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Influence of Zone Factor on Seismic Performance of Multi-Storied RCC Frame using ETABS 2016

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***Abstract:** In tall buildings lateral loads are premier one which will increase rapidly with increase in height. The analysis and design takes care of the requirements of strength, rigidity and stability. It is mandatory to do the seismic analysis and design to structural against collapse. It is highly impossible to prevent an earthquake from occurring, but the damage to the buildings can be controlled through proper analysis and design. Structure is analyzed in such a way that reducing damage during an earthquake makes the structure quite uneconomical. In this project a residential 10, 15 and 20 story building are studied for earthquake load using ETABS 2016. Assuming that material property is linear static and Response spectrum analysis is performed. These analyses are carried out by considering different seismic zones. Different response like story displacements, Time Period and Acceleration, base shear is plotted for different zones.*

***Keywords:** RCC Building, multistorey, zones, Response Spectrum Analysis, Disp., Time Period and Acceleration.*

I. INTRODUCTION

The vast devastation of engineered systems and facilities during the past few earthquakes has exposed serious deficiencies in the design and construction practices. Conventional civil engineering structures are designed on the basis of two main criteria that are strength and rigidity. The strength is related to damageability or ultimate state, assuring that the force level developed in structures remains in the elastic range, or some limited plastic deformation. The rigidity is related to serviceability limit state, for which the structural displacements must remain in some limits. This assures that no damage occurs in non structural elements. In case of Earthquake design, ductility is an essential attribute of a structure that must respond to strong ground motions. Ductility serves as the shock absorber in a building, for it reduces the transmitted force to one that is sustainable. Therefore, the survivability of a structure under strong seismic actions relies on the capacity to deform beyond the elastic range, and to dissipate seismic energy through plastic deformations. So, the ductility is related to the control of whether the structure is able to dissipate the given amount of seismic energy considered in structural analysis. Therefore while designing an earthquake resisting structure these three factors rigidity (serviceability), strength (damageability) and ductility (survivability) should be taken under consideration. But, while designing an earthquake resistant structure the major importance will be given to the increase of ductility of the building (IS 456, 2000). The ductility of the building can be increased by increasing the reinforcement (steel) in the structure. But the reinforcement plays an important role in the economy of the structure.The present IS code 1893:2002 provides information regarding the excess amount of reinforcement to be used in the earthquake design but it doesn't prescribe the percentage of steel that should be increased in the earthquake resistant design when compared with the normal design as per IS 456 code.

This project mainly gives the variations in the percentage of the reinforcement when the building designed as per IS 456 and when the building is designed in different earthquake zones considering earthquake force as per IS 1893:2002. This gives the approximate percentage increase in the economy compared with normal design.

Earthquakes all over the world have affected the seismic resistant design in different countries and made a revision necessary in many areas. In the present study, the main factors constitute the seismic load have been studied and dynamic analysis results for various structural systems are compared using IS 1893 (Part 1):2002.

Even though the codes differ in detail, they have essential common features and are comparable. At first, the codes and their backgrounds are introduced and the design procedures are described. For calculating the seismic load according to code, the base shear coefficient, seismic zoning, spectral content, fundamental period, structural behavior coefficient, importance factor, effect of soil profile and foundation, and effect of the weight of buildings are precisely discussed and the differences have been mentioned.

This project deals with a study of influence of various zone factors and the codal provisions provided in IS 1893 (Part 1): 2002. Their similarities and differences are presented with dynamic analysis results carried out using modernized structural engineering software package ETABS2016 for various lateral load resisting structural systems with varying zone factors. Response spectrum analysis is carried out for IS code of practices for all structural systems considered in this study.

A. Necessity of seismic zoning in India

Seismic zonation is a process, which provided information about any decision making for urban regional planning or for earthquake design in earthquake areas. In principle, seismic zoning map is the main source of zoning, which is displaying quantities related to the expected frequency and intensity of shaking caused by earthquakes .The task of seismic zoning is multidisciplinary and involves the best of inputs from geologists, geotechnical's, seismologists, earthquake and structural engineers .The rapid urbanization due to population outburst ,coming up of mega cities in potential seismic zones is the main reason of the seismic hazard in India

B. Recent seismic zones in India

Following are the varied seismic zones of the nation which are predoinently shown in the map (Fig.no.1)

