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Dynamic analysis of different vertical irregular RC building frames

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ABSTRACT: In present context various kind of vertical irregular building structures are constructed more than regular building structures which are dangerous from engineering point of view. So, it is necessary to analyse buildings with response spectrum analysis and time history analysis which are more accurate in data calculation. The main aim of the project to carry out response spectrum and time history analysis of the vertical irregular structures such as mass irregular structure, stiffness irregular structure and vertical geometric irregular structure and obtain different structural parameters such as base shear, storey shear, drift, displacement, modal time period and compare with regular structures. From the results, it is obtained that mass irregular structure shows more value of base shear value when compared to regular structure and stiffness irregular and vertical geometric irregular structure show less base shear than regular structure. Storey displacement and drift values of stiffness and vertical geometric irregular structures are greater than regular structure. Moreover, different structural parameters obtained from response spectrum analysis are lesser than time history analysis.

KEYWORDS: Response Spectrum Method, Time History Method, storey shear, storey displacement, storey drift, modal time period, base shear

I. INTRODUCTION

While an earthquake occurs, failure of structure begins at factors of weak point. This weakness starts because of irregular in mass, stiffness and geometry of structure. The structures having these irregularities are defined as irregular structures. Vertical irregularities are one of the causes of failures of structures in earthquake ground motion. Change in stiffness and mass provides the dynamic characteristics of these structures different from the 'regular' building. Irregular structures are more destructive than regular structures.

Response Spectrum Analysis

A response spectrum is a curve which is plotted between maximum response of single degree of freedom system which is subjected to a specified seismic motion and its frequency (or time period). This spectrum helps in obtaining peak structural responses (only when linear) it is also possible to find lateral forces developed in a building due to an earthquake, hence used for design of earthquake resistant structure.

Steps for obtaining response spectrum analysis in Etabs

- i) Define response spectrum functions
- ii) Choose function type
- iii) Assign seismic coefficients C_a and C_v
- iv) Assign damping ratio
 - v) This completes defining response spectra function
 - vi) Now define response spectrum cases
 - vii) In response spectrum cases assign damping ratio
- viii) Select type of model combination and Next select type of directional combination
- ix) To input response spectra is next step in which we have to calculate scale factor from following formula



Scale factor= $I g/2R$

Where, I=importance factor, g=acceleration due to gravity, R=response reduction factor and run analysis and obtain results.

Time history analysis

It is defined as an analysis in which for each increment of time dynamic response is analyzed, when the base is under seismic motion. For time history analysis previous earthquake data is required. This method is most widely used since it is applicable for all the regular and irregular buildings.

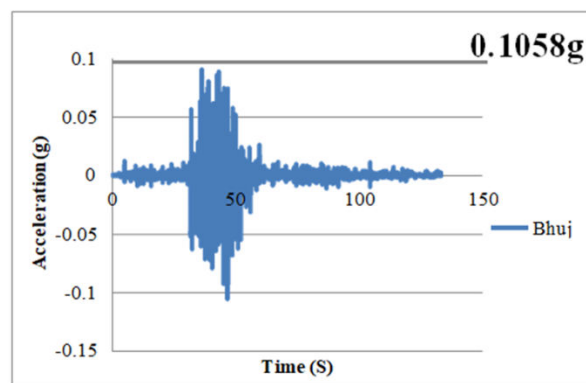


Fig 1: Input Time History Acceleration plot of a Bhuj Earthquake (2001)

II. OBJECTIVE OF THE STUDY

- i) To evaluate the Base Shear, storey shear, storey drift, storey displacement, modal time of regular structure with different vertical irregular structures by the use of RSA and THA.
- ii) To compare dynamic behaviour of vertical irregularities in structures namely mass, stiffness irregularities, vertical geometric irregularities etc.
- iii) To demonstrate the comparison results for dynamic analysis.

III. METHODOLOGY



IV. MODELLING AND ANALYSIS

The variation of seismic response of regular structure, mass irregular structure, stiffness irregular structure and vertical geometric irregular structure by using Response spectrum method and time history method. The comparison of various vertical irregularities with regular structure.



