UNDERSTANDING BI-DIRECTIONAL EARTHQUAKE IMPACTS ON PODIUM STRUCTURE DESIGN

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ABSTRACT

In this time situation the space requirement is the major problem in every city which results into the congestion of structures and also they are very dangerous whenever lateral forces for example earthquake forces are experienced by the structures. To ensure safety against seismic forces for podium structure hence, there is need to study of seismic analysis to design earthquake resistance structures. We considered the podium type building of 15 storied structures for the seismic analysis and it is located in zone II, III, IV, V. Different earthquakes Time Histories applied at various angles like 10°, 20°, 30°, 40°, etc and most severe analysis will be study for each cases. In this topic we compared the different shape of podium type building. In the present study time histories of the different locations in India is specified such as Bhuj, Chamoli, Uttarkashi, etc. The models were analyzed using structural software for building analysis SAP 2000 software. Response Spectrum analysis, time history method of podium building will be carried out in SAP 2000 software. This topic was analyzed the Indian standard code IS: 1893-2016.

Keywords: *Static analysis, Response spectrum analysis, Time history analysis, Podium structure*.

I. INTRODUCTION

Nowadays population was a major problem and is increasing day by day, thus resulting in construction of more vertical housing due to shortage of land. There are new innovative architectural techniques are used in high rise buildings and in mega tall structures with the advanced and powerful structural analysis. Podiums are augmented floor area at the lower level of a high rise building which are common in metropolitan areas in regions of low-to-moderate seismicity. Podium was the multi-tasking structures in which large variation in plan and elevation was seen. Among various construction forms, medium/high-rise building constructed with podium structure is a popular engineering scenario, by which a large open space for commercial uses, for instances, car parking, shopping arcade, restaurants or hotel lobbies, at ground level can be achieved. Podium building is very beneficial type of building in terms of residential as well as commercial. In podium type building up to 3 or 4 floors commercial shops are constructed and after third or fourth floor plan area is reduced and residential flats are constructed. Earthquake is a common disastrous phenomenon that each and every structure on earth may suffer to certain damage. Thus the safety of people and contents is assured in earthquake resistant design of buildings, and there by disaster is avoided.One of the biggest challenges of a structural engineer is to design an earthquake resistant building in seismic region.

II. MODELING AND ANALYSIS

Three dimensional space frame analysis is carried out for five different configurations of buildings under the action of seismic load. In the first case, podium structure is considered at centre as shown in fig.1, second case, podium structure is considered on upper side(+Y direction) as shown in fig.2, third case, podium structure is considered on down side(-Y direction) as shown in fig.3, fourth case, podium structure is considered on right side(+X direction) as shown in fig.4 and fifth case, podium structure is considered on left side(-X direction) as shown in fig.5, Buildings have been analyzed for seismic loads including static and dynamic analysis. Dynamic response of these buildings, in terms of base shear, fundamental time period and top floor displacement is presented, and compared within the considered configuration as well as with other configurations.

The following data is been considered for the research work:

- The podium structure is considered for the present research work consist of 15 storied podium building which has beam size of podium building 250X500mm, column size for the commercial building 1st to 3rd floor 450X450 mm and residential building 4th to 15th floor 400X400 mm, slab 125mm, grade of concrete 20Mpa, grade of steel 415. The plan (24mX24m) of podium building and it changes according to the Shape of building.

- The dead load is 1 kN/m^2, live load is 4 kN/m^2, storey height of the building is 4m also response reduction factor is 5 and importance factor is 1. The static and dynamic analysis is carried out in SAP-2000 using the parameters for the design as per the IS: 1893-2016 for the zones-2, 3, 4 and 5.
- Time histories are also applied to the podium building such as Bhuj, Chamoli, Uttarkashi, etc. Comparison of parameters like base shear, roof displacement, column moment for static, response and time histories is been done in this research work.