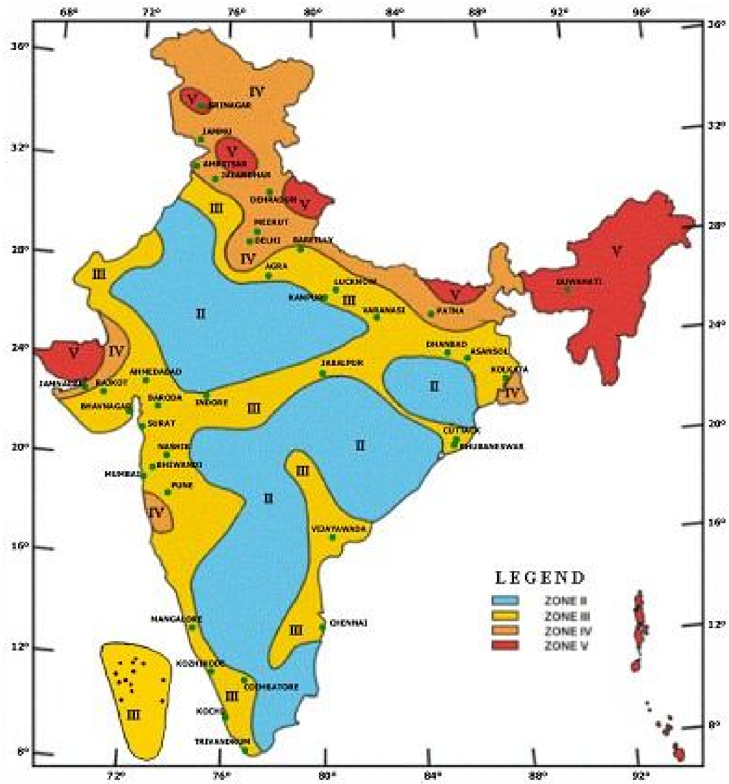

Fig 1: zones in indian map

1) *Zone – II:* This is said to be the least active seismic zone.
2) *Zone –III:* It is included in the moderate seismic zone
3) *Zone –IV:* This is considered to be the high seismic zone (severe)
4) *Zone- V:* It is the highest seismic zone (very severe)

C. 1893:2002 Provisions For Zones

According to IS 1893 code, seismic zonation map of a country is a guide to the seismic status of a region and its susceptibility to earthquakes. India has been divided into four zones with respect to severity of earthquakes Zone factor (Z) given in table 1, is for the maximum considered earthquake (MCE) and service life of a structure in a zone. For design horizontal seismic coefficient Ah=(Z/2)(Sa/g)(I/R) factor 2 in the denominator of Z is used so as to reduced the Maximum Considered Earthquake zone factor to the factor for design basis earthquake (DBE).

For any structure with t<0.1 s, the value of Ah will not be taken less than Z/2 whatever be the value of I/R

Table 1: Zone Factor, Z(Clause 6.4.2)				
Seismic Zone	II	III	IV	V
Intensity	Low	Moderate	Severe	Very Severe
Z	0.10	0.16	0.24	0.36

D. Methods Of Seismic Analysis

Once the structural model is selected ,it is necessary to perform analysis to determine the seismically induced forces in the structure .Lots of research is carried out in this area to propose simplified methods that will predict results with reasonable accuracy. So there are different methods of analysis are invented which provide different degree of accuracy. The analysis process and the available an be categorized on the basis of three factors: the type of externally applied loads, the behavior of structure or the structural materials and the type of structural model selected. Based on the type of external action and behavior of structure, the analysis can be further classified as linear static analysis, linear dynamic analysis, non-linear static analysis, or non-dynamic analysis. Linear static analysis or equivalent static analysis used only for regular structure with limited height .linear dynamic analysis (i.e. Response Spectrum Analysis) considers the effect of higher mode of vibration and the actual distribution of forces in the elastic range in the better way.

II. ANALYTICAL WORK

A. Types Of Cases Used For Analysis Of Structure

There is each of four basic cases of same moment resisting frame to analyze 10, 15 & 20-storey structure so that assignment of effect of seismic intensity can be predicted.

