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Comparison of Equivalent Static Analysis and Response Spectrum Analysis on G+10 Storied Building in All Seismic Zones and Soil Types

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ABSTRACT: Earthquakes are the most unpredictable and dangerous of all natural disasters, which severely effect our engineering properties and life. Hence in order to overcome this problem we need to determine the seismic performance of the built environment through the development of various analytical procedures, which help the structures to withstand during frequent minor earthquakes and produce enough caution whenever subjected to major earthquake events so that it can save as many lives as possible. Analysing G+10 storied building using Linear static and linear dynamic methods in all seismic zones and soil types by varying the buildings L/B ratio using staad.pro. The parameters considered are base shear. How will this parameters going to vary in Equivalent static analysis and Response spectrum analysis.

KEY WORDS*:* Base shear, Story drift, Equivalent static analysis, Response spectrum analysis, Staad software

I.INTRODUCTION

Earthquake is a sudden movement of earth crust ,which originates naturally at or below the surface of crust. The study of earthquakes is called seismology .The instrument used for measuring the intensity of earthquake is called seismograph. The earthquake occur at shallow depths (2-8km) are mostly small .The occurrence of earthquake with magnitude greater than 6 is rare. About 90% of all earthquakes result from tectonic events, primarily movements on the faults. The remaining is related to volcanism, collapse of subterranean cavities or manmade effects. Tectonic earthquakes are triggered when the accumulated strain exceeds the shearing strength of rocks. Elastic rebound theory gives the physics behind earthquake genesis.

The seismic zoning map of India getting changed from then to now depending on the data obtained during an Earthquake. In past Indian map is divided into five zones (I, II, III, IV, V).In which zone I is completely safe from Earthquakes, Zone II low risk zone, zone III is moderate risk zone in which low frequency Earthquakes may occur, zone IV is high risk zone in which low to high frequency Earthquakes may occur, zone V is very high risk zone where Earthquake may occur of any frequency at any time. Later on, after experiencing lot of Earthquakes it is concluded that there is no such a region which is completely safe. So, seismic Zoning map of India got modified and zone I is removed. The present seismic zoning map used in India is divided into four zones (II, III, IV, V).

A. Seismic analysis of Building:

There are different methods of analysis which provide different degrees of accuracy.

B.**Equivalent static method:** It can only be used for regular structures with limited height.[1]Seismic analysis of most of the structures are still carried out on the basis of lateral force assumed to be equivalent to the actual loading.

C.Response spectrum analysis: [1]This method is applicable for those structures where modes other than the fundamental one affect significantly the response of the Structure. This method is more scientific than the Equivalent static method and is recommended by the Indian code for the design of building greater than 40m and up to 90m situated in all zones of India.

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 4, Issue 5 , May 2017

II. MODELLING IN STAAD

Staad.pro is a user friendly software because structures can be analysed and designed easily using this software which is created by Bently. In staad.pro we can develop building prototype as per the requirements of the client whether it is a simple or complex model. It offers the flexibility to design tunnels, culverts, bridges etc and it allows to design structure, extending limitation factors like displacement, modal participation factor, load, forces, bending moments, mode shapes, structural analysis.

The Equivalent static method and Response spectrum method in STAAD can be analysed in five steps

A. Geometric Modelling
B. Sectional properties and Material properties
C. Supports
D. Loads and load combinations
E. Analysis specification and design command

A. Geometric modelling:

In Geometric modelling the first step is to specify the nodal co-ordinates data followed by selection of elements. But now a days beam elements are selected to model the structure.

B.Sectional properties and Material properties:

After creating the geometry of the structure the next part is to assign section properties to the elements like assigning beam cross section for beams ,Thickness for plate elements etc. After assigning the sectional property it is important to assign material properties to the members, Material properties include modulus of elasticity, poisson's ratio, weight density, thermal coefficient, damping ratio and shear modulus.

C.Support and boundary condition:

After assigning the sectional and material properties, boundary condition is assigned to the structure in the form of fixed, hinged, roller support to the structure. For analysing my structure boundary condition used is fixed support.

