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Comparative Study of Tune Mass Damper Building in Seismic Zone-II and Zone-V

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Abstract – *In many high-rise buildings, architectural requirements may result in a variable configuration for the vertical structural elements between the stories of the building. A Tuned mass damper (TMD) is a device consisting of a mass, and spring that is attached to a structure in order to reduce the dynamic response of the structure. The frequency of the damper is tuned to a particular structural frequency so that when that frequency is excited, the damper will resonate out of phase with the structural motion. To compared the high rise building with and without using tune mass damper having 5% of mass of the building at the top of the building floor. Analysis the building for response spectrum factor and find out the variable effects on both the modelled.*
Key Words: *High rise building, response spectrum analysis, Tune Mass Damper (TMD), Seismic zone, ETAB.*

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I. INTRODUCTION

Currently, high-rise buildings are commonly constructed for various uses and occupancy demands. A Tuned Mass Damper (TMD), also called a "harmonic absorber", is a device mounted to a specific location in a structure, so as to reduce the amplitude of vibration to an acceptable level whenever a strong lateral force such as an earthquake or high winds hit. There are two basic types of TMD; the Horizontal TMD which is normally found in slender buildings, communication towers, spires and the like. Tuned mass damper (TMD) is a relatively simple and efficient vibration-reduction device, consisting of a mass, stiffness elements (springs), and a damper. The types of dampers used in TMD devices include pneumatic or hydraulic dashpots, viscoelastic materials, and magnetic dampers (also referred to as eddy current dampers). As the machine or structure vibrates, the tuned mass damper vibrates at the same frequency but out of phase with the machine. The inertial force of the TMD reduces the vibrational energy transmitted to the machine and dissipates that energy as heat. The good thing about a TMD is that it can either be included during the initial concept design of a building to reduce the size of vertical or horizontal elements (provided strength requirements have been achieved) or as a retrofit to an existing structure where vibration and acceleration issues are determined. Some of the major considerations that should be carefully assessed are its location and effect to space allocation; and cost comparison with and without a TMD. Nowadays, TMD's are very much existent in every part of the world due to their notable efficiency and design flexibility.

II. Preliminary Data Considered for the Analysis:

Building Details-

1) 2-D details:-

- Plan Dimension : 26.65 X 22.17 m.
- Total Height of the building : 63 m
- Floor to Floor Height : 3 m

2) Codes used for analysis of the structure:-

- R.C.C. design : IS 456: 2000
- Earthquake design : IS1893: 2002
- Code for Dead load : IS875: Part 1
- Code for Live load : IS875: Part 2

3) *The basic Load considered for the Analysis*

- Slab depth: 125 mm thick : Assumed
- Live load in floor area : 2kN/sq. m

- Floor finish load :1.5 kN/ sq. m
- Wall thickness : 150 mm thick wall
- Stair case loading : 3 kN/sq. m
- Characteristic compressive strength of concrete, fck= 25 N/mm2
- Grade of steel: fy500
- Modulus elasticity of concrete: 5.5N/mm2
- Poison's ratio of concrete, μ=0.2
- Column Details

	Zone-II	Zone-V
Base to 6 th	300 X 600	300 X 600
7th to 13th story	300 X 530	300 X 530
14th to 20th story	300 X 450	300 X 450

- Beam Details

	Zone-II	Zone-V
Base to 6 th	300 X 600	300 X 600
7th to 13th story	300 X 530	300 X 530
14th to 20th story	300 X 450	300 X 450

- 3-D model for the static analysis and dynamic time history analysis of the building in E-TAB.