1) *Model 1 Zone II:* 20 storey Building model has considered in lowest seismic intensity area. (i. e. Seismic Intensity, Z=0.10)
2) *Model 2 Zone III:* 20 storey Building model has considered in Moderate seismic intensity area. (i. e. Seismic Intensity, Z=0.16)
3) *Model 3 Zone IV:* 20 storey Building model has considered in Severe seismic intensity area. (i. e. Seismic Intensity, Z=0.24)
4) *Model 4 Zone IV:* 20 storey Building model has considered in Very Severe seismic intensity area. (i. e. Seismic Intensity, Z=0.36)
5) *Model 5 Zone II:* 15 storey Building model has considered in lowest seismic intensity area. (i.e. Seismic Intensity, Z=0.10)
6) *Model 6 Zone III:* 15 storey Building model has considered in Moderate seismic intensity area. (i.e. Seismic Intensity, Z=0.16)
7) *Model 7 Zone IV:* 15 storey Building model has considered in Severe seismic intensity area. (i.e. Seismic Intensity, Z=0.24)
8) *Model 8 Zone IV:* 15 storey Building model has considered in Very Severe seismic intensity area. (i.e. Seismic Intensity, Z=0.36)
9) *Model 9 Zone II:* 10 storey Building model has considered in lowest seismic intensity area. (i.e. Seismic Intensity, Z=0.10)
10) *Model 10 Zone III:* 10 storey Building model has considered in Moderate seismic intensity area. (i.e. Seismic Intensity, Z=0.16)
11) *Model 11 Zone IV:* 10 storey Building model has considered in Severe seismic intensity area. (i.e. Seismic Intensity, Z=0.24)
12) *Model 12 Zone IV:* 10 storey Building model has considered in Very Severe seismic intensity area. (i.e. Seismic Intensity, Z=0.36)

B. Structural Data

Building consists of 12 m in short direction and 21 m in long direction, so from preliminary design the sizes of various structural members were estimated as, Brick masonry wall is provided with 230 mm (External) and 150mm (Internal) thickness for all storey of different cases. And 1.2m height parapet wall is also considered. Storey height is kept as 3m for bottom storey and all upper floors. Grade Fe-500 hot rolled deformed steel is used. Concrete having M-30($E=5000\sqrt{f_{ck}}$ as per IS456) strength for columns, beams and slabs is to be employed. Columns were kept of 300 X 900mm size for overall structure. All beams are of uniform size of 300 X 750mm having 125 mm thick slab for all the spans. Only staircase slab having 150mm thick and 150mm sunk considered at sunk slab.

C. Gravity Loading

Dead Load (DL):

Intensity of wall (External)	=12.34 KN /m (for 3m height)
Intensity of wall (Internal wall)	=8.88 KN /m (for 3m height)
Intensity of parapet wall	=6.17 KN /m (for 1.2m height)
Intensity of floor finish load	=1 KN /m^2
Load Intensity on sunk slab (150mm)	=2.5 KN /m^2
Load Intensity on staircase slab	=3 KN /m^2
Intensity of roof treatment load	=1 KN /m^2

Live load(LL):

Intensity of live load	=2 KN /m^2 (On all regular Slab)
	=3 KN /m^2 (On Staircase Slab)

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D. Lateral Loading

Lateral loading **(**IS 1893 (Part I):2002): Building under consideration is in Zones II, III, IV & V.

Load Case:

1) SpecX
2) SpecY

a) For 20-Story Building Models

Period Calculation: Program Calculated
Top Storey: Storey- 20th
Bottom Storey: Base
Response reduction factor, R = 5
Importance factor, I = 1
Building Height H = 60 m
Soil Type = II(Medium Soil)

b) For 15-Story Building Models

Period Calculation: Program Calculated
Top Storey: Storey- 15th
Bottom Storey: Base
Response reduction factor, R = 5
Importance factor, I = 1
Building Height H = 45 m
Soil Type = II (Medium Soil)

c) For 10-Story Building Models

Period Calculation: Program Calculated
Top Storey: Storey- 10th
Bottom Storey: Base
Response reduction factor, R = 5
Importance factor, I = 1
Building Height H = 30 m
Soil Type = II (Medium Soil)

E. Building Under Consideration

The building under consideration is twenty, fifteen & ten story residential building of plan as shown in Figure below with considered zones.

