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Dynamic Analysis of Tall Building under the Effect of Different Parameters in Different Seismic Zones

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Abstract

In this project, the major concern is kept on the static, dynamic analysis & comparisons of different parameters in different seismic zones with and without shear wall like base shear, storey drift, support reaction, storey shear, lateral loads, displacements along with the comparisons of design data with manual and software results also the design failure check has been made for the building in different zone with different elevation of the residential building model and the comparative values of displacement have been derived for building model for different zones under static and dynamic analysis. Whereas the dynamic analysis is performed as response spectrum analysis and the design has done for the same. A symmetric plan of a multi-story (tall) apartment building is taken and it has been model in Etabs with different structural elements with different preliminary sizes of structural element by following all aspects of Indian standard for selection of the sizes for analysis purpose for minimum story displacement, minimum story drifts and to avoid torsional irregularity, mass irregularity and other seismic checks has been performed followed by various design check also which is briefly described. For the purpose of comparison of different parameters under seismic zones as e.g. Zone 2 (Town-Bhilai), Zone 3 (Town-korba), Zone 4 (Delhi), Zone 5 (Town-Bhuj) is taken for better understanding

Keywords: *Response Spectrum Analysis, Time History Analysis, Dynamic Analysis, Linear and Non-Linear Analysis, Story Drift, Story Shear, Bracing, Etabs, Displacement, Deflection, Torsional Irregularity.*

1. Introduction

A quick release of huge amount of energy in the Earth's crust which will creates seismic waves results in earthquake, which is also known as a tremor, a quake or a temblor. The frequency, type and magnitude of earthquakes experienced over a period of time define the seismicity (seismic activity) of that area. The observations from a seismometer are used to measure earthquake. Earthquakes greater than approximately 5 are mostly reported on the scale of moment magnitude. Those smaller than magnitude 5, which are more in number, as reported by the national seismological observatories are mostly measured on the local magnitude scale, which is also known as the Richter scale. There are many buildings that have primary structural system, which do not meet the current seismic requirements and suffer extensive damage during the earthquake. According to Seismic Zoning Map of IS-1893-2002, which says the region is least probable for earthquakes. Most of the structures in India are low rise structures (up to four stories). A close look at response spectrum from IS 1893 will indicate that short period structures (structures with less height) are subjected to large amount of earthquake force. In spite of this fact most of the design engineers ignore severity of the problem subjecting the occupants to a higher level of risk during earthquakes. The buildings which do not fulfill the requirements of seismic design, may suffer extensive damage or collapse if shaken by a severe ground motion.

2. Literature Review

2.1- Dynamic Analysis of Multi-storey RCC Building- "Alhamd farqaleet"

The important objective of earthquake engineers is to design and build a structure in such a way that damage to the structure and its structural component during the earthquake is minimize. This report aims towards the dynamic analysis of a multi-storey RCC building with symmetrical configuration. For the analysis purpose model of ten storey RCC with symmetrical floor plan is consider. The analysis is by carried by using finite element-based software SAP 2000. Various response parameters such as lateral force, base shear, story drift, story shear can be determined. For dynamic analysis time history method or response spectra method can be used.

2.2- Earthquake Analysis of Multi Storied Residential Building- "E. Pavan Kumar"

The main objective this paper is to study the seismic analysis of structure for static and dynamic analysis in ordinary moment resisting frame and special moment resisting frame. Equivalent static analysis and response spectrum analysis are the methods used in structural seismic analysis. We considered the residential building of G+ 15 storied structure for the seismic analysis and it is located in zone II. We observed the response reduction of cases ordinary moment resisting frame and special moment resisting frame values with deflection diagrams in static and dynamic analysis. The special moment of resisting frame structured is good in resisting the seismic loads.

3. General Structural Details & Working Principle-

Table 1 Structural Details

Pooja Room	**4'3"x5'**
Bedroom	12'3"X11' & 13'x10' & 11'9"X11'6"
Living Room and Dinning	28'x12'6"
Kitchen	11'3"x10'
Balcony	4'x8' and 4'x9'6"
Bath And Wc	7'x4'6"
Brick Wall	9" (ext. wall)
	4.5"(interior and partition wall)
Shear Wall & Lift Wall	9" & 9"
Lift Size	4.5'x6' (each core size)
Staircase	1.5 Mt width each flight Landing width-1.5m Tread-12' & Riser-6'