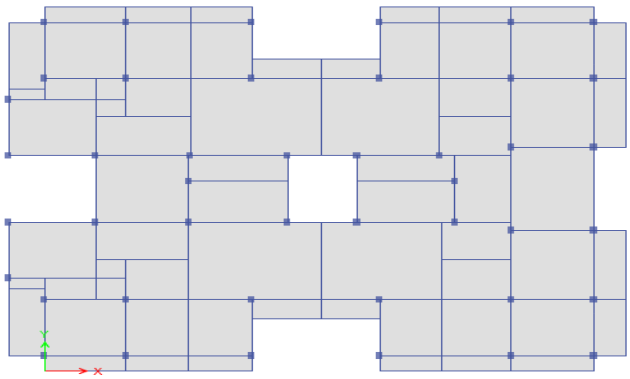


Fig 01: 2D the Plan of the Building

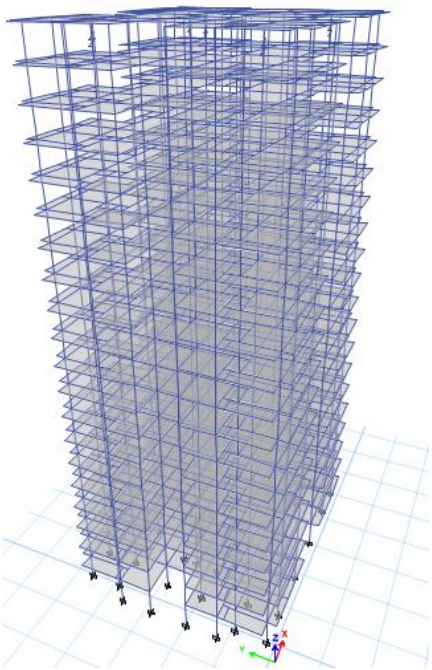


Fig 02: Shows the skeleton model and 3d view of the structure with TMD at top floor

4) Modelling with ETAB:-

5) *Earthquake parameters considered:-*
- Zone : II, V
- Soil Type : Type-2
- Importance factor : 3

6) wind parameters considered
- Basic wind speed for zone-II :47m/s
- Basic wind speed for zone-II :50m/s
- Terrain category : 2
- Important Factor : 1.00
- Risk coefficient K1 :1
- Topography K3 : 1

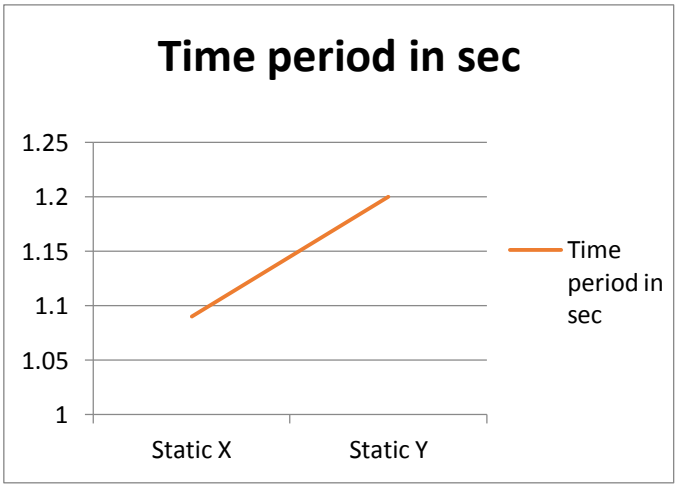
7) TMD Property:-
- Assume mass ratio = 5%
- Mass of damper = 1628802.972kN.
- Total number of dampers = 5.
- Mass of one damper = 325760.594 kN
- Frequency of the building, ω =0.8760541 rad/sec
- Stiffness of damper, Kd = 1190532 N/m
- Optimum damping ratio, ξd = 0.133
- The value of damping, Cd = 252.71 Ns2 /m.

III. RESULTS: -

3.1 Static Fundamental Time Period and Modal Time Period

Table 3.1: Static Fundamental time period of Primary RCC Structure, and Tuned Mass Damper: -

Case	Time period in sec
Static X	1.09
Static Y	1.2



3.1.2 Modal Time Period-

Table 3.2 - Modal Time Period for Mode-1, 2 and 3 for zone-II and zone-V

	With TMD		Without TMD	
Mode	Zone-II	Zone-V	Zone-II	Zone-V
1	5.292	5.301	4.979	4.979
2	4.65	4.66	4.357	4.357
3	3.845	3.854	3.663	3.663
4	1.769	1.78	1.68	1.68
5	1.549	1.562	1.467	1.467