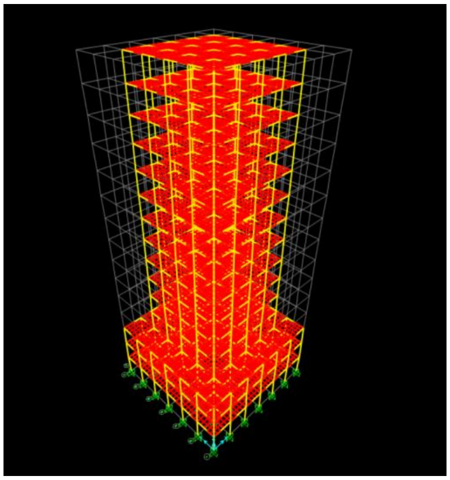


Fig 1 Center podium building

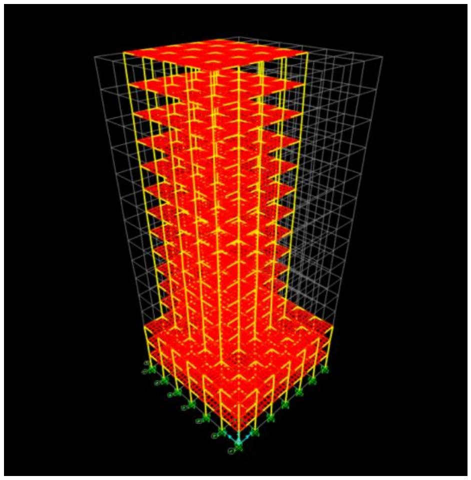


Fig 2 Upper (+Y) podium building

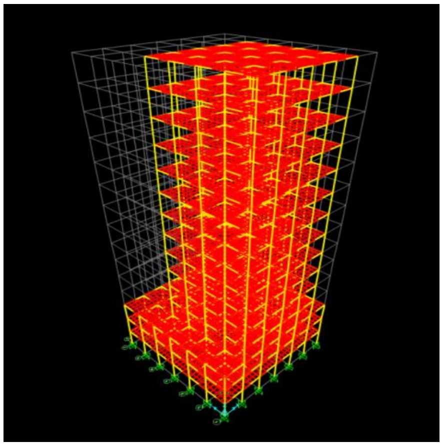


Fig 3 Down (-Y) podium building

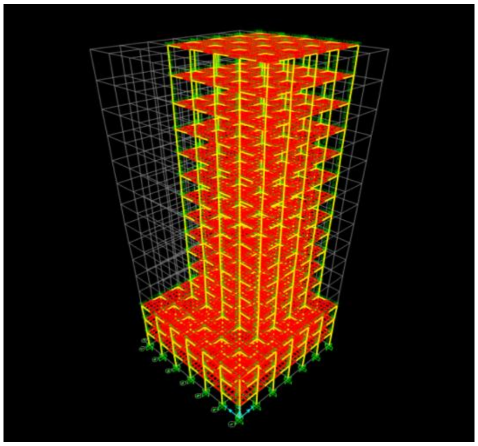


Fig 4 Right (+X) podium building

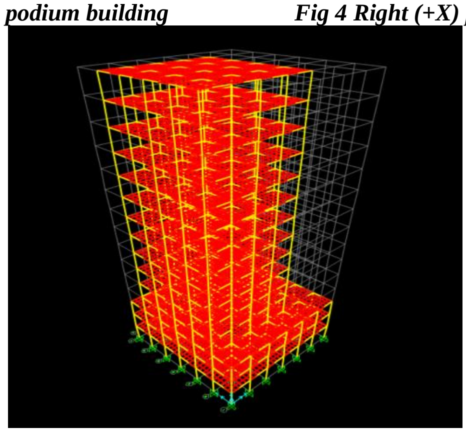
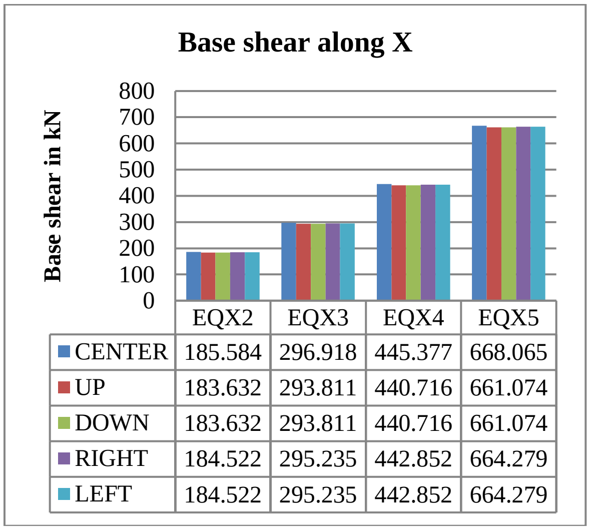


