DYNAMIC ANALYSIS AND CONDITION ASSESSMENT OF RC BUILDING BY VARYING MATERIAL DAMPING AND TIME DEPENDENT PROPERTIES

Latha H R[1], Syed Ahamed[2]

[1]*Post Graduate Student, Civil Engineering, Ghousia College of Engineering, Ramanagaram, Karnataka, India*
[2]*Assistant Professor, Civil Engineering, Ghousia College of Engineering, Ramanagaram, Karnataka, India*

Abstract

In the present dissertation study, an SMRF building situated in seismic zone-III having G+ 10 storey has been considered for performing linear dynamic or response spectrum method of analysis, to achieve and compare various results such as storey drift, storey displacement for considered DCON-2 and DCON-3 load combinations as per IS: 1893-2002 (Part-I), all imposed load are considered as per IS 875:2000. Also the condition assessment of the building models through system identification approach and extract the modal identification parameters like frequency, damping, mode shapes. Furthermore spectral displacement, spectral velocity and spectral acceleration are obtained for various percentages of damping i.e., 0, 5 and 10, for all the considered SMRF building models. The overall dissertation flow has been carried out to perform linear dynamic analysis (response spectrum method) for the parameters ELCENTRO, using the finite element method based analytical software ETABS-15 version.

Keywords: *Linear dynamic, Condition assessment, Material damping, Time dependent and Response spectrum*

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1. INTRODUCTION

1.1 General

Earthquake is the faction or trembling caused due to the sudden discharge of energy in the earth's crust, the sudden discharge of energy is due to the movement of rocks in the earth's crust. Depending on magnitude, intensity and effect of the earthquake may small or large earthquake. Large earthquake usually begin with slight tremors but rapidly take from of one or more violent shocks. The subterranean point of source of an earthquake is called its focus; the point on the plane directly over the focus is the epicenter. In some parts of the world, earthquake is related with volcanic activity. As most of the earthquake occur from stress build-up due to deformation of the earth's crust, and also calls upon the knowledge of the physics of the earth. There are three main types of geological fault that may cause an earthquake: normal, reverse and strike-slip. Normal faults occur in areas where the crust is being extended. Reverse faults occur in areas where the crust is being shortened. Strike-slip faults are steep structures where the two sides of the faults slip horizontally past each other.

Condition assessment is very important as a measure of safety, it is nothing but assessing the condition of the structures frequently. By doing the dynamic analysis we get the frequency response functions which are used in assessing and analyzing the damage in the structure, its load-bearing capacity and serviceability are assessed, and any damage to structural elements is detected.

1.2 Objectives

- To carry out linear static (Equivalent static method) and linear dynamic (response spectrum method) analysis for the considered SMRF building models situated in zone-III as per IS 1893:2002 Part-I for the considered load combinations.
- To evaluate the condition of the considered SMRF building model using system identification approach.
- To execute linear dynamic analysis to obtain the modal identification parameters such as frequency, damping and mode shapes.
- To study the varying effect of material damping and time dependent properties for the considered SMRF building models.
- To perform linear dynamic response spectrum method of analysis and obtain various results like storey drift, storey displacements are tabulated and are plotted on graph.
- Linear dynamic parameters such as spectral displacement, spectral velocity and spectral acceleration are obtained for various percentages of damping i.e., 0, 5 and 10, for all the considered SMRF building models.

1.3 Methods of Analysis

1. Linear static analysis
2. Linear dynamic analysis (Response spectrum method)

The above two method of analysis is carried out using ETABS-2015 software. Linear static method is adopted to obtain the retort of a building. In this method the total design lateral force along any principal direction are obtained. In response spectrum method of analysis the response of the structure to the several earthquake motions is obtained in the form of smooth design spectra. This method gives the maximum displacements, design seismic force, base shear storey drift for each mode of vibration.

2. MODELLING AND ANALYSIS

Table-1: Model Details

Structure Type	SMRF
No of storeys	11
Height of the building	33.5
Materials	Concrete M30 and Steel Fe500
Plan Dimension	36m×20m
No of bay in X direction	6
No of bay in Y direction	4
Size of Column	500×600mm
Size of Beam	400×600mm
Thickness of Slab	150mm
Density of Concrete	25Kn/m^2
Poisson's Ratio	0.25
Seismic Zone	III
Zone factor(Z)	0.16
Soil Type	II(Medium soil)
Importance Factor(I)	1.5
Response Reduction Factor(R)	5
Model-1	Bare frame type
Model-2	Material damping type
Model-3	Time dependent type