D.Loads and load combinations:

Loads are a primary consideration in any building design because they define the nature and magnitudes of hazards are external forces that a building must resist to provide a reasonable performance (i.e., safety and serviceability) throughout the structure's useful life. The anticipated loads are influenced by a building's intended use (occupancy and function), configuration (size and shape) and location (climate and site conditions). Ultimately, the type and magnitude of design loads affect critical decisions such as material collection, construction details and architectural configuration. Thus, to optimize the value (i.e., performance versus economy) of the finished product, it is essential to apply design loads realistically. In the present project works following loads are considered for analysis. (i) **Dead Loads (IS- 875 PART 1).** (ii) **Live Loads (IS 875 PART 2).** (iii) **Earthquake Loads by SCM (IS 1893:2002)** In addition to the above mentioned loads, dynamic loads in form of Response Spectrum method can also be assigned. STAAD also uses IS 1893 – 2002 (Part 1) parameters mentioned below to evaluate seismic output parameters in form of design seismic coefficient, base shear storey shear and mass participation factor. 1. Seismic Zone Coefficient 2. Response Reduction Factor 3. Importance Factor 4. Soil Site Factor 5. Type of Structure 6. Damping Ratio (obtain Multiplication Factor for Sa/g) 7. Depth of Foundation below Ground Level In the present study above mentioned parameters are kept constant and discussed in the seismic analysis results.

E.Analysis specification and design command:

[2]After assigning the loads to the structure, analysis is done to evaluate the shear force bending moment and dynamic results in form of base shear, storey drift and lateral forces. After analysis design can be executed in STAAD as it includes various international codes and the structure can be designed using these codes. After following above mentioned steps the results obtained from the study are summarized in below part.

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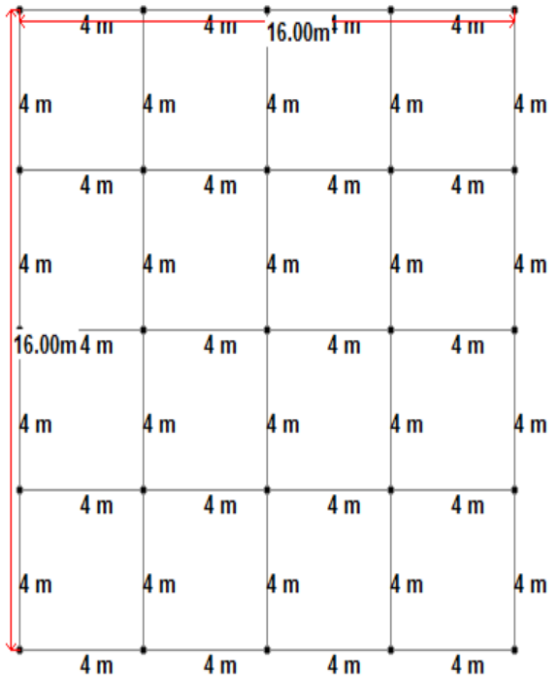
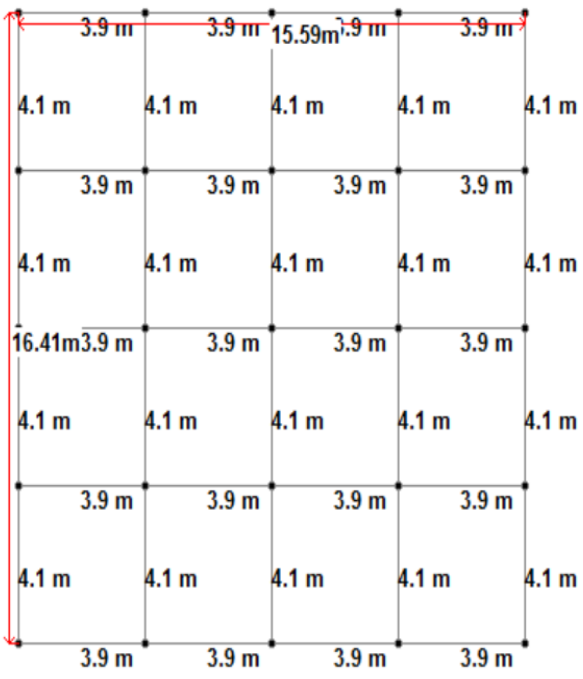
Vol. 4, Issue 5 , May 2017

III. RESULTS OF SEISMIC ANALYSIS IN STAAD

Using STAAD software building plan area of 256m^2,but changing its L/B ratios from 1.0 to 0.75 having plan area 16m x 16m, 16.415m x15.594m,16.865m x 15.178m, 17.354m x 14.751m, 17.888m x 14.310m, 18.475m x 13.856m as shown in below figure 2 respectively.