Table.4.1

Name of parameter	Value	Unit
Number of stories	13	Nos.
Height of Building	40.9	M
Floor to floor height	3.15	M
Length in x direction	28.8	M
Length in y direction	28	M
Size of the columns	450X600	MM
Size of the beams	300X600	MM
Thickness of external wall	0.23	M
Live load on slab	3.5	KN/M
Floor finish load	0.75	KN/M
Grade of concrete for column	M30	-
Grade of concrete for beam and slab	M25	
Density of concrete	25	KN/M3
Damping	5	%
Seismic Zone	V	-
Importance factor (I)	1	-
Response reduction factor	5	-
Soil type	Medium	-
Depth of slab	150	MM
Wall load	10.557	KN/M

MODELS ARE DESCRIBED AS BELOW:

Table.4.2

Model 1	Regular RC framed structure
Model 2	Vertically irregular RC structure with mass irregularity Weight of 6 th &13 th story=2*weight of adjacent stories)(increment of depth to 200mm with live load and floor load)
Model 3	Vertically irregular RC structure with stiffness irregularity (Soft storey)(zero wall load in 1 st storey)
Model 4	Vertically irregular RC structure with vertical Geometric irregularity

Building model

Model-1: Regular RC framed structure

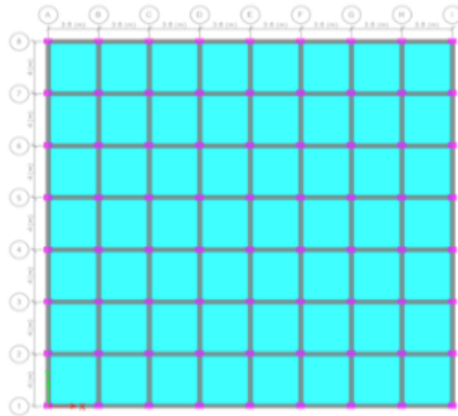


Fig 4.1: Plan view of the Model-1

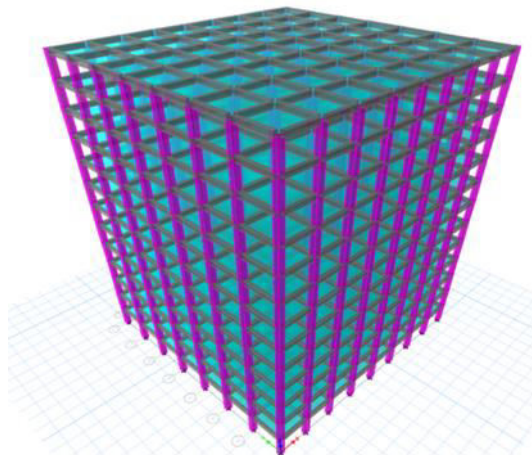


Fig 4.2: Isometric View of the Model-1

Model-2: Vertically irregular RC structure with mass irregularity

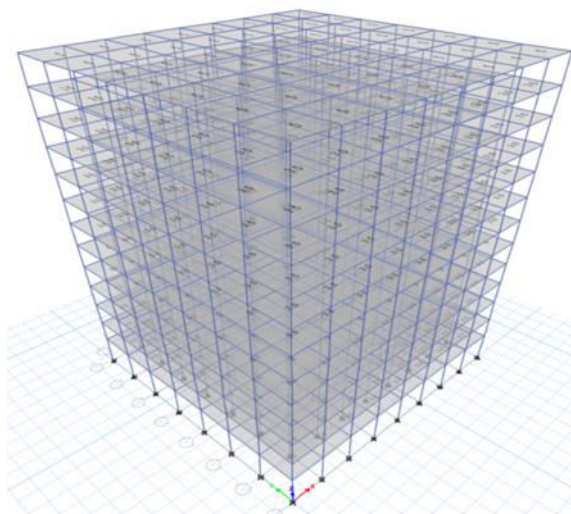


Fig 4.3: 3D View of the Model-2

Model-3: Vertically irregular RC structure with Stiffness irregularity

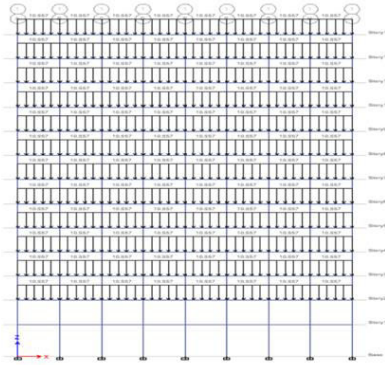


Fig 4.4: Elevation View of the Model-3