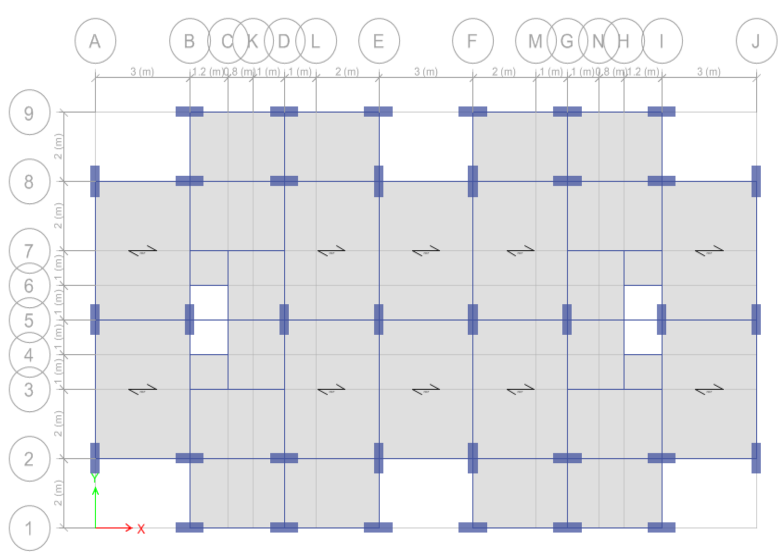

Fig.2: Plan of structure for analysis work

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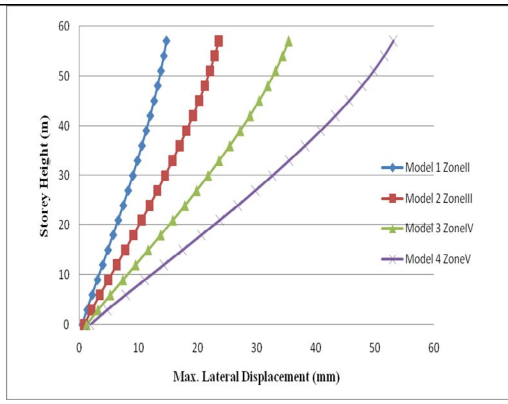
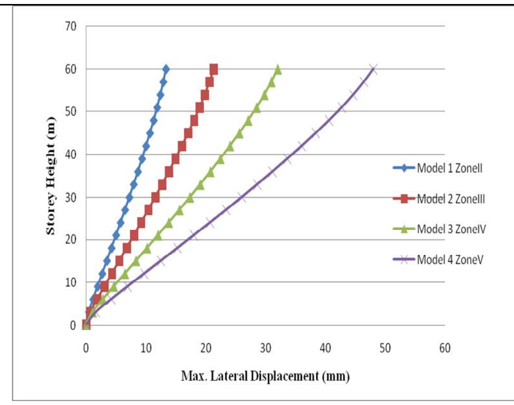
III. RESULT & DISCUSSION

A. Maximum Lateral Displacement

1) Maximum Lateral Displacement of 20 story building



Spec X



SpecY

Graph1: Comparisons Maximum Lateral displacement of all 20 storey Building models in SpecX & SpecY direction respt with respect to height

Table 2 : Comparisons Maximum Lateral displacement of all 20 storey Building Model

		In SpecX direction				In SpecY direction			
Storey No's	Height (m)	Model1 ZoneII	Model2 ZoneIII	Model3 ZoneIV	Model4 ZoneV	Model1 ZoneII	Model2 ZoneIII	Model3 ZoneIV	Model4 ZoneV
20	60	14.76	23.616	35.425	53.137	13.343	21.36	32.04	48.059
19	57	14.325	22.92	34.38	51.569	12.902	20.654	30.981	46.472
18	54	13.834	22.135	33.202	49.803	12.412	19.87	29.805	44.707
17	51	13.284	21.254	31.882	47.823	11.872	19.005	28.507	42.76
16	48	12.68	20.288	30.432	45.648	11.288	18.07	27.104	40.656
15	45	12.029	19.246	28.87	43.305	10.668	17.077	25.615	38.423
14	42	11.338	18.14	27.211	40.816	10.018	16.037	24.056	36.084
13	39	10.612	16.979	25.469	38.203	9.346	14.961	22.441	33.661
12	36	9.857	15.771	23.656	35.484	8.654	13.854	20.781	31.172
11	33	9.076	14.521	21.782	32.672	7.948	12.724	19.085	28.628
10	30	8.272	13.234	19.852	29.777	7.229	11.572	17.358	26.037
9	27	7.446	11.914	17.871	26.806	6.498	10.402	15.603	23.404
8	24	6.601	10.562	15.843	23.764	5.756	9.214	13.82	20.731
7	21	5.739	9.182	13.773	20.659	5.003	8.008	12.012	18.018
6	18	4.861	7.778	11.667	17.5	4.24	6.787	10.181	15.271
5	15	3.973	6.357	9.535	14.303	3.469	5.554	8.331	12.496
4	12	3.08	4.928	7.391	11.087	2.695	4.314	6.471	9.706
3	9	2.191	3.505	5.258	7.887	1.922	3.077	4.615	6.922
2	6	1.323	2.116	3.174	4.761	1.162	1.86	2.79	4.186
1	3	0.52	0.832	1.249	1.873	0.45	0.72	1.08	1.62