PRELIMINARY SECTION PROPERTIES			
1	**Frame Section**	**Beam M30 grade**	PRIMARY BEAMS - 300x500mm
			SECONDARY BEAMS-250x350mm
			PLINTH BEAMS-250x450mm
		Columns M35 grade	EXTERIOR-300x500mm
			INTERIOR - 300x700mm
2	**Wall section**	**Lift wall**	9x9
		Shear wall	250 mm THICK M35 GRADE
3	**Slab section**	**General slab**	125mm
		Staircase slab	250mm
		Oht&lmr	200mm
		Slab Section of M30 Grade	
4	**AAC Walls**	230 mm thick brick masonry walls only at periphery and lobby area 4.5-inch brick masonry (partition and another wall)	

General Details			
-	An Architectural Plan of Building confirming to all Architectural aspects as required		
-	Type of Structure	:	Multi-Storey Rigid Jointed RC Frame Structure
-	No. of Storey/ floors	:	G+15 Storey
-	Floor to Floor Height	:	3.25 meter
-	Plinth Level	:	1.25 meter above Ground Level
-	Location of Structure	:	Ahmedabad Gujarat-India
SITE DETAILS			
-	Surrounding Location of Structure	:	Urban Region: Developed Complex Area
-	Type of Soil on which Structure is	:	Medium Soil (Poo Graded Sand: Stiff Soil)
-	Safe Bearing Capacity of Soil	:	400 kN/m2
Method Of Analysis			
Static- Equivalent Static Analysis & Dynamic Analysis- Response Spectrum Analysis Method			
Seismic Analysis Important Terms			
-	Seismic Zone	:	III
-	Zone Factor (Z)	:	0.16
-	Site Type	:	II for Medium Soil as per Table 4 of IS 1893 (Part 1): 2016
-	Importance Factor (I)	:	1.2 as per Cl.7.2.3 and Table 8 of IS 1893 (Part 1): 2016
-	System	:	SMRF (Special Moment Resisting Frame)
-	Response Reduction Factor (R)	:	4 as per Cl.7.2.6 and Table 9 of IS 1893 (Part 1): 2016
-	Percentage of Imposed Load to be Considered in Seismic Weight	:	25% for LL is up to 3 kN/m2
			as per Cl.7.3.1 and Table 10 of IS 1893 (Part 1): 2016

3.1 General principles for analysis-

1).Cracked RC Section Properties-Taken from IS16700 code and 0.35&7 Times I_{gross} for Beam and column respectively as per IS1893: 2016

2).Regular and irregular configuration-

- Torsional irregularities-

the maximum horizontal displacement of any story in the direction of the lateral force at one end of the floor is more than 1.5 times its minimum horizontal displacement at the far end of the same floor in that direction then this is called as torsional irregular building which is shown in figure.

- Re-entrant corners-

Re-entrant corner is a type of plan irregularity shown in the figure when a building is said to have a re-entrant and corner in any plan direction when its structural configuration in plan has a projection of size greater than 15% of its overall plan dimension in that direction.

3). Story drift limitations-

At any storey the storey drift should not be exceeded to (0.004xstorey height) under the action of design base shear V_b.

Table 1-Determination of Scale Factor

Importance Factor	**-**	**1**
Gravitational Factor	-	9.80665 m/s2
		9806.65 mm/sec 2
	-	Etabs metric default setting is in mm/sec2.
Response Reduction Factor	-	5
Scale Factor (Ig /2R)	-	980.665
After using the scale factor, we have to run the analysis to check base shear EX & EY with RSX & RSY.		
RSX & RSY must match with the EX & EY resp. If it is not matched then we have to rescale the scale factor.		
To save time we can run analysis without modifying the default scale factor and then try to match response base shear and earthquake base shear.		
Base Shear, EX	1582.266	
Base Shear, EY	548.802	
Shear For RSX	41808.24	
Shear For RSY	43338.27	
Default Scale Factor	9806.65	
Multiplying Factor for U1	0.037846	
Multiplying Factor for U2	0.012663	
Scale Factor Value Sfx For U1	371.1404	
Scale Factor Value Sfx For U2	124.183	

4. Comparisons of Analysis and Design Results-

4.1 Modal periods and frequency

Table4.1- Modal periods and frequency comparison

		Without Shear wall		With Shear wall	
Case	**Mode**	**Period**	**Frequency**	**Period**	**Frequency**
		sec	cyc/sec	sec	cyc/sec
Modal	1st	2.826	0.354	0.195	5.127
Modal	7th	0.502	1.993	0.113	8.88
Modal	14th	0.171	5.843	0.041	24.344
Modal	20th	0.111	9.049	0.037	26.886
Modal	21st	0.106	9.454	0.037	27.163