Model-4: Vertically irregular RC structure with vertical Geometric irregularity

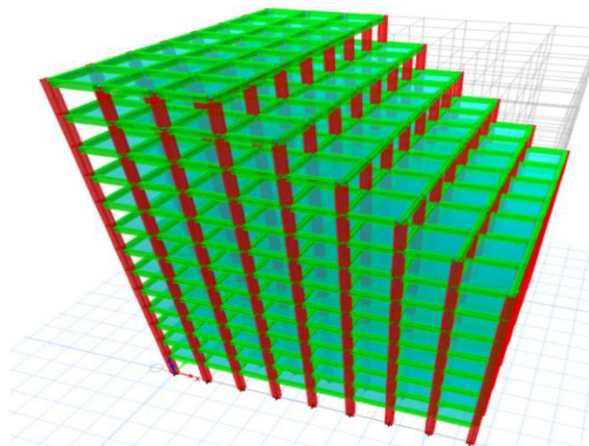


Fig 4.5: 3D View of the Model-4

V. RESULTS AND DISCUSSIONS

5.1 Mode Period

Table 5.1: Mode period

ModePeriod(sec)			
Models	Mode-1	Mode-2	Mode-3
Model-1	1.174 (Y-dir)	1.024 (X-dir)	1.002 (Torsion)
Model-2	1.194(X-dir)	1.041(Y-dir)	1.018 (Torsion)
Model-3	1.214 (X-dir)	1.075(Torsion)	1.005 (Y-dir)
Model-4	1.064(Y-dir)	0.886(X-dir)	0.805(Torsion)

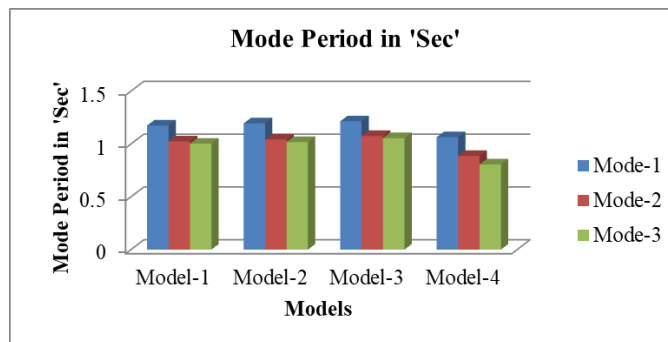


Fig.5.1: Mode Period of all the Models

5.2 Comparison of Storey displacement (mm) along X-X direction of Model-1 with model-2, Model-3 and Model-4 due to RSA and THA

Table 5.2: Storey Displacement in RSA and THA along X-X direction in 'mm'

Storey	Model-1		Model-2		Model-3		Model-4	
	RSA	THA	RSA	THA	RSA	THA	RSA	THA
Storey-13	16.59	60.85	16.90	58.58	17.45	68.06	17.70	69.72
Storey-12	16.21	59.17	16.49	56.89	17.07	66.32	17.25	68.27
Storey-11	15.62	56.57	15.87	54.34	16.50	63.62	16.61	66.17
Storey-10	14.83	53.11	15.05	51.04	15.73	60.08	15.80	63.35
Storey-9	13.85	48.99	14.04	47.15	14.78	55.88	14.84	59.81
Storey-8	12.68	44.36	12.86	42.82	13.65	51.21	13.72	55.54
Storey-7	11.36	39.31	11.52	38.54	12.37	46.12	12.43	50.49
Storey-6	9.90	33.91	10.04	33.88	10.95	40.59	10.93	44.53
Storey-5	8.30	28.21	8.42	28.57	9.40	34.61	9.25	37.77
Storey-4	6.60	22.26	6.69	22.76	7.74	28.27	7.40	30.31
Storey-3	4.81	16.10	4.87	16.58	5.98	21.67	5.42	22.51
Storey-2	2.96	9.87	3.00	10.20	4.15	14.92	3.36	14.09
Storey-1	1.17	3.88	1.18	4.02	2.26	8.07	1.34	5.63