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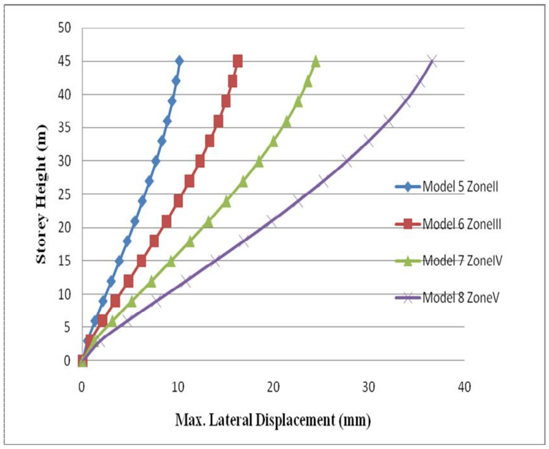
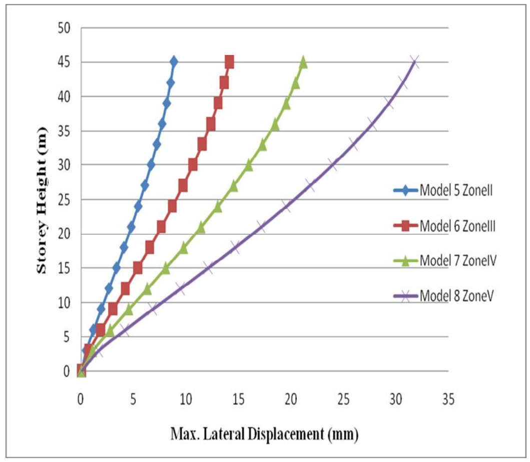
2) Maximum Lateral Displacement of15 story building



Spec X



SpecY

Graph2: Comparisons Maximum Lateral displacement of all 15 storey Building models in SpecX & SpecY direction respt with respect to height

Table 3 : Comparisons Maximum Lateral displacement of all 15 storey Building Model

		In SpecX direction				In SpecY direction			
Storey No's	Height (m)	Model5 ZoneII	Model6 ZoneIII	Model7 ZoneIV	Model8 ZoneV	Model5 ZoneII	Model6 ZoneIII	Model7 ZoneIV	Model8 ZoneV
15	45	10.176	16.282	24.423	36.635	8.821	14.113	21.169	31.754
14	42	9.827	15.724	23.586	35.378	8.513	13.62	20.431	30.646
13	39	9.404	15.047	22.571	33.856	8.14	13.023	19.535	29.302
12	36	8.904	14.246	21.369	32.053	7.699	12.318	18.477	27.715
11	33	8.332	13.331	19.997	29.995	7.198	11.517	17.276	25.913
10	30	7.697	12.316	18.474	27.711	6.646	10.634	15.951	23.927
9	27	7.009	11.214	16.821	25.231	6.051	9.681	14.522	21.783
8	24	6.273	10.037	15.055	22.583	5.418	8.669	13.004	19.505
7	21	5.498	8.797	13.195	19.792	4.754	7.606	11.409	17.113
6	18	4.69	7.504	11.255	16.883	4.062	6.499	9.749	14.623
5	15	3.856	6.17	9.255	13.882	3.348	5.357	8.036	12.054
4	12	3.006	4.809	7.214	10.82	2.618	4.189	6.283	9.424
3	9	2.149	3.438	5.157	7.736	1.879	3.006	4.509	6.763
2	6	1.303	2.085	3.128	4.692	1.142	1.828	2.742	4.112
1	3	0.515	0.823	1.235	1.853	0.444	0.711	1.066	1.599

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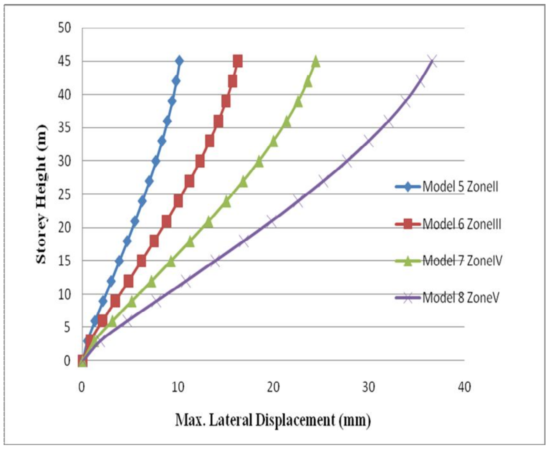
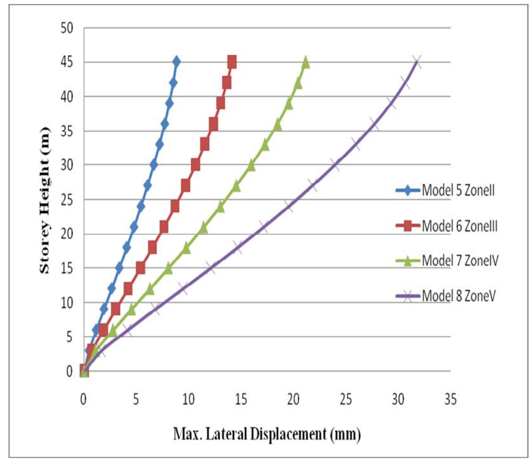
3) Maximum Lateral Displacement of10 story building



