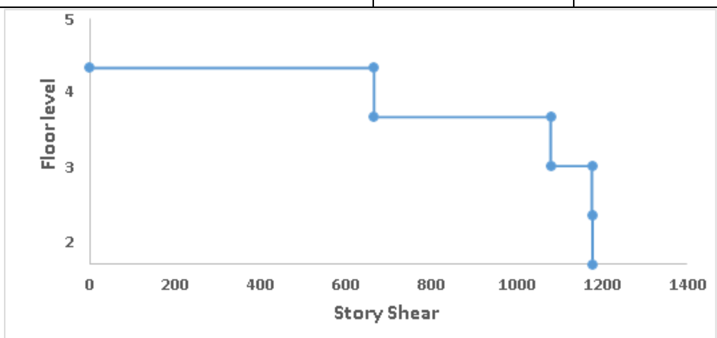
Maximum Displacement (SLZ)

Base shear:

The building experienced a base shear force proportional to its overall seismic weight. The lower height resulted in a relatively higher stiffness, which limited the overall shear demand. Maximum story shear is obtained at the top floor with a shear of 666.41 kN and the least is obtained at the ground floor with 1.662 kN.

Table 4 Base shear values of low-rise building

sno	floors	height(m)	story-shear	Cumulative
1	4	5	666.41	666.41
2	3	5	413.838	1080.248
3	2	4.1	96.473	1176.721
4	1	1.1	1.662	1178.383
Total			1178.383	



Base shear for low-rise building

Bending Moments:

Critical bending moments were concentrated at the beam-column joints, especially at the lower levels, where inertia forces are the highest. The bending moment distribution followed a typical parabolic trend. The Maximum bending moment is obtained for the load combination 1.5(DL+LL)

with a moment of 364.836 kN-m and the least is obtained for the seismic load in Z-direction with a moment of 0 kN-m.

Bending Moment values of low-rise building

BENDING MOMENTS							
s.no.	load case	B2001		B2002		B2003	
		Left	Right	Left	Right	Left	Right
1	DL	124.699	-147.202	182.618	-182.636	146.958	-125.011
2	LL	19.63	-27.859	60.606	-60.626	27.58	-19.986
3	SLX	-157.493	-149.989	-143.239	-143.24	-149.992	-157.496
4	SLZ	-0.113	-0.106	0	0.006	0.112	0.118
5	1.5(DL+LL)	216.494	-262.591	364.836	-364.892	261.808	-217.496
6	1.2(DL+LL+SLX)	-15.796	-390.06	119.982	-463.801	29.456	-362.991
7	1.5(DL+SLX)	-49.19	-445.787	59.069	-488.813	-4.55	-423.76
8	0.9DL+1.5SLX	-124.009	-357.466	-50.502	-379.232	-92.725	-348.754

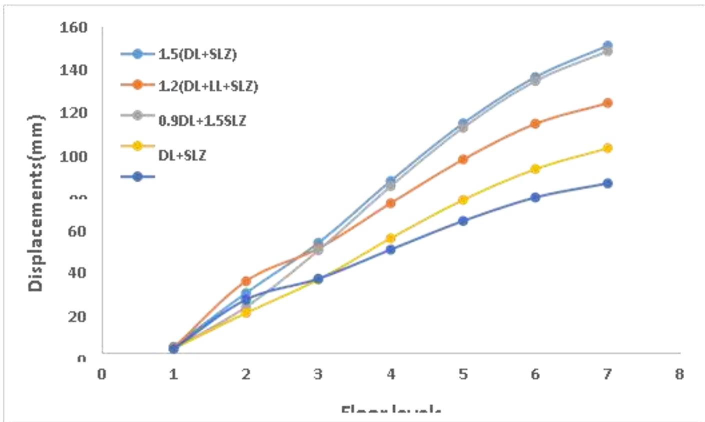
Medium rise Building (G+5 floors):

Lateral Displacement:

Compared to the 3-storey structure, the 6-storey building exhibited greater displacements. The top- storey displacement was high with a displacement of 150.523mm for the load combination 1.5(DL+SLZ). The minimum displacement was observed in the ground floor with 2.063mm displacement for the load combination DL+SLZ.