Steps involved to carry out this analysis is as follows

- Modeling of the finite elemental frame.
- Define and assign the properties of beams, column and slabs.
- Define and assign the static load combination.
- Carryout linear static analysis.
- Dynamic analysis is carryout by using Response spectrum method.
- Displacement, time period, frequency response are obtained which are verified and validated

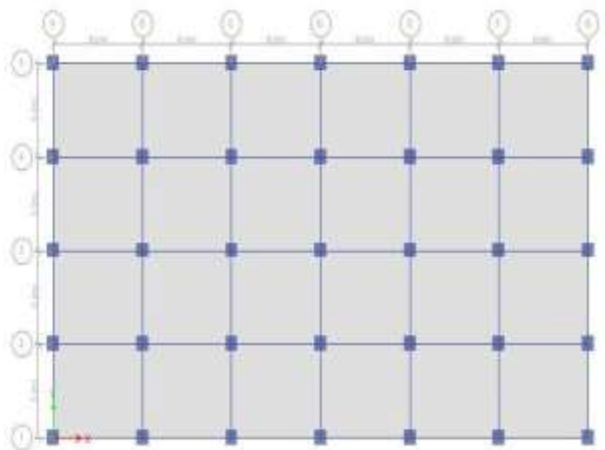

Fig 1: Plan of the frame model from ETABS-2015

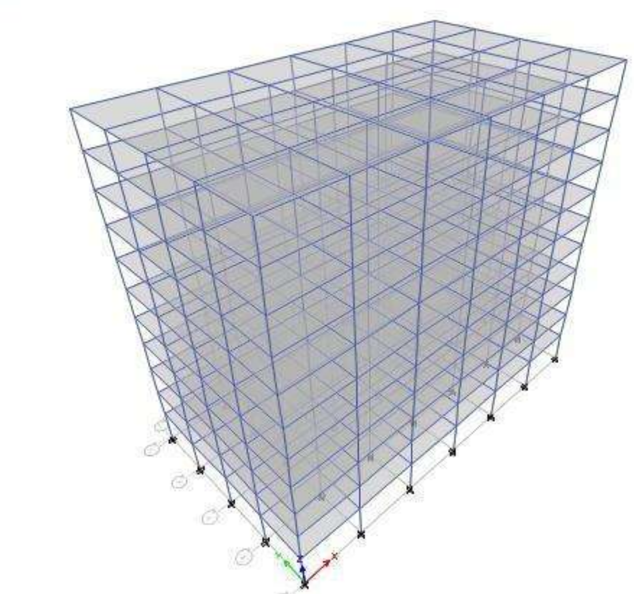

Fig 2: 3D view of the frame model from ETABS-2015

3. LINEAR DYNAMIC RESULTS

3.1 Storey Displacement

Table- 2: Storey displacement of all models in X direction

Storey no	Model-1 RSX	Model-2 RSX	Model-3 RSX
1	16.5	15	16
2	16.1	14.7	15.7
3	15.5	14.2	15.1
4	14.5	13.4	14.2
5	13.3	12.3	13
6	11.9	11	11.6
7	10.3	9.6	10
8	8.4	7.9	8.3
9	6.4	6	6.3
10	4.2	4	4.1
11	1.9	1.9	1.9

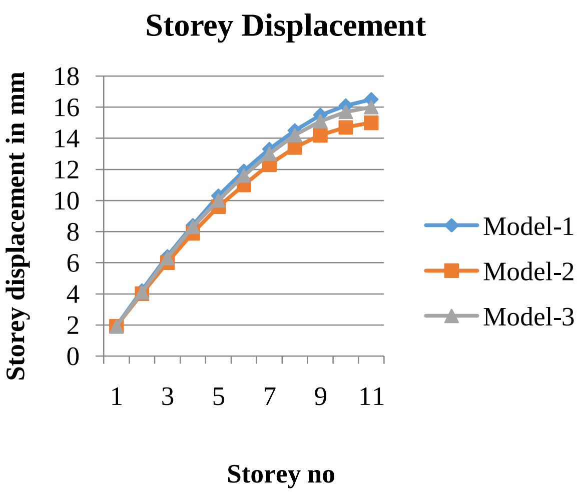

Chart 1: Storey displacement curve of all models in X direction

3.2 Storey Drift

Table-3: Storey drifts of all models in X direction

Storey no	Model-1	Model-2	Model-3
	RSX	RSX	RSX
1	0.000148	0.000122	0.00014
2	0.000271	0.000226	0.000257
3	0.000383	0.000328	0.000366
4	0.00047	0.000412	0.000453
5	0.000538	0.00048	0.000521
6	0.000594	0.000537	0.000577
7	0.000645	0.000589	0.000628
8	0.000694	0.000641	0.000677
9	0.000738	0.000689	0.000722
10	0.000754	0.000713	0.000739
11	0.000556	0.000533	0.000547