Fig 5 Left (-X) podium building

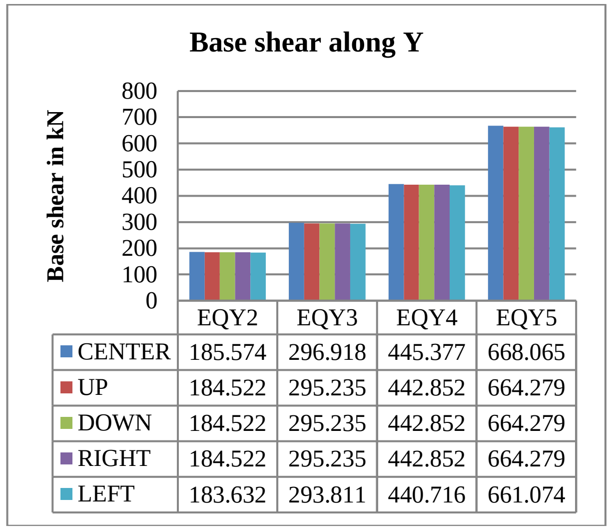
III. RESULTS AND DISCUSSION

The following are the results derived from the static, response and time history method.



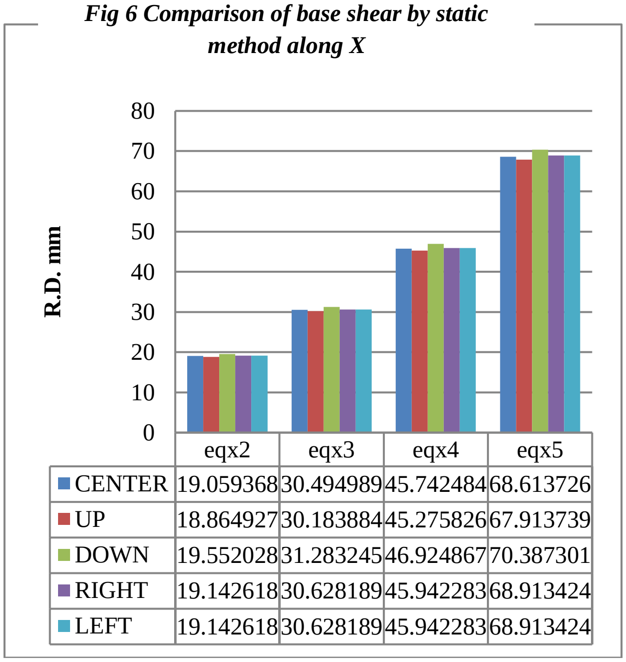
	EQX2	EQX3	EQX4	EQX5
CENTER	185.584	296.918	445.377	668.065
UP	183.632	293.811	440.716	661.074
DOWN	183.632	293.811	440.716	661.074
RIGHT	184.522	295.235	442.852	664.279
LEFT	184.522	295.235	442.852	664.279

Fig 6 Comparison of base shear by static method along X



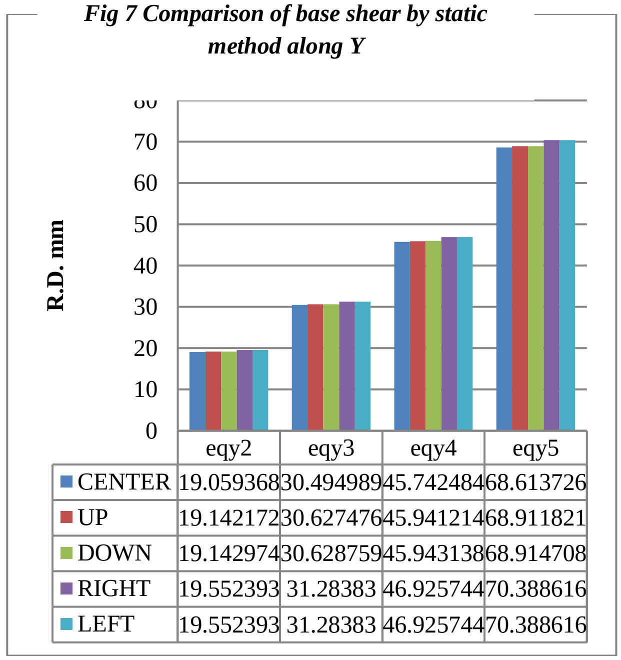
	EQY2	EQY3	EQY4	EQY5
CENTER	185.574	296.918	445.377	668.065
UP	184.522	295.235	442.852	664.279
DOWN	184.522	295.235	442.852	664.279
RIGHT	184.522	295.235	442.852	664.279
LEFT	183.632	293.811	440.716	661.074