Displacements of Medium rise building

Sno	floors	1.5(DL+LL)	1.5(DL+SLZ)	1.2(DL+LL+SLZ)	0.9DL+1.5SLZ	DL+SLZ	DL+0.8(LL+SLZ)
1	7	45.972	150.523	122.446	147.856	100.349	83.129
2	6	47.456	135.146	112.274	133.245	90.098	76.176
3	5	46.03	112.484	94.77	110.356	74.989	64.655
4	4	43.842	84.256	73.372	81.7	56.17	50.641
5	3	41.098	53.999	51.261	50.334	36.001	36.412
6	2	38.193	29.414	35.173	22.553	19.61	26.163
7	1	2.951	3.095	2.552	2.111	2.063	2.046



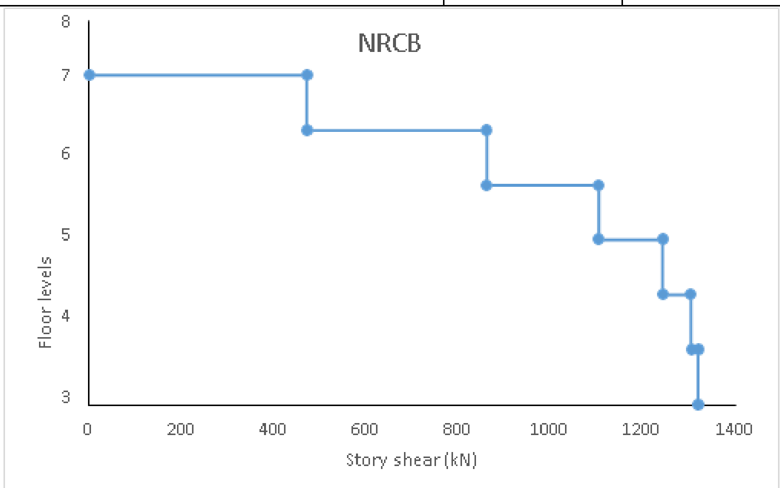
Maximum Displacement for medium building

Base Shear:

The base shear increased with the additional mass of the building but the distribution along the height remained linear under equivalent static load conditions. Maximum story shear is obtained at the top floor with a shear of 472.442 kN and the least is obtained at the ground floor with 0.308 kN.

Base shear values of medium rise building

sno	floors	Height	story-shear	Cummulative
1	7	5	472.442	472.442
2	6	5	390.306	862.748
3	5	5	242.705	1105.453
4	4	5	137.424	1242.877
5	3	5	61.884	1304.761
6	2	4.1	15.961	1320.722
7	1	1.1	0.308	1321.03
Total			**1321.03**	



Story shear of medium rise building

Bending Moments:

Higher moments were observed at the lower floors, as the seismic forces accumulated toward the base. The Maximum bending moment is obtained for the load combination 1.5(DL+LL) with a moment of 372.205 kN-m and the least is obtained for the seismic load in Z-direction with a moment of 0.55 Kn-m.

Bending moment values of medium rise building

BENDING							
		B2001		B2002		B2003	
s.no.	load case	Left	Right	Left	Right	Left	Right
1	DL	120.228	-156.679	189.047	-188.992	156.743	-120.156
2	LL	18.71	-29.271	59.09	-59.027	29.345	-18.628
3	SLX	-224.983	-206.177	-191.663	-191.663	-206.178	-224.983
4	SLZ	-1.01	-0.94	-0.681	-0.707	-0.55	-0.615
5	1.5(DL+LL)	208.406	-278.924	372.205	-372.029	279.132	-208.175
6	1.2(DL+LL+SLX)	-103.254	-470.552	67.768	-527.618	-24.108	-436.52
7	1.5(DL+SLX)	-157.132	-544.284	-3.924	-570.982	-74.152	-517.709
8	0.9DL+1.5SLX	-229.269	-450.277	-117.352	-457.587	-168.198	-445.615

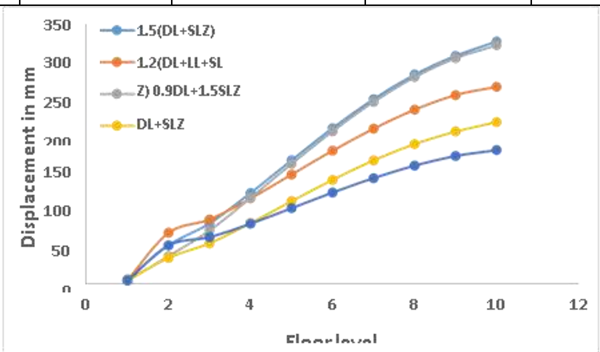
High rise Building (G+8 floors):

Lateral Displacement:

The 9-storey structure displayed even higher lateral displacements, more than the 6-storey building. The top-stored displacement was high with a displacement of 327.687mm for the load combination 1.5(DL+SLZ). The minimum displacement was observed in the ground floor with 3.375mm displacement for the load combination DL+SLZ. The increase highlights the necessity for more robust lateral load-resisting systems in taller buildings.