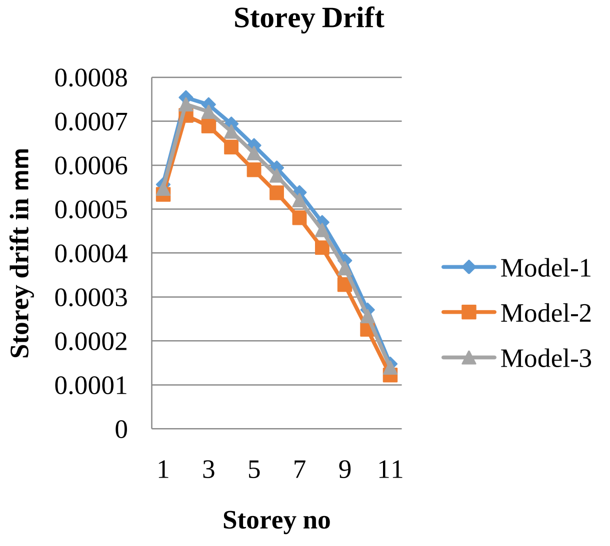

Chart 2: Storey drift curve of all models in X direction

3.3 Base Spectral Displacement

Table-4: Base Spectral displacement for model-1

Period (sec)	Spectral Displacement for model-1 in mm		
	Damping 0	Damping 0.05	Damping 0.1
0.03	0.2	0.2	0.2
0.04	0.4	0.4	0.4
0.05	0.6	0.7	0.7
0.1	2.6	2.7	2.6
0.15	10.8	9.4	8.1
0.2	24.5	7.2	7.1
0.25	31.6	26.2	20.8
0.5	64.8	63.5	59.8
1	214.5	202.7	187.8
2	430.2	432.5	432.1
5	2725.6	2631.4	2555.5

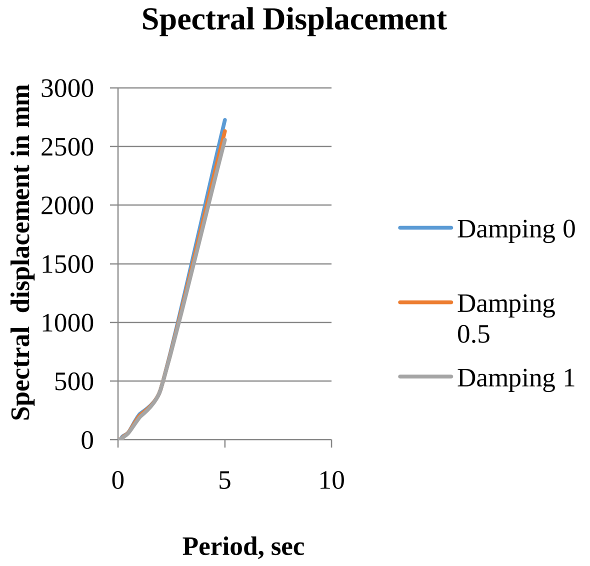

Chart 3: Base spectral displacement curve for model-1

Table-5: Base Spectral displacement for model-1

Period (sec)	Spectral Displacement for model-2 in mm		
	Damping 0	Damping 0.05	Dampin g 0.1
0.03	0.5	0.5	0.5
0.04	0.8	0.9	0.9
0.05	1.3	1.4	1.4
0.1	5.3	5.4	5.4
0.15	22.1	19.5	16.7
0.2	67.7	13	14.1
0.25	64.8	53.8	42.7
0.5	133.1	130.4	122.9
1	440.3	416.2	385.6
2	883.3	888	887.2
5	5596.1	5402.6	5246.7