Fig 7 Comparison of base shear by static method along Y



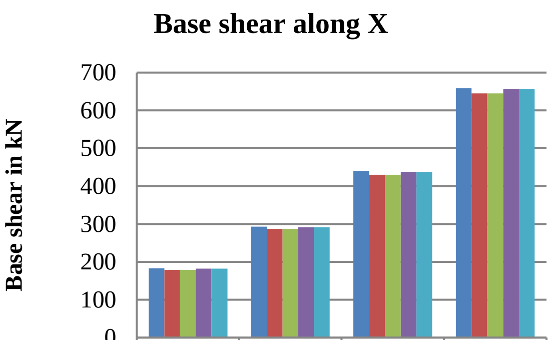
	eqx2	eqx3	eqx4	eqx5
CENTER	19.059368	30.494989	45.742484	68.613726
UP	18.864927	30.183884	45.275826	67.913739
DOWN	19.552028	31.283245	46.924867	70.387301
RIGHT	19.142618	30.628189	45.942283	68.913424
LEFT	19.142618	30.628189	45.942283	68.913424

Fig 8 Comparison of Roof displacement by static method along X



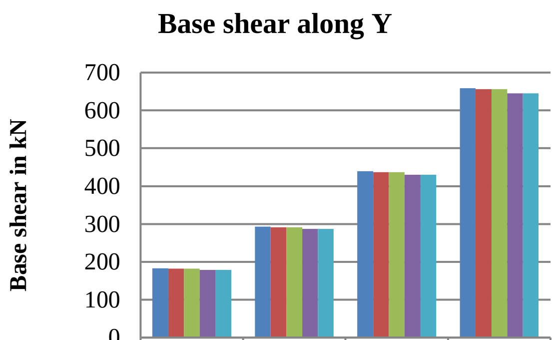
	eqy2	eqy3	eqy4	eqy5
CENTER	19.059368	30.494989	45.742484	68.613726
UP	19.14217	30.627476	45.941214	68.911821
DOWN	19.142974	30.628759	45.943138	68.914708
RIGHT	19.552393	31.28383	46.925744	70.388616
LEFT	19.552393	31.28383	46.925744	70.388616

Fig 9 Comparison of Roof displacement by static method along Y



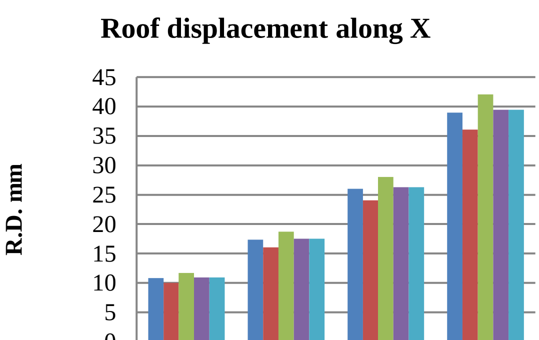
	RES2	RES3	RES4	RES5
CENTER	182.928	292.811	439.177	658.768
UP	179.11	286.69	430.051	645.019
DOWN	179.11	286.69	430.051	645.019
RIGHT	182.114	291.503	437.245	655.838
LEFT	182.114	291.503	437.245	655.838

Fig 10 Comparison of base shear by response method along X



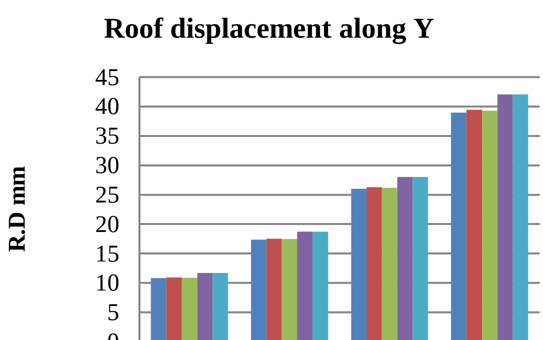
	RES2	RES3	RES4	RES5
CENTER	182.928	292.811	439.177	658.768
UP	182.114	291.503	437.245	655.838
DOWN	182.114	291.503	437.245	655.838
RIGHT	179.11	286.69	430.051	645.019
LEFT	179.11	286.69	430.051	645.019