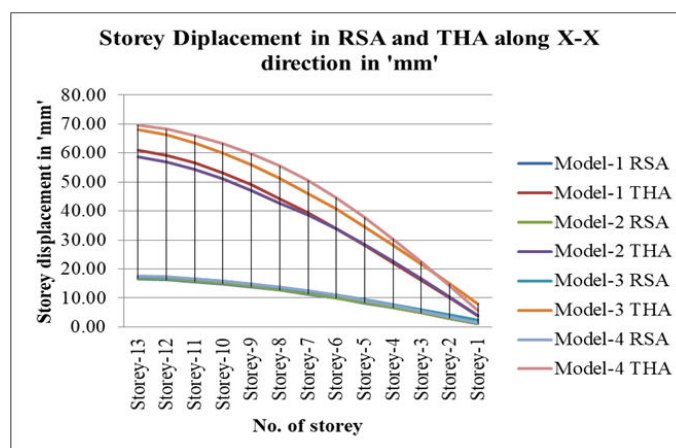


Fig 5.2: Storey displacement along X-X direction of all models due to RSA and THA



5.3 Comparison of Storey displacement (mm) along Y-Y direction of Model-1 with model-2, Model-3 and Model-4 due to RSA and THA

Table 5.3: Storey Displacement in RSA and THA along Y-Y direction in 'mm'

Storey	Model-1		Model-2		Model-3		Model-4	
	RSA	THA	RSA	THA	RSA	THA	RSA	THA
Storey-13	18.96	88.89	19.22	88.55	19.97	80.63	21.37	75.83
Storey-12	18.57	86.80	18.79	86.36	19.59	79.14	20.94	74.53
Storey-11	17.93	83.41	18.12	82.90	18.97	76.77	20.26	72.41
Storey-10	17.05	78.79	17.22	78.29	18.13	73.48	19.32	69.42
Storey-9	15.95	73.12	16.10	72.63	17.08	69.34	18.14	65.54
Storey-8	14.65	66.49	14.78	66.01	15.83	64.40	16.73	60.76
Storey-7	13.17	59.01	13.29	58.54	14.41	58.72	15.10	55.05
Storey-6	11.53	50.77	11.64	50.32	12.84	52.35	13.26	48.45
Storey-5	9.73	41.95	9.82	41.49	11.11	45.36	11.22	41.03
Storey-4	7.80	32.80	7.87	32.37	9.26	37.79	9.00	32.92
Storey-3	5.76	23.60	5.81	23.25	7.28	29.70	6.64	24.25
Storey-2	3.63	14.55	3.66	14.42	5.21	21.20	4.18	15.20
Storey-1	1.51	5.95	1.52	5.94	3.01	12.25	1.72	6.24

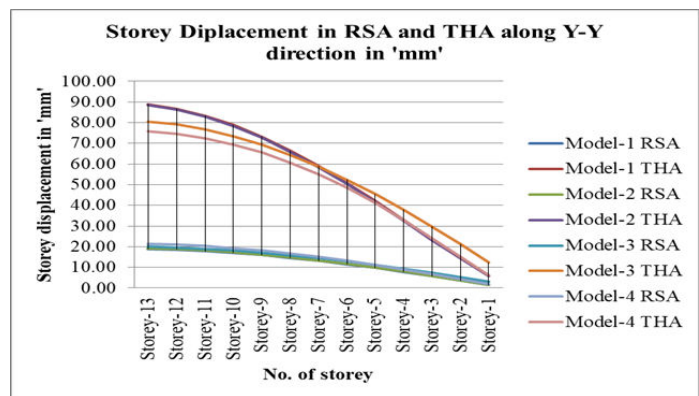


Fig 5.3: Storey displacement in mm along Y-Y direction of all models due to RSA and THA



5.4 Comparison of Storey Shear along X-X direction of Model-1 with Model-2, Model-3 and Model-4 due to RSA and THA

Table 5.4: Storey Shear in RSA and THA along X-X direction in 'kN'