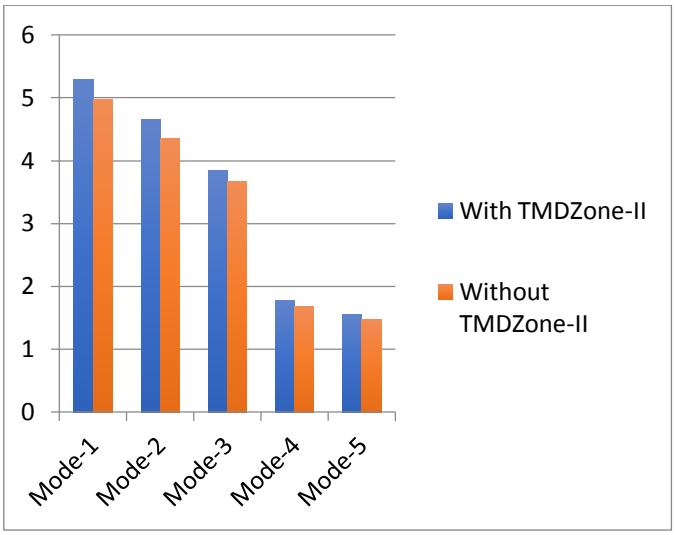
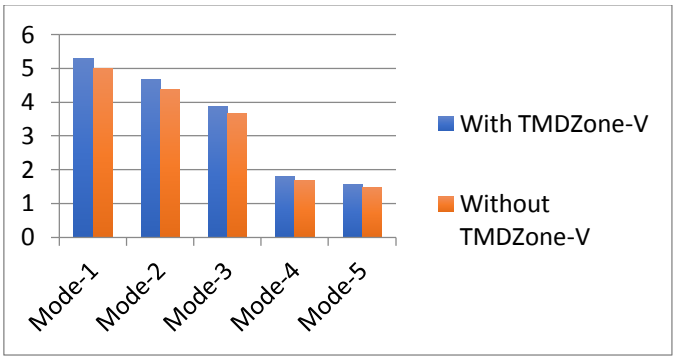


Fig 03 - Modal Time Period for Mode-1, 2 and 3 for zone-II

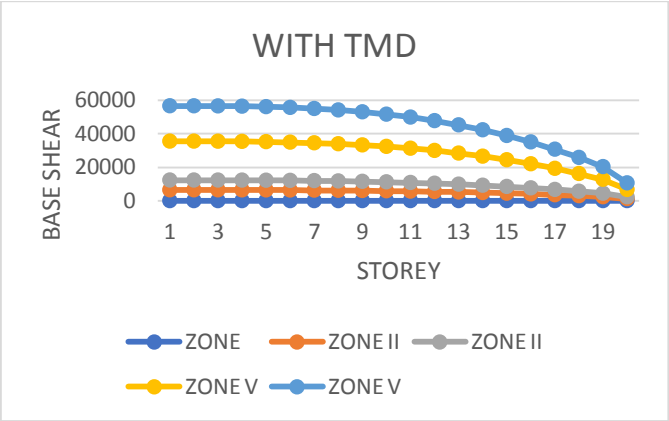


Graph 04- Modal Time Period for Mode-1, 2 and 3 for zone-V

3.3 Base shear Details:-

Table 3.3– Base shear Details for Static load Condition in X and Y Direction

	With TMD			
Base Shear	Zone-II		Zone-V	
Story	Static Ex	Static Ey	Static Ex	Static Ey
BASE	0	0	0	
1	6455.3117	5863.58	23239.1	21108.9
2	6453.2783	5861.73	23231.8	21102.2
3	6445.1443	5854.34	23202.5	21075.6
4	6426.843	5837.72	23136.6	21015.8
5	6394.3073	5808.16	23019.5	20909.4
6	6343.4703	5761.99	22836.5	20743.1
7	6270.2651	5695.49	22573	20503.8
8	6170.6245	5604.98	22214.2	20177.9
9	6043.4083	5489.43	21756.3	19761.9
10	5882.4003	5343.18	21176.6	19235.5
11	5683.5726	5162.58	20460.9	18585.3
12	5443.0544	4944.11	19595	17798.8
13	5156.8179	4684.11	18564.5	16862.8
14	4820.8877	4378.97	17355.2	15764.3
15	4431.2881	4025.09	15952.6	14490.3
16	3995.7061	3629.43	14384.5	13066
17	3500.2196	3179.37	12600.8	11445.7
18	2940.8619	2671.28	10587.1	9616.62
19	2313.7618	2101.67	8329.54	7566
20	1207.5989	1096.9	4347.36	3948.85