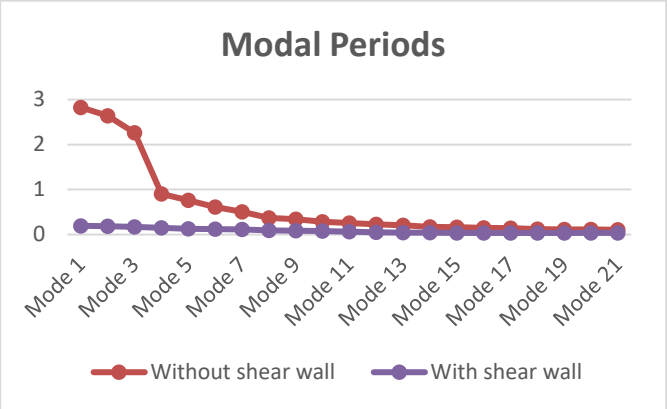


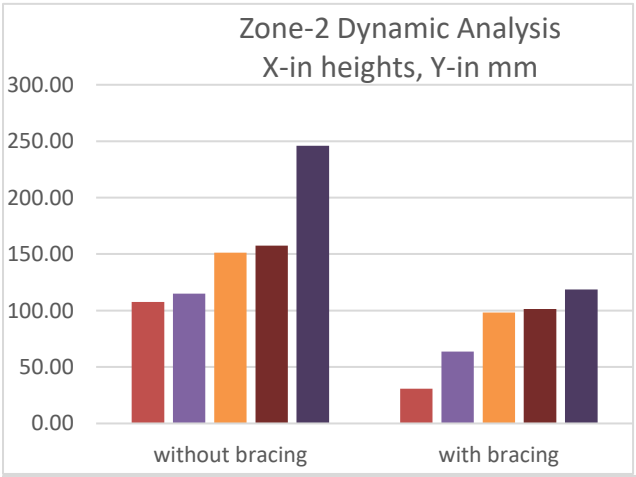
Figure4.1 Modal Periods

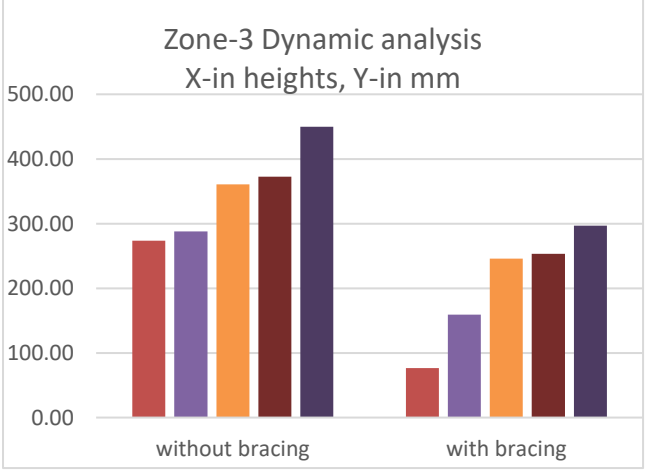
4.2 Displacement values for Different ht. of building respective to Bracings-

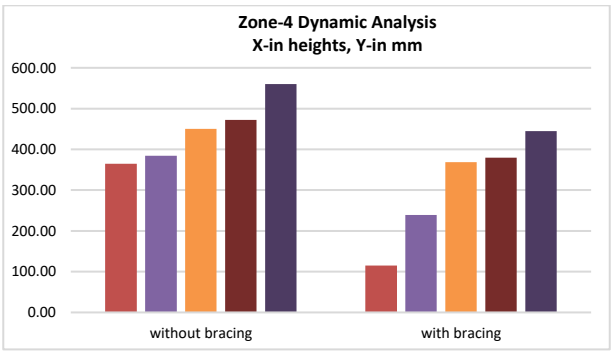
Table4.2- Displacement values for Different ht. of building respective to Bracings.

Zone 2	**Static Analysis**		**Zone 2**	**Dynamic Analysis**	
	Displacement			**Displacement**	
Building Height	Without Bracing	With Bracing	Building Height	Without Bracing	With Bracing
20m	16.90	10.20	20m	107.70	30.70
30m	23.80	17.50	30m	115.00	63.70
40m	27.40	22.40	40m	151.40	98.30
50m	42.50	32.70	50m	157.40	101.30
60m	65.20	44.70	60m	245.90	118.70
Zone 3	**Static Analysis**		**Zone 3**	**Dynamic Analysis**	
	Displacement			**Displacement**	
Building Height	Without Bracing	With Bracing	Building Height	Without Bracing	With Bracing