Storey	Model-1		Model-2		Model-3		Model-4	
	RSA	THA	RSA	THA	RSA	THA	RSA	THA
Storey-13	457.580	1862.909	528.958	2117.322	436.162	1984.333	243.611	838.149
Storey-12	923.910	3778.552	983.486	3972.135	886.271	4074.455	552.238	1955.651
Storey-11	1324.921	5391.486	1373.363	5527.772	1278.129	5898.453	873.334	3147.701
Storey-10	1671.553	6669.266	1710.944	6703.862	1617.369	7384.328	1204.311	4368.285
Storey-9	1976.680	7650.931	2008.743	7485.702	1914.988	8492.583	1547.541	5926.420
Storey-8	2245.908	8566.720	2271.685	8354.269	2177.897	9253.015	1899.348	7624.608
Storey-7	2486.012	9350.598	2505.880	9105.216	2412.494	9789.147	2221.056	9228.915
Storey-6	2704.716	9862.006	2754.894	9951.988	2626.272	10341.497	2509.640	10640.789
Storey-5	2902.716	10229.966	2950.828	10677.152	2822.490	11018.046	2762.887	11781.795
Storey-4	3076.512	10596.480	3121.672	11136.555	2999.419	11674.524	2977.160	12672.474
Storey-3	3222.682	10963.115	3264.978	11383.669	3154.193	12194.869	3150.291	13474.359
Storey-2	3329.575	11232.788	3369.656	11534.803	3279.599	12590.972	3272.390	14157.120
Storey-1	3377.650	11365.844	3416.667	11618.279	3361.376	12827.998	3326.075	14478.973

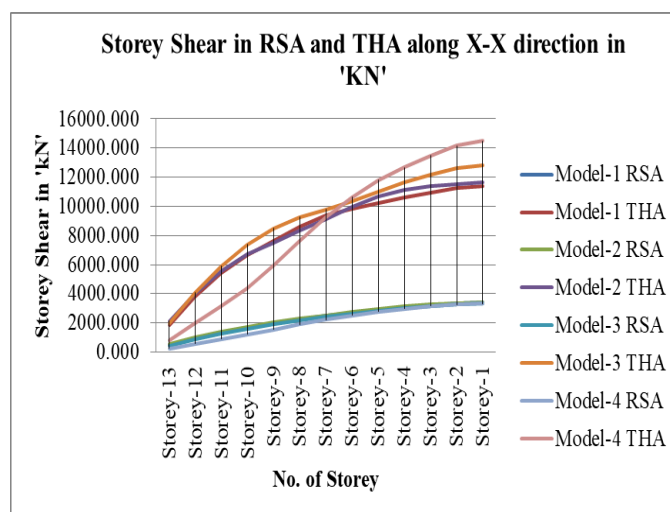


Fig 5.4: Storey shear along X-X direction of all models due to RSA and THA



5.5 Comparison of Storey Shear along Y-Y direction of Model-1with Model-2, Model-3 and Model-4 due to RSA and THA

Table 5.5: Storey Shear in RSA and THA along Y-Y direction in 'KN'

Storey	Model-1		Model-2		Model-3		Model-4	
	RSA	THA	RSA	THA	RSA	THA	RSA	THA
Storey-13	417.51	1833.32	481.57	2054.64	392.25	1434.70	206.04	827.29
Storey-12	840.32	3746.12	891.85	3867.00	796.07	2958.28	466.53	1880.37
Storey-11	1196.82	5417.43	1236.26	5452.99	1142.91	4321.58	727.73	2945.20
Storey-10	1497.79	6861.87	1527.26	6849.98	1436.95	5609.37	981.45	3968.12
Storey-9	1757.88	8157.69	1779.24	8156.63	1689.56	6807.35	1230.65	4933.51
Storey-8	1984.44	9376.68	1998.87	9370.51	1909.19	7985.01	1474.68	5874.19
Storey-7	2185.84	10483.66	2193.77	10418.91	2103.74	9257.42	1695.34	6840.11
Storey-6	2371.76	11366.83	2404.52	11366.30	2282.27	10450.20	1895.13	7829.30
Storey-5	2544.41	11910.89	2575.00	11850.98	2449.84	11452.45	2074.53	8699.49
Storey-4	2700.78	12082.76	2728.22	12082.16	2605.96	12186.83	2231.10	9366.36
Storey-3	2837.74	11977.68	2862.18	12507.38	2748.25	12653.24	2365.03	9807.18
Storey-2	2943.21	11904.49	2965.33	12780.17	2869.91	12923.21	2468.05	10042.03
Storey-1	2994.11	12017.03	3015.05	12895.19	2956.04	13070.87	2518.14	10549.67