Graph 07– Base shear Details for Static load Condition in X AND Y Direction

Table 3.4 – Base shear Details for Dynamic load Condition in X and Y Direction

	With TMD			
Base Shear	Zone-II		Zone-V	
Story	Dynamic Dx	Dynamic Dy	Dynamic Dx	Dynamic Dy
BASE	0	0		
1	607.4602	520.7725	2183.541	1870.347
2	597.1639	513.2518	2146.753	1843.554
3	580.1284	497.8834	2085.707	1788.712
4	563.3886	478.5895	2025.501	1719.674
5	548.9579	459.4661	1973.634	1651.024
6	533.8184	442.7237	1919.535	1590.805
7	515.5473	428.0972	1854.273	1538.291
8	495.4541	413.9265	1782.13	1487.627
9	475.9771	398.7644	1711.924	1433.479
10	456.1949	381.7424	1640.755	1372.454
11	434.5029	363.6788	1562.818	1307.286
12	410.857	345.3066	1477.464	1240.655
13	386.5652	326.7012	1389.427	1173.074
14	361.4301	307.7096	1298.841	1104.293
15	333.6614	288.3641	1199.697	1034.75
16	303.612	268.4446	1092.009	963.6066
17	272.773	245.2807	980.6368	881.1247
18	240.8379	215.5266	865.9153	775.185
19	200.1328	175.6156	720.4931	632.4494
20	109.7692	93.9248	396.3845	338.8409

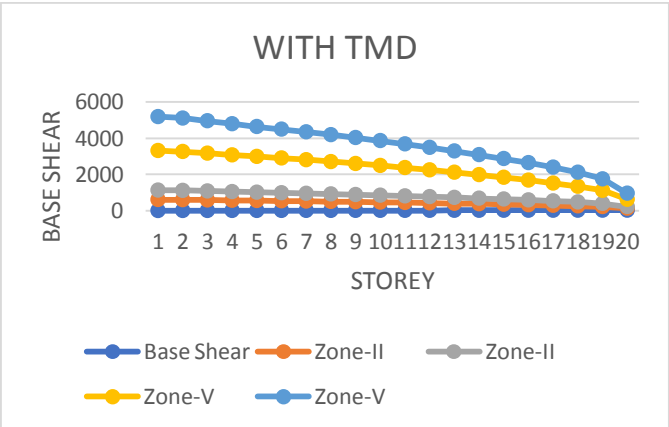
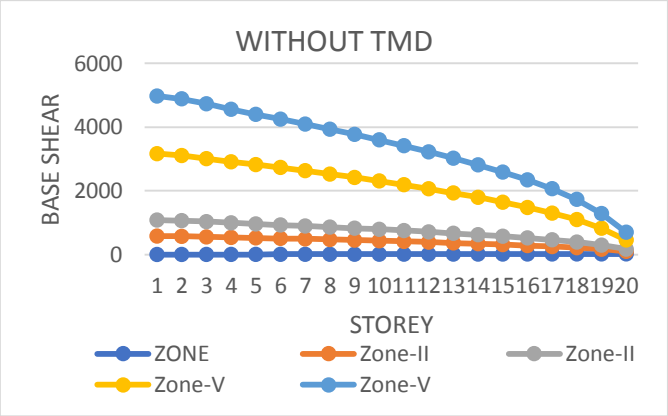