Displacements of high-rise building

Sno	floors	1.5(DL+LL)	1.5(DL+SLZ)	1.2(DL+LL+SLZ)	0.9DL+1.5SLZ	DL+SLZ	DL+0.8LL+0.8SLZ
1	10	93.113	327.687	266.22	322.57	218.458	180.343
2	9	97.051	308.348	254.962	305.047	205.565	172.359
3	8	95.985	282.928	235.215	279.448	188.618	159.327
4	7	94.406	249.525	209.419	245.741	166.35	142.348
5	6	92.259	210.039	179.577	205.796	140.026	122.747
6	5	89.569	166.622	147.272	161.643	111.081	101.627
7	4	86.364	122.307	114.934	115.743	81.537	80.658
8	3	82.884	80.986	86.373	71.34	53.99	62.397
9	2	79.045	51.289	68.262	36.594	34.192	51.038
10	1	4.742	5.062	4.241	3.574	3.375	3.385



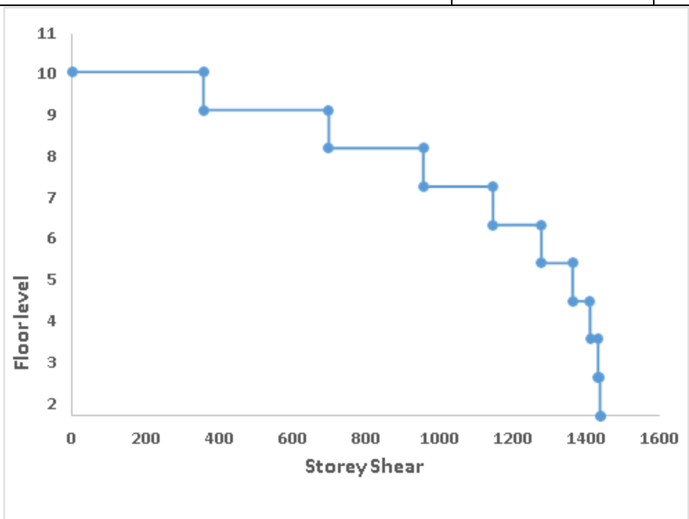
Maximum Displacement for high building

Base Shear:

Although the base shear increased overall, the building's greater height caused a slight redistribution of seismic forces across floors, with mid-level stories experiencing higher forces than expected. Maximum story shear is obtained at the top floor with a shear of 357.903 kN and the least is obtained at the ground floor with 0.104 kN.

Base shear values of high-rise building

sno	floors	Height	story-shear	Cumulative
1	10	5	357.903	357.903
2	9	5	341.716	699.619
3	8	5	257.741	957.36
4	7	5	189.72	1147.08
5	6	5	132.099	1279.179
6	5	5	84.879	1364.058
7	4	5	48.06	1412.118
8	3	5	21.642	1433.76
9	2	4.1	5.569	1439.329
10	1	1.1	0.104	1439.433
Total			1439.433	



Story shear of high-rise building

Bending Moments:

The bending moments followed an increasing trend with building height but showed some nonlinearities, particularly near the base, due to P-Delta effects becoming more pronounced in taller buildings. The Maximum bending moment is obtained for the load combination 1.5(DL+LL) with a moment of 367.308 kN-m and the least is obtained for the seismic load in Z-direction with a moment of -0.684 Kn-m.

Bending moment values of High-rise building

BENDING MOMENTS							
		B2001		B2002		B2003	
s.no.	load case	Left	Right	Left	Right	Left	Right
1	DL	132.024	-143.706	183.734	-183.521	143.924	-131.797
2	LL	22.474	-24.919	61.138	-60.896	25.169	-22.215
3	SLX	-215.708	-208.647	-204.238	-204.238	-208.648	-215.709
4	SLZ	-0.866	-0.839	-0.744	-0.747	-0.684	-0.709
5	1.5(DL+LL)	231.747	-252.938	367.308	-366.626	253.64	-231.018
6	1.2(DL+LL+SLX)	-73.453	-452.726	48.761	-538.386	-47.465	-443.665
7	1.5(DL+SLX)	-125.527	-528.53	-30.757	-581.639	-97.085	-521.258
8	0.9DL+1.5SLX	-204.741	-442.306	-140.997	-471.526	-183.44	-442.18

The seismic analysis and design of low, medium, and high-rise buildings are investigated and the conclusions are obtained from this study are illustrated below.

- High-rise building has exhibited highest base shear among the three buildings with 1439 kN. The least base shear is induced in low-rise building (1178 kN). It is concluded that the base shear value for the high-rise building increased by 18% compared to low-rise building.
- It is concluded that the lateral displacement is found maximum at roof for all buildings and minimum at ground floor. The displacement results are found in descending order for roof to ground floor.
- The maximum lateral displacement is obtained at the top floor of high-rise building for the load combination of 1.5(DL+SLZ) among the all buildings. The displacement obtained is 327.68 mm.
- Peak storey drift of magnitude 0.0039 is found in high-rise building and least magnitude 0.0011 is found under the low-rise building.
- The minimum steel and concrete materials consumption is for low-rise building of 403.447kN and 186.7 m^3 respectively and the maximum for high-rise building of 591.044kN and 610.6 m^3 respectively.

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