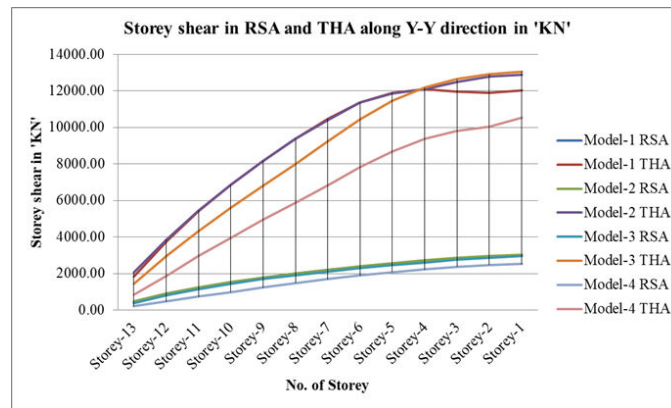


Fig 5.5: Storey shear along Y-Y direction of all models due to RSA and THA



5.6 Comparisons of Storey drift along X-X direction of Model-1 with Model-2, Model-3 and Model-4 due to RSA and THA

Table 5.6: Storey Drift in RSA and THA along X-X direction

Storey	Model-1		Model-2		Model-3		Model-4	
	RSA	THA	RSA	THA	RSA	THA	RSA	THA
Storey-13	0.00013	0.00013	0.00014	0.00014	0.00013	0.00013	0.00016	0.00016
Storey-12	0.00021	0.00084	0.00022	0.00086	0.00020	0.00092	0.00023	0.00099
Storey-11	0.00028	0.00112	0.00029	0.00113	0.00027	0.00123	0.00029	0.00123
Storey-10	0.00034	0.00135	0.00035	0.00133	0.00033	0.00149	0.00033	0.00137
Storey-9	0.00039	0.00152	0.00040	0.00147	0.00038	0.00169	0.00038	0.00147
Storey-8	0.00044	0.00165	0.00045	0.00157	0.00043	0.00182	0.00043	0.00170
Storey-7	0.00048	0.00175	0.00049	0.00167	0.00047	0.00191	0.00049	0.00195
Storey-6	0.00052	0.00183	0.00052	0.00178	0.00050	0.00199	0.00054	0.00215
Storey-5	0.00055	0.00190	0.00056	0.00189	0.00054	0.00207	0.00059	0.00238
Storey-4	0.00057	0.00195	0.00058	0.00198	0.00056	0.00212	0.00063	0.00256
Storey-3	0.000587	0.00198	0.000595	0.00203	0.00058	0.00215	0.00066	0.00268
Storey-2	0.00057	0.00191	0.00058	0.00197	0.00060	0.00218	0.00064	0.00269
Storey-1	0.00037	0.00123	0.00038	0.00128	0.00054	0.00192	0.00042	0.00179