Spec X



SpecY

Graph3: Comparisons Maximum Lateral displacement of all 10 storey Building models in SpecX & SpecY direction respt with respect to height

Table 4 : Comparisons Maximum Lateral displacement of all 10 storey Building Model

		In SpecX direction				In SpecY direction			
Storey No's	Height (m)	Model9 ZoneII	Model10 ZoneIII	Model11 ZoneIV	Model12 ZoneV	Model9 ZoneII	Model10 ZoneIII	Model11 ZoneIV	Model12 ZoneV
10	30	5.922	9.475	14.213	21.319	5.037	8.059	12.088	18.132
9	27	5.652	9.043	13.564	20.346	4.824	7.718	11.578	17.366
8	24	5.274	8.438	12.657	18.985	4.517	7.227	10.841	16.261
7	21	4.788	7.66	11.49	17.235	4.113	6.581	9.872	14.808
6	18	4.205	6.729	10.093	15.139	3.624	5.799	8.699	13.048
5	15	3.543	5.668	8.502	12.754	3.064	4.902	7.353	11.03
4	12	2.817	4.507	6.76	10.14	2.445	3.912	5.869	8.803
3	9	2.047	3.275	4.912	7.369	1.784	2.855	4.282	6.424
2	6	1.258	2.012	3.019	4.528	1.1	1.76	2.639	3.959
1	3	0.502	0.803	1.205	1.807	0.432	0.692	1.038	1.556

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B. Time Period and Acceleration

Table 4 : Comparisons Acceleration values for particular time period of all 20 storey building Models

		In SpecX direction				In SpecY direction			
Mode	Period	Model 1 ZoneII	Model 2 ZoneIII	Model 3 ZoneIV	Model 4 ZoneV	Model 1 ZoneII	Model 2 ZoneIII	Model 3 ZoneIV	Model 4 ZoneV
	(sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)
1	1.989	115.11	184.18	276.27	414.41	93.73	150.05	225.07	337.61
2	1.812	126.39	202.22	303.33	454.99	102.91	164.74	247.11	370.67
3	1.491	154.18	246.68	370.02	555.03	125.54	200.97	301.45	452.17
4	0.616	385.04	616.06	924.09	1386.14	313.52	501.89	752.84	1129.26
5	0.566	411.87	658.99	988.49	1482.74	335.37	536.87	805.3	1207.96
6	0.487	420.63	673	1009.5	1514.25	342.5	548.28	822.42	1233.63
7	0.331	420.63	673	1009.5	1514.25	342.5	548.28	822.42	1233.63
8	0.307	420.63	673	1009.5	1514.25	342.5	548.28	822.42	1233.63
9	0.281	420.63	673	1009.5	1514.25	342.5	548.28	822.42	1233.63
10	0.229	420.63	673	1009.5	1514.25	342.5	548.28	822.42	1233.63
11	0.212	420.63	673	1009.5	1514.25	342.5	548.28	822.42	1233.63
12	0.196	420.63	673	1009.5	1514.25	342.5	548.28	822.42	1233.63

Table 5 : Comparisons Acceleration values for particular time period of all 15 storey building Models

		In SpecX direction				In SpecY direction			
Mode	Period	Model 5 ZoneII	Model 6 ZoneIII	Model 7 ZoneIV	Model 8 ZoneV	Model 5 ZoneII	Model 6 ZoneIII	Model 7 ZoneIV	Model 8 ZoneV
	(sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)
1	1.372	166.42	266.27	399.41	599.11	134.25	214.8	322.2	483.3
2	1.272	179.9	287.83	431.75	647.63	145.12	232.19	348.29	522.43
3	1.094	209.8	335.68	503.52	755.28	169.24	270.79	406.18	609.28
4	0.436	418.5	669.6	1004.4	1506.6	337.6	540.16	810.24	1215.36
5	0.404	418.5	669.6	1004.4	1506.6	337.6	540.16	810.24	1215.36
6	0.357	418.5	669.6	1004.4	1506.6	337.6	540.16	810.24	1215.36
7	0.24	418.5	669.6	1004.4	1506.6	337.6	540.16	810.24	1215.36
8	0.223	418.5	669.6	1004.4	1506.6	337.6	540.16	810.24	1215.36
9	0.205	418.5	669.6	1004.4	1506.6	337.6	540.16	810.24	1215.36
10	0.166	418.5	669.6	1004.4	1506.6	337.6	540.16	810.24	1215.36
11	0.154	418.5	669.6	1004.4	1506.6	337.6	540.16	810.24	1215.36
12	0.142	418.5	669.6	1004.4	1506.6	337.6	540.16	810.24	1215.36