Fig 08 – Base shear Details for Dynamic load Condition in X and Y Direction

Table 3.5 – Base shear Details for Static load Condition in X and Y Direction-

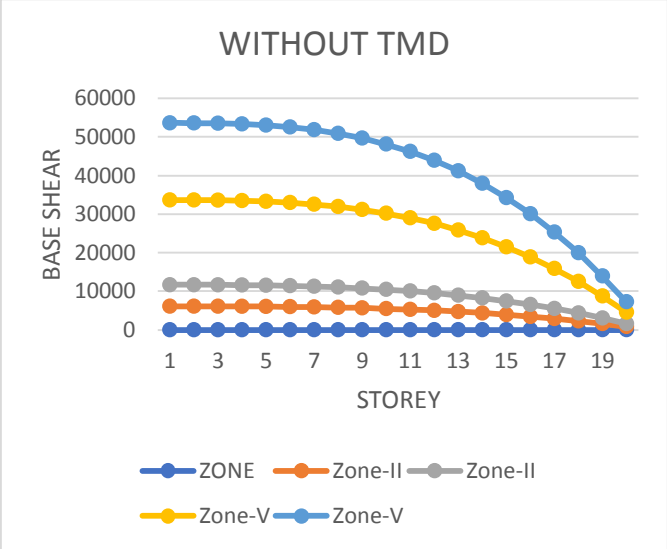
	Without TMD			
Base Shear	Zone-II		Zone-V	
Story	Static Ex	Static Ey	Static Ex	Static Ey
1	6108.1546	5548.24	21989.4	19973.7
2	6105.9352	5546.22	21981.4	19966.4
3	6097.0574	5538.16	21949.4	19937.4
4	6077.0826	5520.02	21877.5	19872.1
5	6041.5717	5487.76	21749.7	19755.9
6	5986.0859	5437.36	21549.9	19574.5
7	5906.1864	5364.79	21262.3	19313.2
8	5797.4343	5266	20870.8	18957.6
9	5658.5848	5139.88	20370.9	18503.6
10	5482.8535	4980.26	19738.3	17928.9
11	5265.844	4783.14	18957	17219.3
12	5003.3318	4544.69	18012	16360.9
13	4690.9205	4260.92	16887.3	15339.3
14	4324.2712	3927.88	15567.4	14140.4
15	3899.0448	3541.63	14036.6	12749.9
16	3423.6312	3109.8	12325.1	11195.3
17	2882.8352	2618.58	10378.2	9426.87
18	2272.3271	2064.03	8180.38	7430.51
19	1587.8822	1442.33	5716.38	5192.37
20	825.2753	749.625	2970.99	2698.65



Graph 09– Base shear Details for Static load Condition in X AND Y Direction for without TMD

Table 3.6– Base shear Details for Dynamic load Condition in X and Y Direction

	Without TMD			
Base Shear	Zone-II		Zone-V	
Story	Dx	Dy	Dx	Dy
BASE				
1	578.1393	502.411	2081.302	1808.68
2	567.2036	494.4006	2041.933	1779.842
3	549.2487	478.1042	1977.295	1721.175
4	531.8238	457.8133	1914.566	1648.128
5	516.9097	437.9375	1860.875	1576.575
6	501.1634	420.7414	1804.188	1514.669
7	482.1828	405.7889	1735.858	1460.84
8	461.599	391.2569	1661.756	1408.525
9	441.8909	375.6818	1590.807	1352.455
10	421.8495	358.2789	1518.658	1289.804
11	399.8454	339.9431	1439.443	1223.795
12	376.0299	321.3531	1353.708	1156.871
13	351.4997	302.4767	1265.399	1088.916
14	325.5037	283.0428	1171.813	1018.954
15	296.3035	262.7694	1066.692	945.9697
16	264.8999	240.6923	953.6395	866.4923
17	232.2922	213.1395	836.2521	767.302
18	196.0928	176.4699	705.934	635.2915
19	147.5426	127.9429	531.1535	460.5945
20	80.3189	67.5508	289.148	243.1829