L/B Ratio 1.0

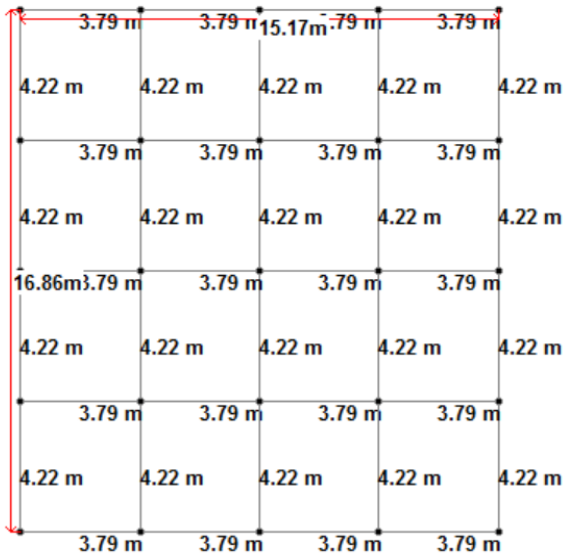


L/B Ratio 0.95

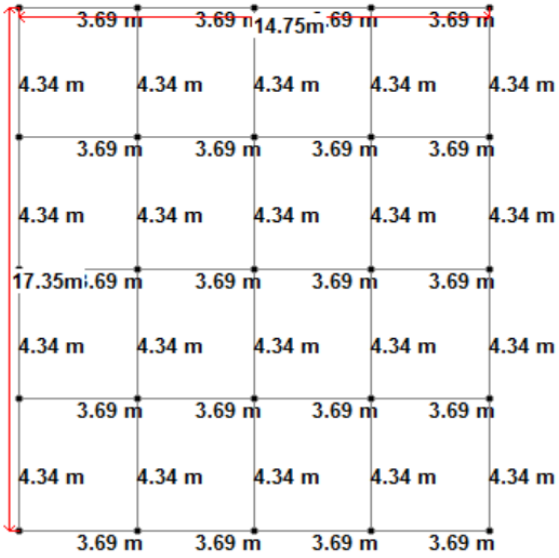
ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