Fig 11 Comparison of base shear by response method along Y



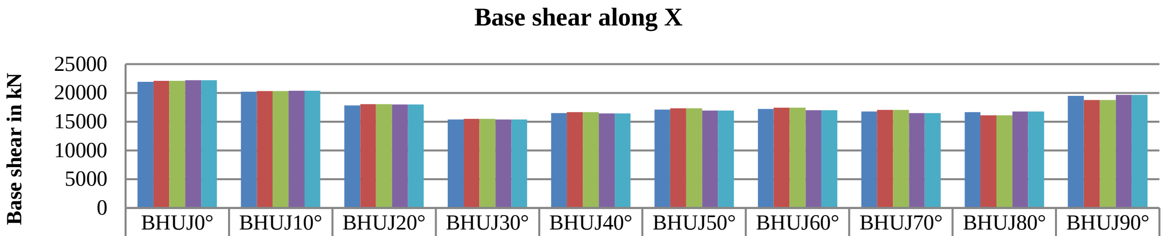
	RES2	RES3	RES4	RES5
CENTER	10.820343	17.329805	25.989265	38.984199
UP	10.015109	16.038806	24.058906	36.082497
DOWN	11.673341	18.694389	28.044531	42.057665
RIGHT	10.945868	17.530038	26.293479	39.436319
LEFT	10.945868	17.530038	26.293479	39.436319

Fig 12 Comparison of Roof displacement by response method along X



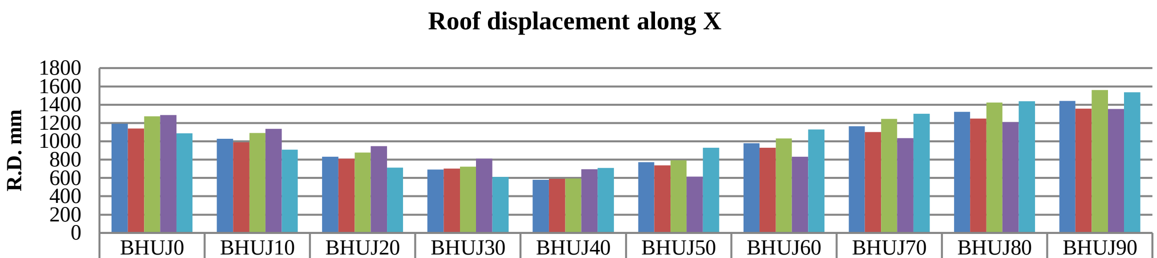
	RES2	RES3	RES4	RES5
CENTER	10.820343	17.329805	25.989265	38.984199
UP	10.945833	17.529982	26.293394	39.436191
DOWN	10.898713	17.454533	26.18042	39.266537
RIGHT	11.673556	18.694734	28.04505	42.058442
LEFT	11.673556	18.694734	28.04505	42.058442

Fig 13 Comparison of Roof displacement by response method along Y



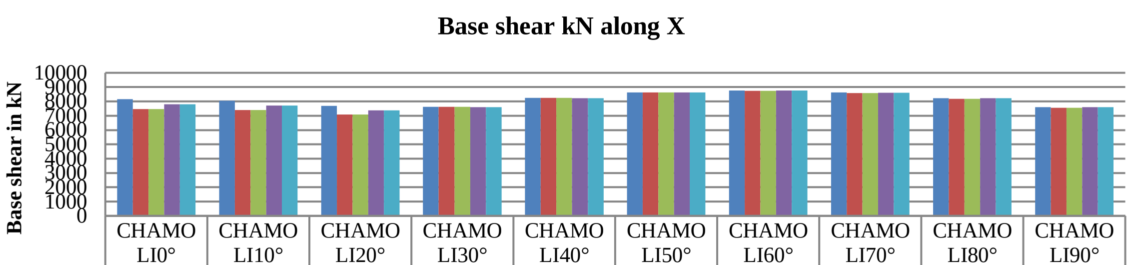
	BHUJ0°	BHUJ10°	BHUJ20°	BHUJ30°	BHUJ40°	BHUJ50°	BHUJ60°	BHUJ70°	BHUJ80°	BHUJ90°
CENTER	21926.391	20184.32	17848.195	15385.261	16494.388	17109.422	17204.983	16778.167	16651.705	19477.94
UP	22070.714	20335.851	18053.623	15504.513	16661.966	17313.686	17439.872	17036.69	16123.778	18766.807
DOWN	22070.712	20335.848	18053.62	15504.51	16661.963	17313.683	17439.869	17036.687	16123.775	18766.809
RIGHT	22208.76	20394.809	17968.918	15380.956	16416.277	16953.186	16975.367	16484.05	16776.015	19645.739
LEFT	22208.772	20394.821	17968.928	15380.964	16416.284	16953.19	16975.37	16484.052	16776.022	19645.747