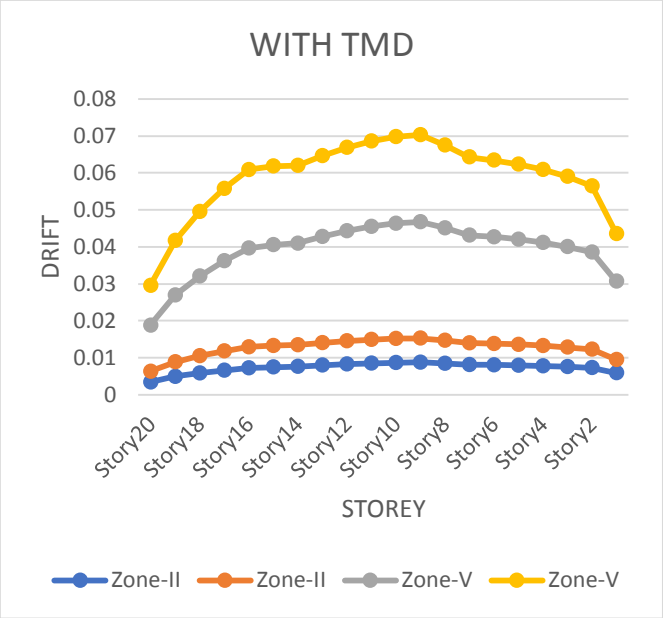


Graph 10– Base shear Details for Dynamic load Condition in X AND Y Direction for without TMD

3.7 Drift Details:-

Table 3.7– Drift Details for Static load Condition in X and Y Direction-

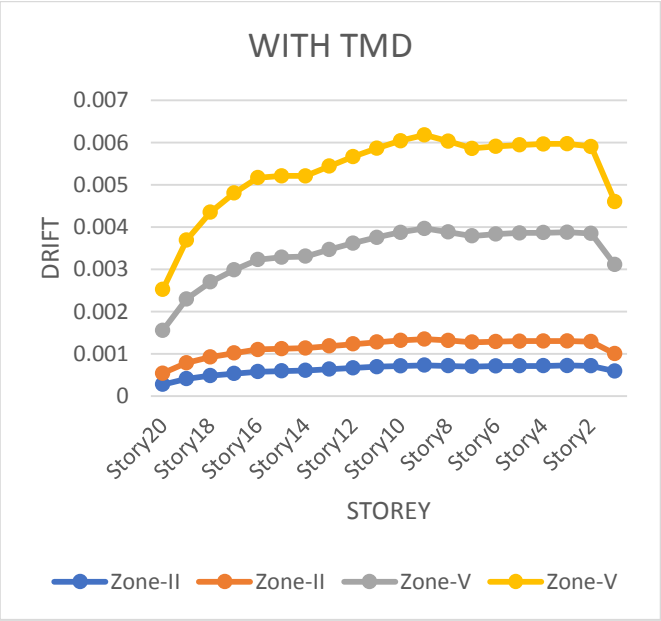
	With TMD			
Drift	Zone-II		Zone-V	
Story	Static Ex	Static Ey	Static Ex	Static Ey
Story20	0.003375	0.002901	0.012477	0.010783
Story19	0.004888	0.003965	0.018084	0.01477
Story18	0.005819	0.004673	0.021585	0.01746
Story17	0.006573	0.005228	0.024407	0.019562
Story16	0.007211	0.005679	0.02676	0.02122
Story15	0.007461	0.005793	0.027307	0.021293
Story14	0.007617	0.005833	0.027491	0.021081
Story13	0.00797	0.006064	0.028734	0.021878
Story12	0.008264	0.006264	0.029789	0.022585
Story11	0.00849	0.006414	0.030596	0.023121
Story10	0.008651	0.006512	0.031174	0.023469
Story9	0.008738	0.006538	0.031481	0.023559
Story8	0.008445	0.006227	0.030422	0.022437
Story7	0.008099	0.005875	0.029173	0.021166
Story6	0.008018	0.005771	0.028881	0.020786
Story5	0.007906	0.005646	0.028473	0.020335
Story4	0.007752	0.005485	0.027916	0.019752
Story3	0.007555	0.005281	0.027205	0.019016
Story2	0.007298	0.004975	0.026278	0.017914
Story1	0.005895	0.003571	0.021224	0.012858
Base	0	0	0	0