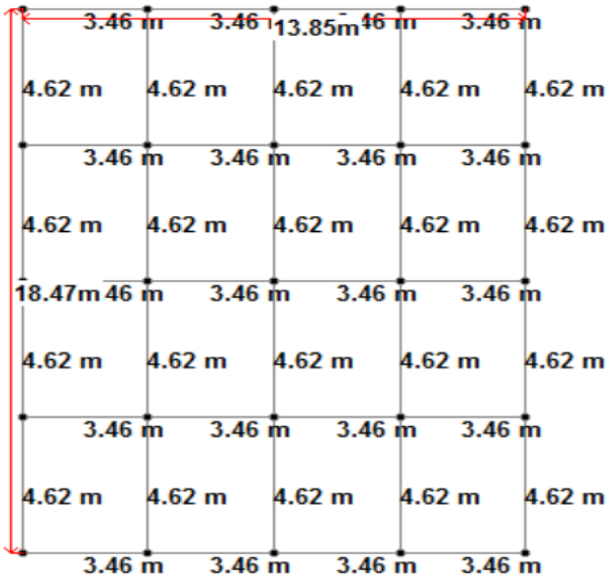
Vol. 4, Issue 5 , May 2017



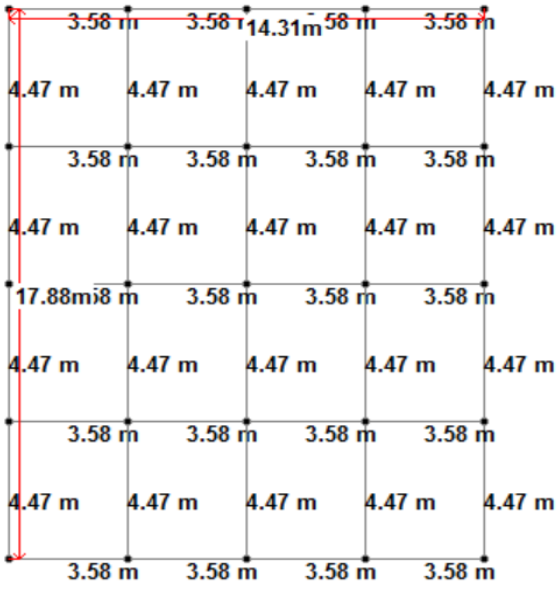
L/B Ratio 0.9



L/B Ratio 0.85



L/B Ratio 0.8



L/B Ratio 0.75

Fig.1 L/B Ratios of G+10 storied building

ISSN: 2350-0328
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Vol. 4, Issue 5 , May 2017

Structure	Member properties	Size B x D (mm)
1-2	Beams Columns	230 x 400 450 x 500
3-4	Beams Columns	230 x 400 450 x 450
5-8	Beams Columns	230 x 400 400 x 400
9-11	Beams Columns	230 x 400 350 x 400

Table 1 Geometrical and section properties of G+11 stored building

Seismic Load Parameters	Value
1. Zone Factor	0.1,0.16,0.24,0.36
2. Reaponse Reduction factor	5
3. Importance factor	1
4. Type of soil strata	1(Hard), 2(Medium), 3(Soft)
5. Damping	5%

Table 2 Seismic load parameters

Load calculations:
A.Dead Load

Self weight of slab
Thickness of slab = 0.12m
Density of concrete= 25 KN/m^3
Self weight of slab = Density of concrete x Thickness of slab
= 25 x 0.12
= 3KN/m^2
Floor finish at floor level = 1KN/m^2
Total slab weight at floor level = 4KN/m^2

Wall load calculation:
Width of the outer wall=150mm
Width of the inner wall=115mm
Beam size=300x450mm
Height of floor =3m
Wall Weight (outer) = Thickness of wall x Height of wall x Density of brick wall
= 0.23 x 3 x 20
= 13.8kN/m

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 4, Issue 5 , May 2017

Wall Weight (inner) = Thickness of wall x Height of wall x Density of brick wall
= 0.115 x 3 x 20
= 6.9kN/m

B. Live load:

Floor load:

Live Load Intensity specified = 4 kN/m^2

Half of live load is considered for imposed uniformly distributed loads above 3 KN/m^2 as per IS 1893(Part 1) : 2002 = 2 KN/m^2

L/B Ratio	Type of zone	Type of soil	Base shear value For Equivalent static analysis in X and Z directions (KN)		Base shear value for Response spectrum analysis (KN)		% Difference	
			X	Z	X	Z	x	z
1	II	Hard Med soft	387.369 531.60 651.110	387.369 531.60 651.110	142.55 193.87 238.06	143.19 194.74 239.13	171.743 174.206 173.507	170.528 174.980 172.283
	III	Hard Med Soft	622.264 848.916 1038.48	622.264 848.916 1038.48	228.08 310.19 380.9	229.1 311.58 382.6	172.827 173.676 172.638	171.612 172.455 171.427
	IV	Hard Med Soft	935.456 1269.254 1561.84	935.456 1269.254 1561.84	342.12 465.29 571.35	343.66 467.37 573.91	173.429 172.787 173.359	172.204 171.574 172.141
	V	Hard Med Soft	1401.124 1908.002 2340.702	1401.124 1908.002 2340.702	513.19 697.93 857.02	515.49 701.06 860.86	173.022 173.380 173.121	171.804 172.159 171.902
0.95	II	Hard Med soft	387.265 531.459 650.935	387.265 531.459 650.935	143.56 195.25 239.75	142.12 193.29 237.34	169.758 172.194 171.505	172.491 174.954 174.262
	III	Hard Med Soft	622.096 848.687 1038.20	622.096 848.687 1038.20	229.7 312.39 383.6	227.4 309.26 379.75	170.829 171.675 170.646	173.569 174.425 173.391
	IV	Hard Med Soft	935.204 1268.911 1561.420	935.204 1268.911 1561.420	344.55 468.59 575.4	341.09 463.89 569.63	171.427 170.793 171.362	174.181 173.537 174.111
	V	Hard Med Soft	1400.764 1907.487 2340.071	1400.764 1907.487 2340.071	516.83 702.89 863.1	511.64 695.83 854.44	171.026 171.377 171.124	173.775 174.131 173.871
0.9	II	Hard Med soft	387.408 531.655 651.175	387.408 531.655 651.175	144.66 196.74 241.59	141.07 191.85 235.59	167.805 170.232 169.537	174.621 177.120 176.401
	III	Hard Med Soft	622.325 849.0 1038.583	622.325 849.0 1038.583	231.46 314.79 386.54	225.71 306.97 376.94	168.869 169.703 168.687	175.719 176.574 175.53

ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 4, Issue 5 , May 2017

	IV	Hard Med Soft	935.549 1269.379 1561.996	935.549 1269.379 1561.996	347.2 472.19 579.82	338.57 460.45 565.41	169.455 168.828 169.392	176.324 175.682 176.259
	V	Hard Med Soft	1401.263 1908.190 2340.983	1401.263 1908.190 2340.983	520.79 708.28 869.72	507.84 690.68 848.11	169.064 169.411 169.165	175.920 176.277 176.023
0.85	II	Hard Med soft	387.926 532.36 652.047	387.926 532.36 652.047	145.82 198.31 243.51	139.88 190.23 233.6	166.031 168.452 167.770	177.328 179.854 179.129
	III	Hard Med Soft	623.158 850.137 1039.973	623.158 850.137 1039.973	233.3 317.29 379.62	223.81 304.38 373.76	167.106 167.936 166.920	178.432 179.301 178.246
	IV	Hard Med Soft	936.801 1271.079 1564.087	936.801 1271.079 1564.087	349.96 475.94 584.43	335.71 456.56 560.63	167.688 167.067 167.626	179.051 178.404 178.987
	V	Hard Med Soft	1403.139 1910.745 2344.067	1403.139 1910.745 2344.067	524.94 713.91 876.64	503.56 684.84 840.95	167.295 167.645 167.392	178.643 179.006 178.740
0.8	II	Hard Med soft	388.446 533.080 652.920	388.446 533.080 652.920	147.03 199.96 245.54	138.67 188.58 231.57	164.195 166.593 165.912	180.122 182.681 181.953
	III	Hard Med Soft	623.993 851.276 1041.36	623.993 851.276 1041.36	235.25 319.94 392.87	221.86 301.74 370.51	165.247 166.073 165.066	181.256 182.123 181.063
	IV	Hard Med Soft	938.057 1275.277 1566.187	938.057 1275.277 1566.187	352.87 479.91 589.3	332.8 452.6 555.77	165.836 165.212 165.770	181.868 181.216 181.804
	V	Hard Med Soft	1405.019 1913.305 2347.208	1405.019 1913.305 2347.208	529.31 719.86 883.95	499.2 678.91 833.66	165.43 165.788 165.536	181.454 181.820 181.554
0.75	II	Hard Med soft	389.208 534.126 654.20	389.208 534.126 654.20	148.33 201.73 247.72	137.41 186.87 229.47	162.393 164.77 164.088	183.245 185.827 185.092
	III	Hard Med Soft	652.217 852.945 1043.40	652.217 852.945 1043.40	237.33 322.77 396.35	219.85 299 367.15	163.437 164.257 163.254	184.384 185.266 184.191
	IV	Hard Med Soft	939.896 1275.277 1569.254	939.896 1275.277 1569.254	356 484.16 594.52	329.78 448.5 550.73	164.015 163.40 163.953	185.007 184.343 184.941
	V	Hard Med Soft	1407.774 1917.057 2351.810	1407.774 1917.057 2351.810	534 726.24 891.78	494.67 672.75 826.09	163.628 163.970 163.720	184.588 184.958 184.691

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Vol. 4, Issue 5 , May 2017

IV CONCLUSION

In this paper an attempt is made to compare the results obtained from Equivalent static method and Response spectrum method for a G+10 storied building by maintaining the same area but varying its L/B ratio(1.0, 0.95, 0.9, 0.85, 0.8, 0.75) in all seismic zones and soil types. The base shear value at each proportion in all zones and soil types is tabulated and percentage difference for both the methods is tabulated.

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