Fig 14 Comparison of base shear by T.H method along X in Bhuj



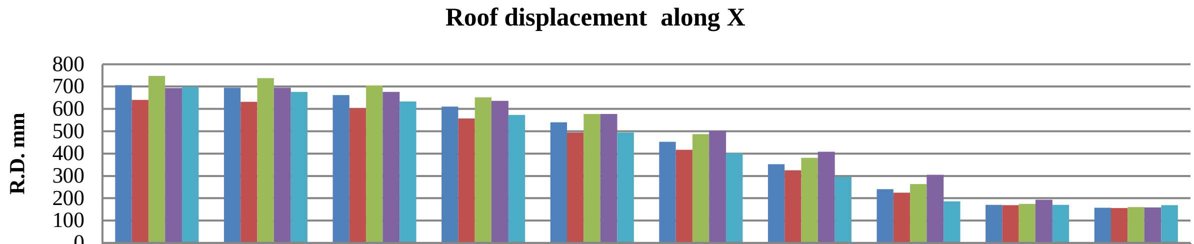
	BHUJ0	BHUJ10	BHUJ20	BHUJ30	BHUJ40	BHUJ50	BHUJ60	BHUJ70	BHUJ80	BHUJ90
Center	1193.9411	1028.802	832.76424	691.10298	578.44002	771.40461	977.43492	1163.3982	1320.6463	1441.6982
Up	1140.5805	989.43778	809.26033	700.69969	590.40948	736.13139	929.58298	1101.8671	1246.9449	1358.3698
Down	1273.5704	1091.5629	877.46784	724.65	594.08296	794.6854	1032.4319	1244.4994	1422.7467	1560.5008
Right	1286.7997	1135.0226	948.94915	812.04304	696.1653	614.71071	832.01992	1033.6912	1209.7221	1351.9142
Left	1086.7338	910.3764	712.61677	610.1897	709.5949	930.45105	1129.7133	1301.0676	1438.3382	1535.8914

Fig 15 Comparison of Roof displacement by T.H method along X in Bhuj



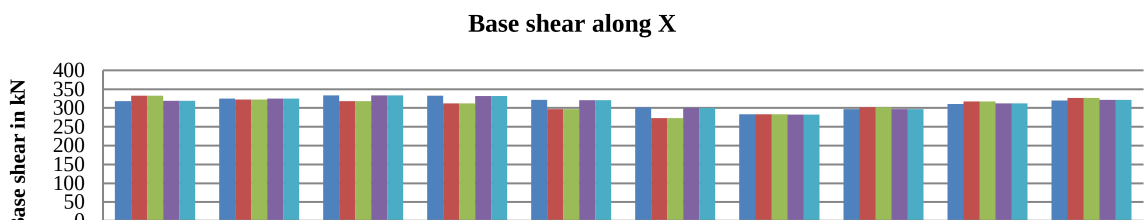
	CHAMOLI0°	CHAMOLI10°	CHAMOLI20°	CHAMOLI30°	CHAMOLI40°	CHAMOLI50°	CHAMOLI60°	CHAMOLI70°	CHAMOLI80°	CHAMOLI90°
Center	8148.104	8038.1	7683.571	7627.444	8258.366	8638.736	8766.75	8626.919	8232.854	7595.511
Up	7474.671	7393.702	7087.585	7617.742	8237.518	8617.924	8734.435	8587.754	8190.485	7547.05
Down	7474.671	7393.702	7087.585	7617.742	8237.517	8617.923	8734.433	8587.752	8190.483	7547.048
Right	7805.501	7709.543	7378.946	7596.991	8229.5	8621.433	8752.303	8615.8	8232.283	7597.704
Left	7805.501	7709.544	7378.946	7596.998	8229.506	8621.44	8752.309	8615.806	8232.289	7597.709