Graph 11– Drift Details for Static load Condition in X AND Y Direction

Table-3.8– Drift Details for Dynamic load Condition in X and Y Direction-

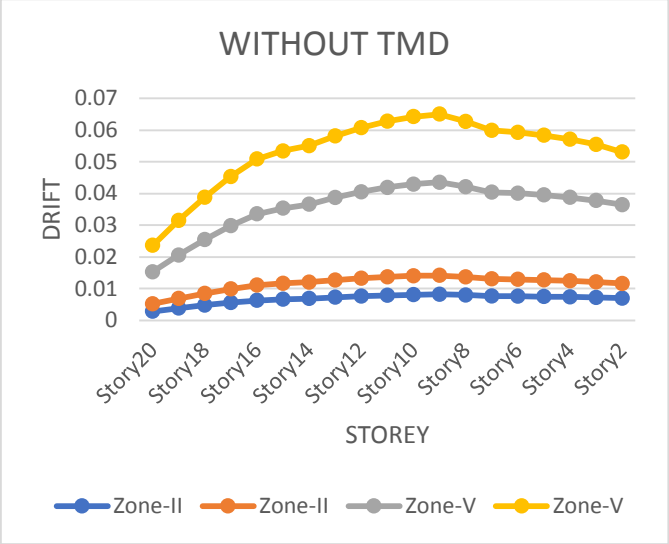
	With TMD			
Drift	Zone-II		Zone-V	
Story	Dynamic Dx	Dynamic Dy	Dynamic Dx	Dynamic Dy
Story20	0.000274	0.00026	0.001016	0.000971
Story19	0.000408	0.000374	0.001511	0.001396
Story18	0.000479	0.000442	0.001778	0.001651
Story17	0.00053	0.000486	0.001969	0.00182
Story16	0.000575	0.00052	0.002134	0.00194
Story15	0.000592	0.000524	0.002167	0.001925
Story14	0.000604	0.000527	0.002177	0.001899
Story13	0.000634	0.000549	0.002282	0.001977
Story12	0.000662	0.000569	0.002384	0.00205
Story11	0.000688	0.000587	0.002477	0.002112
Story10	0.00071	0.000603	0.002557	0.002169
Story9	0.000728	0.000616	0.002619	0.002216
Story8	0.000714	0.000597	0.002571	0.002149
Story7	0.000699	0.000575	0.002516	0.002068
Story6	0.000708	0.000577	0.002547	0.002077
Story5	0.000713	0.00058	0.002564	0.002087
Story4	0.000715	0.000583	0.00257	0.002095
Story3	0.000716	0.000583	0.002575	0.002096
Story2	0.000713	0.000572	0.002563	0.002055
Story1	0.000587	0.000414	0.00211	0.001489
Base	0	0	0	0



Graph 12–Drift Details for Dynamic load Condition in X AND Y Direction

Table 3.9 – Drift Details for Static load Condition in X and Y Direction for without TMD