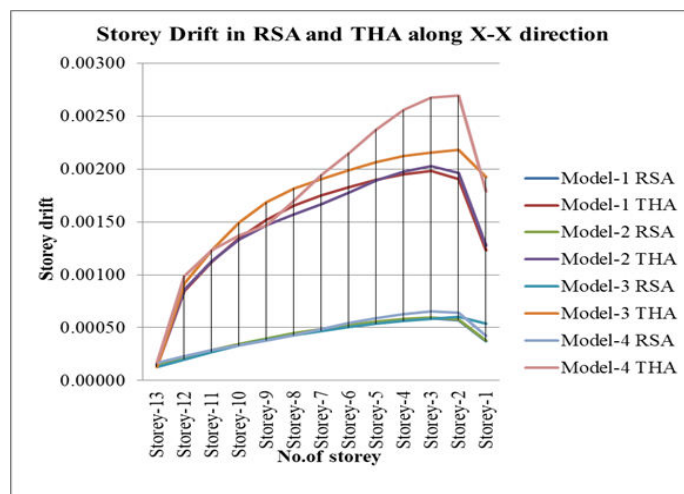


Fig 5.6: Storey drifts along X-X direction of all models due to RSA and THA



5.7 Comparison of Storey drifts along Y-Y direction of Model-1 with Model-2, Model-3 and Model-4 due to RSA and THA

Table 5.7: Storey drift in RSA and THA along Y-Y direction

Storey	Model-1		Model-2		Model-3		Model-4	
	RSA	THA	RSA	THA	RSA	THA	RSA	THA
Storey-13	0.00014	0.00014	0.00016	0.00016	0.00014	0.00014	0.00015	0.00015
Storey-12	0.00023	0.00108	0.00025	0.00110	0.00023	0.00086	0.00025	0.00103
Storey-11	0.00032	0.00146	0.00033	0.00147	0.00031	0.00118	0.00034	0.00138
Storey-10	0.00039	0.00180	0.00040	0.00180	0.00038	0.00148	0.00041	0.00166
Storey-9	0.00045	0.00210	0.00045	0.00210	0.00043	0.00175	0.00048	0.00189
Storey-8	0.00050	0.00238	0.00051	0.00237	0.00048	0.00198	0.00055	0.00207
Storey-7	0.00055	0.00262	0.00055	0.00261	0.00053	0.00215	0.00061	0.00222
Storey-6	0.00059	0.00281	0.00059	0.00280	0.00057	0.00227	0.00066	0.00237
Storey-5	0.00062	0.00291	0.00063	0.00290	0.00060	0.00242	0.00071	0.00258
Storey-4	0.00065	0.00293	0.00066	0.00291	0.00063	0.00257	0.00075	0.00275
Storey-3	0.000677	0.00288	0.000683	0.00284	0.00066	0.00270	0.000784	0.00287
Storey-2	0.000676	0.00274	0.000681	0.00270	0.00070	0.00285	0.000781	0.00285
Storey-1	0.00048	0.00189	0.00048	0.00189	0.00072	0.00292	0.00055	0.00198

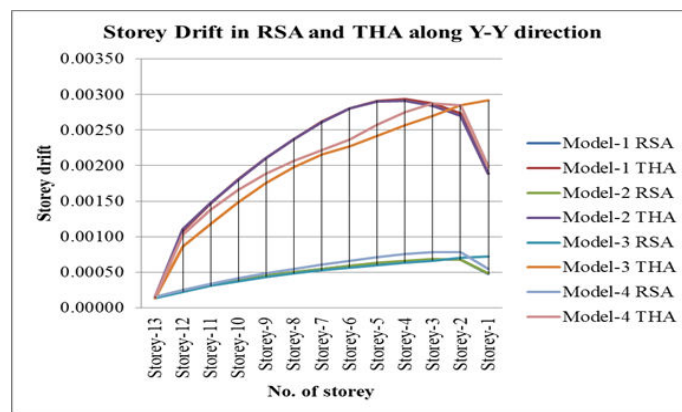


Fig 5.7: Storey drifts along Y-Y direction of all models due to RSA and THA



5.8 Comparison of Base shear along X-X direction of Model-1 with Model-2, Model-3 and Model-4 due to RSA and THA

Table 5.8: Base shear in RSA and THA along X-X direction

Base Shear along X-X direction (KN)		
Models	Response spectrum	Time History
Model-1	3377.65	11365.84
Model-2	3416.667	11618.28
Model-3	3361.376	12828
Model-4	3326.075	14478.97

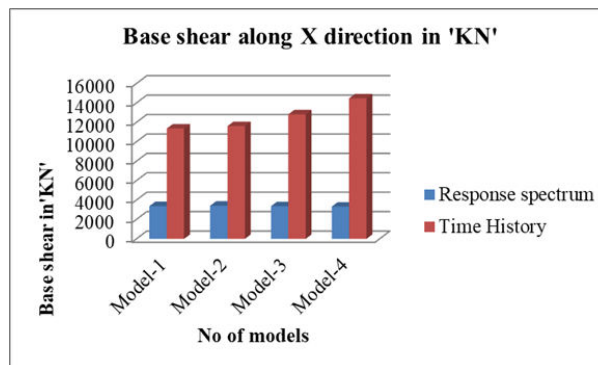


Fig 5.8: Base shear X-X direction of all models due to RSA and THA

5.9 Comparison of Base shear along Y-Y direction of Model-1 with Model-2, Model-3 and Model-4 due to RSA and THA

Table 5.9: Base shear in RSA and THA along Y-Y direction

Base Shear along Y-Y direction (KN)		
Models	Response spectrum	Time History
Model-1	2994.10757	12017.03
Model-2	3015.046	12895.19
Model-3	2956.04164	13070.87
Model-4	2518.14201	10549.67