Fig 16 Comparison of base shear by T.H method along X in Chamoli



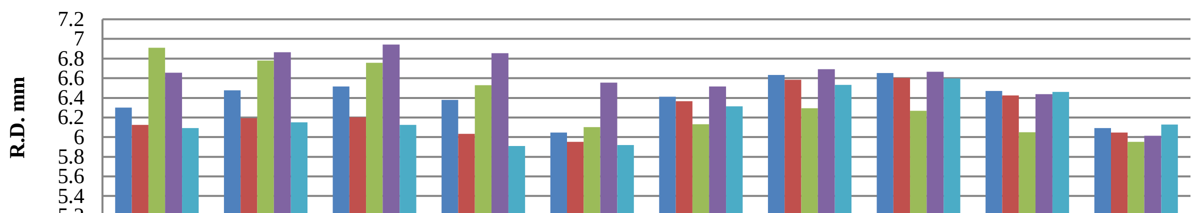
	CHAMOLI0	CHAMOLI10	CHAMOLI20	CHAMOLI30	CHAMOLI40	CHAMOLI50	CHAMOLI60	CHAMOLI70	CHAMOLI80	CHAMOLI90
Center	705.835832	694.763377	662.613724	610.361737	539.616382	452.552321	351.847719	240.749235	170.57775	157.657072
Up	640.68479	631.876952	603.926909	557.644297	494.492037	416.377238	325.732037	225.477925	169.716934	156.632392
Down	748.056542	737.966467	705.453653	651.575798	577.904536	486.761663	380.912017	263.709573	174.341371	160.261891
Right	693.546853	695.479109	676.279586	636.531649	577.457475	500.86937	409.06464	304.895768	192.984436	158.692183
Left	698.857635	676.593732	633.993128	572.433029	493.833434	400.811304	296.700553	186.297637	170.12794	169.341702

Fig 17 Comparison of Roof displacement by T.H method along X in Chamoli



	UTTARA KASHI0°	UTTARA KASHI10 °	UTTARA KASHI20 °	UTTARA KASHI30 °	UTTARA KASHI40 °	UTTARA KASHI50 °	UTTARA KASHI60 °	UTTARA KASHI70 °	UTTARA KASHI80 °	UTTARA KASHI90 °
Center	317.871	325.165	333.656	332.397	321.428	301.081	282.965	296.957	310.772	319.828
Up	332.355	322.277	318.055	312.059	296.969	273.245	283.26	301.65	317.226	326.344
Down	332.355	322.277	318.056	312.059	296.969	273.245	283.26	301.65	317.226	326.344
Right	319.024	324.861	333.093	331.593	320.406	299.873	282.545	297.122	312.521	321.606
Left	319.025	324.861	333.093	331.593	320.406	299.873	282.545	297.122	312.522	321.606

Fig 18 Comparison of base shear by T.H method along X in Uttarakshi



	UTTARA KASHI0	UTTARA KASHI10	UTTARA KASHI20	UTTARA KASHI30	UTTARA KASHI40	UTTARA KASHI50	UTTARA KASHI60	UTTARA KASHI70	UTTARA KASHI80	UTTARA KASHI90
Center	6.301532	6.476397	6.515438	6.378397	6.047551	6.411277	6.632788	6.652766	6.470602	6.091833
Up	6.124264	6.193487	6.204475	6.034188	5.951104	6.364447	6.58441	6.604308	6.423538	6.047592
Down	6.910572	6.780439	6.756893	6.528637	6.10201	6.131749	6.295613	6.268188	6.050308	5.952531
Right	6.655881	6.863851	6.944284	6.85362	6.554712	6.515359	6.692764	6.666814	6.438296	6.014153
Left	6.091764	6.150707	6.123528	5.910289	5.919005	6.313185	6.533587	6.597582	6.461113	6.128326

Fig 19 Comparison of Roof displacement by T.H method along X in Uttarakashi

IV. CONCLUSION

1. In static method value of base shear is almost same all building configuration.
2. In static method displacement measured at top node is same for all building configuration.
3. We are getting 5% to 10% variation in base shear and roof displacement by response spectrum method.
4. In Bhuj earthquake base shear is 10% higher for unsymmetrical building compared to symmetrical building and roof displacement is higher when earthquake is applied at 90 degree to building axis in all building configuration.
5. In Chamoli, time history base shear is 8 to 10 percentage higher when earthquake is applied at 60 degree to building axis in all building and roof displacement is higher when earthquake is applied at 0 degree to building axis in all building.
6. In Uttarakashi, time history base shear is 4 percentages higher when earthquake is applied at 20 degree to building axis in symmetrical building and roof displacement is higher when earthquake is applied at 60 and 70 degree to building axis in all building configuration.

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