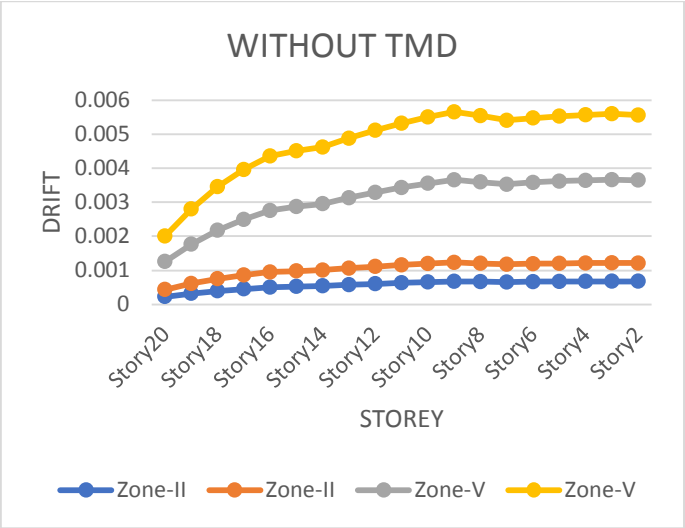
	Without TMD			
Drift	Zone-II		Zone-V	
Story	Static Ex	Static Ey	Static Ex	Static Ey
Story20	0.002802	0.002331	0.010087	0.008391
Story19	0.003798	0.003038	0.013673	0.010938
Story18	0.004718	0.003707	0.016986	0.013346
Story17	0.00554	0.004306	0.019943	0.015501
Story16	0.006246	0.004809	0.022484	0.017313
Story15	0.006591	0.005007	0.023726	0.018026
Story14	0.006835	0.005126	0.024605	0.018454
Story13	0.007235	0.005396	0.026046	0.019425
Story12	0.007571	0.005627	0.027256	0.020259
Story11	0.007834	0.005807	0.028203	0.020907
Story10	0.00803	0.005933	0.028907	0.021359
Story9	0.008147	0.005987	0.029331	0.021552
Story8	0.007901	0.005723	0.028443	0.020602
Story7	0.007599	0.005416	0.027356	0.019497
Story6	0.007542	0.005333	0.027151	0.019201
Story5	0.007451	0.00523	0.026823	0.018827
Story4	0.007317	0.005089	0.026342	0.018321
Story3	0.007141	0.004907	0.025707	0.017666
Story2	0.006906	0.004629	0.02486	0.016663
Story1	0.005583	0.003328	0.020098	0.011982
Base	0	0	0	0



Graph 13– Drift Details for Static load Condition in X AND Y Direction for without TMD

Table 4.10– Drift Details for Dynamic load Condition in X and Y Direction-

	Without TMD			
Base Shear	Zone-II		Zone-V	
Story	Dynamic Dx	Dynamic Dy	Dynamic Dx	Dynamic Dy
Story20	0.000229	0.000207	0.000824	0.000747
Story19	0.000322	0.000288	0.001158	0.001036
Story18	0.000396	0.000356	0.001426	0.001281
Story17	0.000454	0.000407	0.001634	0.001467
Story16	0.000503	0.000445	0.00181	0.001603
Story15	0.000526	0.000455	0.001893	0.001639
Story14	0.000543	0.000462	0.001954	0.001664
Story13	0.000575	0.000486	0.00207	0.001751
Story12	0.000605	0.000508	0.002177	0.001828
Story11	0.000632	0.000525	0.002275	0.001892
Story10	0.000656	0.000542	0.002361	0.00195
Story9	0.000675	0.000555	0.002429	0.001999
Story8	0.000665	0.000541	0.002393	0.001947
Story7	0.000653	0.000523	0.002351	0.001882
Story6	0.000664	0.000527	0.002391	0.001898
Story5	0.000671	0.000532	0.002416	0.001914
Story4	0.000675	0.000536	0.002431	0.00193
Story3	0.000679	0.000539	0.002445	0.001941
Story2	0.000679	0.000531	0.002443	0.001911
Story1	0.00056	0.000386	0.002017	0.00139
Base	0	0	0	0



Graph 14–Drift Details for Dynamic load Condition in X AND Y Direction for without TMD

IV. CONCLUSIONS

1} Modal time period is slightly higher in zone-II for mode 1 to 5 as (5.29 sec for Mode 01) With TMD and without TMD is (4.97 sec) and vise versa. There is slightly changes occurred by changing seismic zone changing from II to V.

2} It is concluded that the base shear for zone-V 23239.1 kn is greatly Higher as compared to zone-II is 6455.31 kn while consideration of static load case.

3} By comparing the results it is concluded Drift occurred in zone-II and V with TMD is less as compared with zone – II and V without TMD while consideration of static , dynamic and in X and Y directions..

4} From the above points it is concluded that the TMD with 5% in mass ratio for zone-II and V reduces the static and dynamic response as compared to without TMD model .

REFERENCES

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