20m	39.43	23.80	20m	273.40	76.75
30m	55.53	40.83	30m	288.00	159.25
40m	63.93	52.27	40m	360.80	245.75
50m	99.17	76.30	50m	372.80	253.25
60m	152.13	104.30	60m	450.00	296.75
Zone 4	**Static Analysis**		**Zone 4**	**Dynamic Analysis**	
	Displacement			**Displacement**	
Building Height	Without Bracing	With Bracing	Building Height	Without Bracing	With Bracing
20m	59.15	35.70	20m	364.53	115.13
30m	83.30	61.25	30m	384.55	238.88
40m	95.90	78.40	40m	450.50	368.63
50m	148.75	114.45	50m	472.50	379.88
60m	228.20	156.45	60m	559.80	445.13







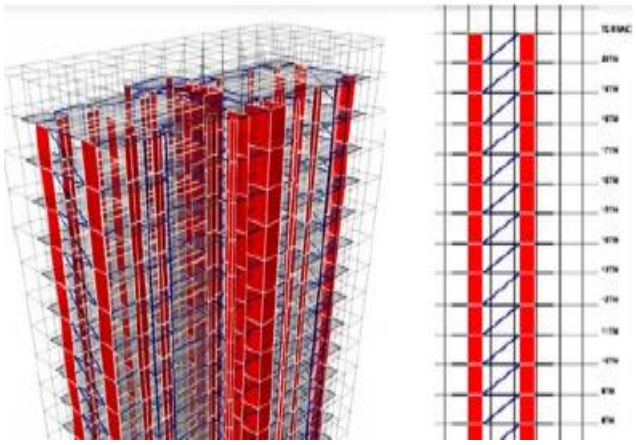


Figure4.2- Zone-2,3 &4 Displacement Values under Dynamic Analysis

4.3. Base Shear in X-Direction-

Table4.3- Base Shear in X-Direction for Zone2-3-4&5.

S. No.	Zone	Base Shear-X (kN) With Shear Wall	% Increment in shear w.r.t Zone II	Base Shear-X (kN) Without Shear Wall
1	II	2875.29	-	2147.37
2	III	4600.47	60.5	3222.84
3	IV	6900.71	140.3	4830.45
4	V	10351.07	260.2	6784.41

NOTE- Base Shear varies considerably from Zone II to Zone V i.e. the value of base shear in Zone III exceeds 60.5 % of that in Zone II, in Zone IV exceeds 140.3% of that in Zone II and in Zone V exceeds 260.2% of that in Zone II. Hence, there is a considerable increase in the value of base shear from Zone II to Zone V.

4.4. Base Shear in Y-Direction

Table4.4- Base Shear in Y-Direction for Zone2-3-4&5.

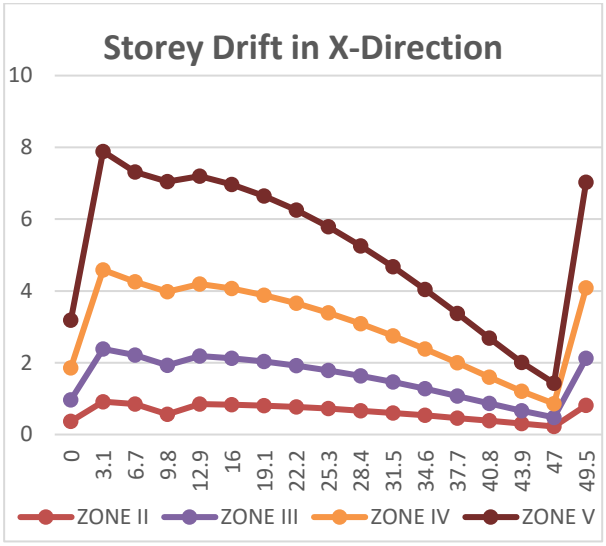
S. No.	Zone	Base Shear-Y (kN) With	% Increment in shear w.r.t Zone	Base Shear-Y (kN) Without

		Shear Wall	II	Shear Wall
1	II	1797.06	-	1069.14
2	III	2975.45	60.5	1597.82
3	IV	4312.94	143.3	2242.68
4	V	6469.41	260.2	2902.75

4.5. Storey Drift in X- Direction

Table4.5- Storey Drift in X- Direction for Zone2-3-4&5.