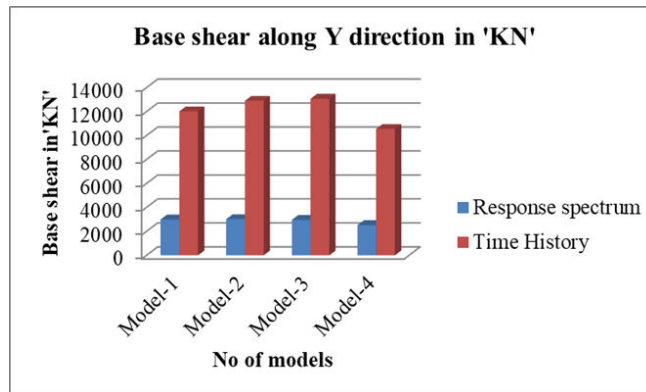


Fig 5.9: Base shear Y-Y direction of all models due to RSA and THA

VI. CONCLUSION

i) Mode period

It is found that in Model-3 and Model-2, the mode period is more compare to Model-1 but less in Model-4. In Model-2, the mode period is increased by 1.7% as compared to Model-1, the mode period of Model-3 is increased by 3.4% as compared to Model-1, and the mode period of Model-4 is decreased by 9.3% as compared to Model-1.

ii) Storey Shear

Storey shear goes on decrease with increase in number of storeys or storey level. In this dynamic analysis, it has been found that Model-4, Model-3 shows lesser storey shear as compared to Model-1 in both X-X and Y-Y direction and Model-2 shows higher value as compared to Model-1 in RSA.

iii) Storey Displacement

The storey displacement in Model-4 is maximum when compare to Model-1, both along X-X and Y-Y direction due to RSA. The value of maximum top storey displacement for Model-2 is increased by 2% as compared to maximum top storey displacement of Model-1. The value of maximum top storey displacement for Model 3 is increased by 5.18% as compared to maximum top storey displacement Model-1. The value of maximum top storey displacement for Model-4 is increased by 6.72% as compared to max top storey displacement Model-1.

The storey displacement in Model-4 is maximum when compare to Model-1, both along X-X and Y-Y direction due to THA. The value of maximum top story displacement of Model-2 is decreased by 3.72% as compared to maximum top story displacement of Model-1. The value of maximum top story displacement of Model-3 is increased by 11.8% as compared to maximum top story displacement of Model-1. The value of maximum top story displacement of Model-4 is increased by 14.57% as compared to maximum top story displacement of Model-1.

It is found that in all the models, the storey displacement are increasing from storey-1 to Storey-13. It is observed that the storey displacement will decrease as the weight of the structure increases.

iv) Storey Drift

The storey drift in Model-4 is maximum when compare to Model-1 both along X-X and Y-Y direction due to RSA. The value of maximum drift value for Model-2 is increased by 1.3% as compared to maximum drift value for Model-1. The value of max drift value for Model-3 is increased by 1.7% as compared to max drift value for Model-1. The value of maximum drift value for Model-4 is increased by 11.75% as compared to max drift value for Model-1.

The storey drift in Model-4 is maximum when compare to Model-1 both along X-X and Y-Y direction due to THA. The value of maximum story drift of Model-2 is increased by 0.89% as compared to story drift of Model-1. The value of maximum story drift of Model-3 is increased by 0.48% as compared to story drift of Model-1. The maximum story drift of Model-4 is increased by 2.02% as compared to story drift of Model-1. It is found that in all the models, the storey drift is increasing from storey-1 to Storey-3 and decreasing to story-13.

v) Base Shear

It has been found that the maximum base shear in Model-2 along longitudinal and transverse directions as compared to Model-1 as lesser in Model-3 and Model- 4 in RSA.



In dynamic analysis it has been found that the value of base shear for Model-2 is increased by 1.15% as compared to base shear of Model-1. The value of base shear for Model-3 has decreased by 0.5% as compared to base shear of Model-1. The value of base shear for Model-3 is decreased by 1.53% as compared to base shear of Model-1 in RSA.

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