Table 6 : Comparisons Acceleration values for particular time period of all 10 storey building Models

		In SpecX direction				In SpecY direction			
Mode	Period	Model 9 ZoneII	Model 10 ZoneIII	Model 11 ZoneIV	Model 12 ZoneV	Model 9 ZoneII	Model 10 ZoneIII	Model 11 ZoneIV	Model 12 ZoneV
	(sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)	(mm/sq sec)
1	0.845	259.68	415.48	623.23	934.84	208.11	332.97	499.46	749.19
2	0.79	277.26	443.61	665.42	998.13	222.2	355.52	533.28	799.91
3	0.706	320.07	512.11	768.16	1152.25	256.51	410.41	615.62	923.42
4	0.272	399.95	639.92	959.88	1439.82	320.53	512.84	769.26	1153.89
5	0.253	399.95	639.92	959.88	1439.82	320.53	512.84	769.26	1153.89
6	0.229	399.95	639.92	959.88	1439.82	320.53	512.84	769.26	1153.89
7	0.153	399.95	639.92	959.88	1439.82	320.53	512.84	769.26	1153.89
8	0.142	399.95	639.92	959.88	1439.82	320.53	512.84	769.26	1153.89
9	0.131	399.95	639.92	959.88	1439.82	320.53	512.84	769.26	1153.89
10	0.105	399.95	639.92	959.88	1439.82	320.53	512.84	769.26	1153.89
11	0.098	394.82	631.71	947.56	1421.34	316.41	506.26	759.39	1139.08
12	0.09	375.86	601.37	902.05	1353.08	301.22	481.94	722.92	1084.38

C. Base Shear

Table 7: Base Shear of 20 story building

Model	SpecX (KN)	SpecY (KN)
Model 1 ZoneII	1069.46	807.9942
Model 2 ZoneIII	1711.1359	1293.4512
Model 3 ZoneIV	2566.7039	1940.1768
Model 4 ZoneV	3850.0558	2910.2652

Table 8: Base Shear of 15 story building

Model	SpecX (KN)	SpecY (KN)
Model 5 ZoneII	1062.4599	803.104
Model 6 ZoneIII	1699.9358	1284.9664
Model 7 ZoneIV	2549.9037	1927.4496
Model 8 ZoneV	3824.8555	2891.1745

Table 9: Base Shear of 10 story building

Model	SpecX (KN)	SpecY (KN)
Model 9 ZoneII	1048.4227	792.3965
Model 10 ZoneIII	1677.4764	1267.8344
Model 11 ZoneIV	2516.2146	1901.7516
Model 12 ZoneV	3774.3219	2852.6274

IV. CONCLUSION

In the present study, the main factors constitute the seismic load have been studied and dynamic analyses results for same structural systems with various zone factors are compared using in IS 1893 (Part 1):2002.Codes. To illustrate the various seismic parameters governing the seismic forces on the building, analytical study is carried out using the modernized structural engineering software package ETABS for structural systems and the similarities and differences are presented for all considered model. The presented approach enables engineers to understand the codal provisions given in IS 1893 (Part 1):2002 in relative to another and the influence of zone factor on the effect of seismic forces are discussed when the same building to be located in different regions. From overall study following conclusion has been made,

A. In case of 20-Story building models (i.e. Model 1 Zone II, Model 2 Zone III, Model 3 Zone IV & Model 4 Zone V) and 15-Story building models (i.e. Model 5 Zone II, Model 6 Zone III, Model 7 Zone IV & Model 8 Zone V) and similarly 10-Story building models (i.e. Model 9 Zone II, Model 10 Zone III, Model 11 Zone IV & Model 12 Zone V) of lateral displacement is increasing nearly 53.33% (average) in ascending order for building which is like different seismic intensity in both Spec X and Spec Y cases.

B. Acceleration values are obtained at top in first mode and it increases with increasing seismic intensity of zones with time interval. This increasing acceleration values are nearly 50% to 60% more than below one zone for all considered models. The energy (vibrations) gets dissipated after getting transferred up to full length of structure hence the top portion has maximum acceleration.

C. The acceleration can be affected by the natural period of the building, or a complete oscillation, which is dependent on the building stiffness.

D. Time Period increases as the height of the building increases because mass of the overall building increases as time period is directly proportional to the mass.