Storey	Level meters	Drift(mm) Zone II	Drift(mm) Zone III
Base	0.00	0.3695	0.5979
G-Storey	3.10	0.9162	1.4678
5th	19.10	0.8063	1.2304
6th	22.20	0.7681	1.1549
7th	25.30	0.7209	1.0667
8th	28.40	0.6658	0.9669
9th	31.50	0.6036	0.8572
10th	34.60	0.5351	0.7389
11th	37.70	0.4613	0.6140
12th	40.80	0.3833	0.4855
13th	43.90	0.3031	0.3598
14th	47.00	0.2246	0.2545
15th	49.50	0.8178	1.3090
Storey	Level	**Drift(mm) Zone IV**	**Drift(mm) Zone V**
Base	meters	0.8879	1.3311
G-Storey	0.00	2.2019	3.3009
5th	3.10	1.8457	2.7670
6th	19.10	1.7324	2.5971
7th	22.20	1.6000	2.3986
8th	25.30	1.4505	2.1744
9th	28.40	1.2858	1.9276
10th	31.50	1.1084	1.6616
11th	34.60	0.9210	1.3807
12th	37.70	0.7283	1.0917
13th	40.80	0.5397	0.8090
14th	43.90	0.3817	0.5722
15th	47.00	1.9627	2.9413
Storey	49.50	0.8879	



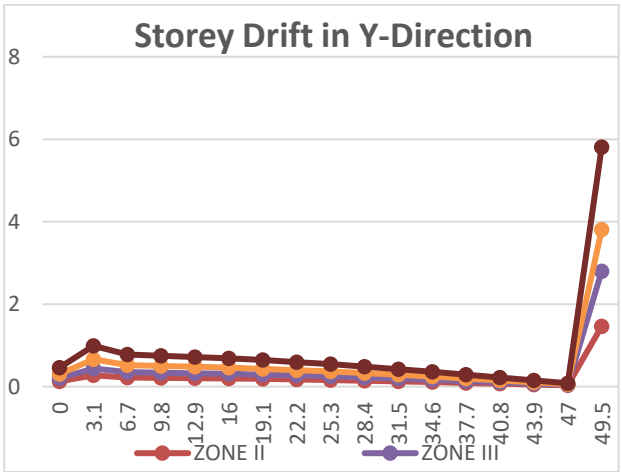


Figure4.3- Storey Drift In X& Y Directions.

4.6 Design Check of Building in Different Zone with Different Elevation–

Table4.6- Design Check of Building in Different Zone with Different Elevation.

Design Check of Building In Different Zone With Different Elevation-					
Levels	**Zone II**	**Zone III**		**Zone IV**	
		With Shear Wall	**Without Shear Wall**	**With Shear Wall**	**Without Shear Wall**
For G+15+Terrace and OHT level	**Passed**	**3-** Conc Member **Fails**	**24-** Conc Member **Fails**	**36-** Conc Member **Fails**	**49-** Conc Member **Fails**
For 15th story	**Passed**	**All Conc Member Passed**	**17-** Conc Member **Fails**	**26-** Conc Member **Fails**	**38-** Conc Member **Fails**
For	**Passed**	**All Conc**	**17-** Conc	**20-** Conc	**32-** Conc

13th story		**Member Passed**	Member **Fails**	Member **Fails**	Member **Fails**
For 11th story	**Passed**	**All Conc Member Passed**	**15-** Conc Member **Fails**	**15-** Conc Member **Fails**	**28-** Conc Member **Fails**
For 9th story	**Passed**	**All Conc Member Passed**	**6-** Conc Member **Fails**	**11-** Conc Member **Fails**	**21-** Conc Member **Fails**
For 7th story	**Passed**	**All Conc Member Passed**	**All Conc Member Passed**	**3-** Conc Member **Fails**	**15-** Conc Member **Fails**
For 5th story	**Passed**	**All Conc Member Passed**	**All Conc Member Passed**	**All Conc Member Passed**	**6-** Conc Member **Fails**

Conclusions

Response Spectrum and Scale Factor-

- There is no inclusion of effect of vertical earthquake as building with stands in zone 3.
- Load calculation are made strictly under the provision and guidelines of IS code since in this project approximate load calculation are done as there will be no large different with respect to exact load calculated.
- Scale factor was found out to be **371.14** and **124.183** and Seismic weight is found as **59666.28** and base shear of **1582.925kN** and **549.06** in x and y direction.

Drift and Torsional Irregularity-

- Different type of checks are performed in which the drift value are under limit (below 12.5mm) where is torsional irregularity is exceeding the allowed limit so as the shear wall is provided as a solution of it.
- Story drift increasing from base to story-7 and then decreasing from story 7 to story 15 in both X and Y direction.

Displacements-

- Displacement value are under limits (max allowed is span/250) under the provision of bracings and shear wall system.

Bracings

- When Response Spectrum analysis is performed for all the models with different height & with and without bracings. The displacement of **35-40%** is reduced when **X type** bracings are provided.
- **X type** bracings is more effective in reducing the lateral loads as compare to v-type and single cross bracing.

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