E. A quantitative comparison of the base shear for four zones is presented. However their seismic performance during the seismic events will vary. Although the four zones have different attributes.

F. The structures located in the seismic zones should be analyzed and designed for the expected seismic force to minimize the structural damages from falling of beams/columns and to protect lives and property. Seismic zoning is used to reduce the human and economic losses caused by earthquakes, thereby enhancing Economic development and Political stability.

G. The losses due to damaging earthquakes can be mitigated through a comprehensive assessment of seismic hazard and risk. Seismic zonation of vulnerable areas for bedrock motion thus becomes important so that the planners and administrators can make use of it after applying appropriate amplification factors to take into account, for better land use planning and safe development.

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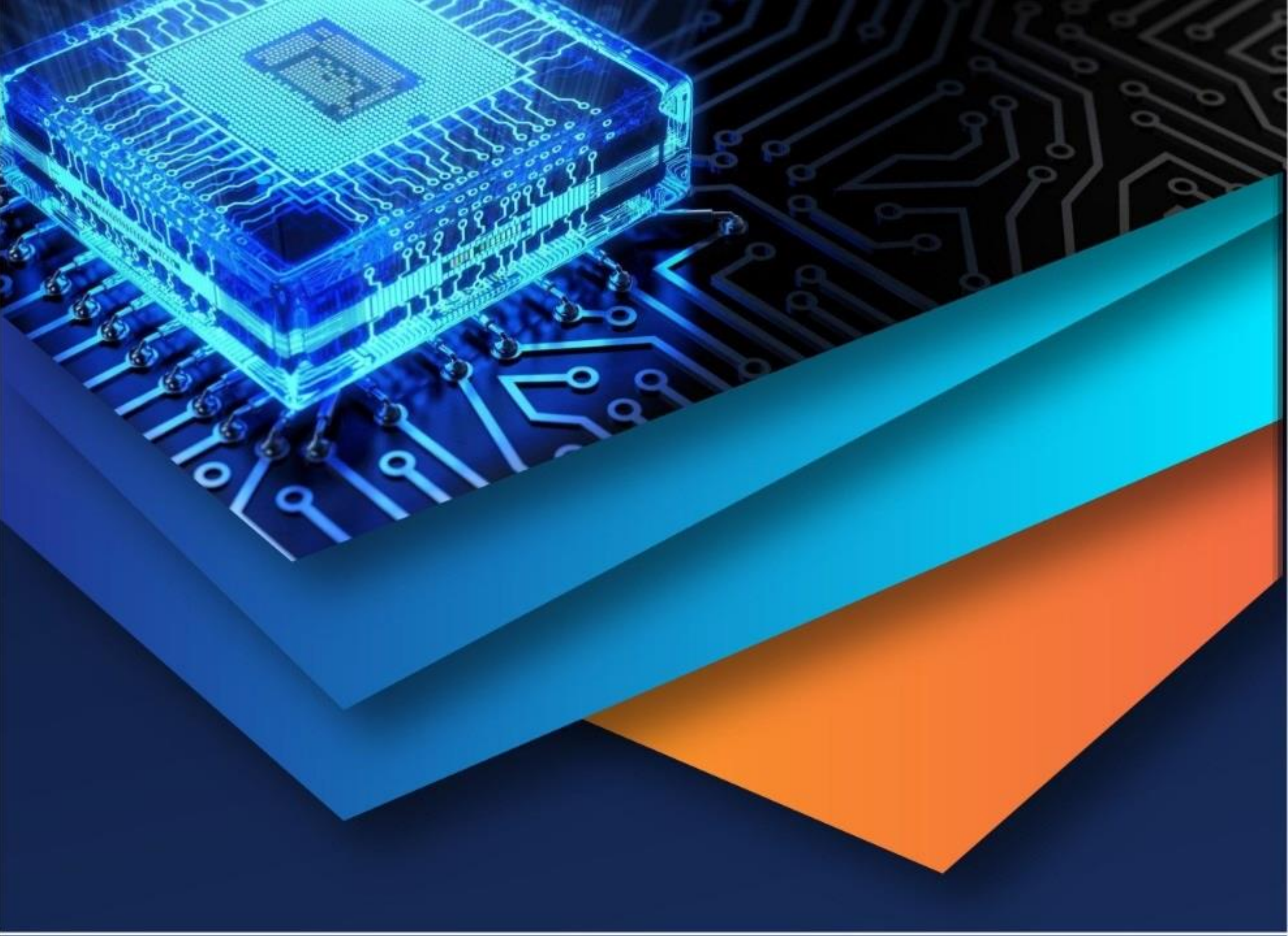

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