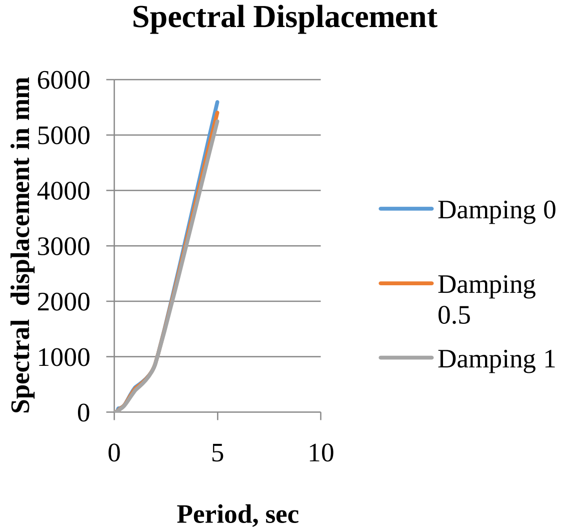

Chart 4: Base spectral displacement curve for model-2

Table-6: Base Spectral displacement for model-3

Period (sec)	Spectral Displacement for model-3 in mm		
	Damping 0	Damping 0.05	Damping 0.1
0.03	0.4	0.4	0.4
0.04	0.7	0.7	0.7
0.05	1.1	1.1	1.1
0.1	4.5	4.6	4.5
0.15	18.5	16.2	14
0.2	42.2	12.3	12.2
0.25	54.3	45.1	35.8
0.5	111.5	109.3	103
1	369	348.8	323.2
2	740.3	744.2	743.5
5	4690	4527.8	4397.2

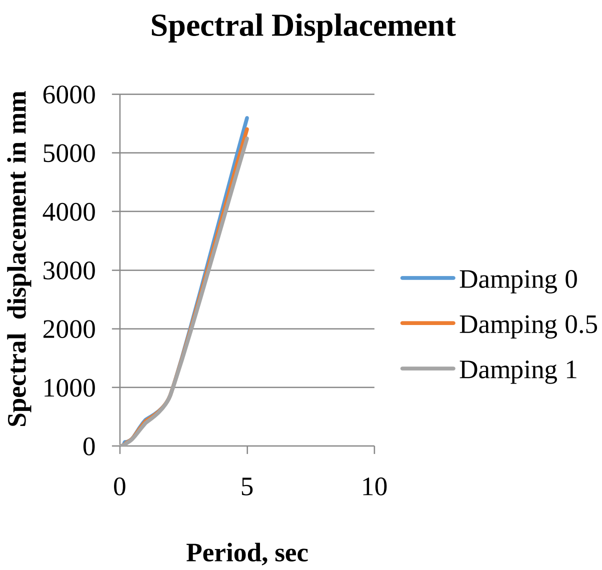

Chart 5: Base spectral displacement curve for model-3

3.4 Spectral Velocity

Table-7: Base Spectral velocity for model-1

Period (sec)	Spectral velocity for model-1 in mm/sec		
	Damping 0	Damping 0.05	Damping 0.1
0.03	4.56	2.52	2.43
0.04	346.14	11.06	6.42
0.05	0	2.7	4.5
0.1	0	5.54	10.85
0.15	95.72	113.49	100.56
0.2	8653.47	1059.68	590.64
0.25	484.33	430.22	312.5
0.5	447.66	428.94	422.39
1	889.12	905.63	900.97
2	485.8	437.16	428.89
5	887.42	845.59	801.76

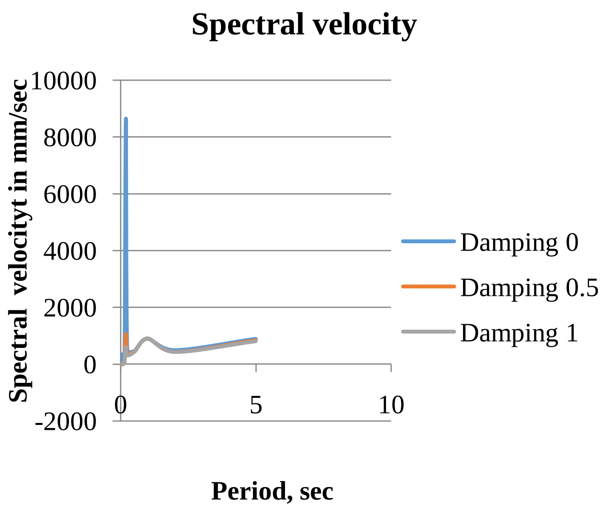

Chart 6: Base spectral velocity curve for model-1

Table-8: Base Spectral velocity for model-2

Period (sec)	Spectral velocity for model-2 in mm/sec		
	Damping 0	Damping 0.05	Damping 0.1
0.03	9.36	5.17	5
0.04	710.67	22.71	13.18
0.05	0	5.55	9.25
0.1	0	11.37	22.29
0.15	194.06	236.17	208.04
0.2	17601.67	2177.78	1214.22
0.25	994.39	883.3	641.6
0.5	919.1	880.68	867.21
1	1825.48	1859.38	1849.81
2	997.4	897.55	880.57
5	1821.98	1736.11	1646.12

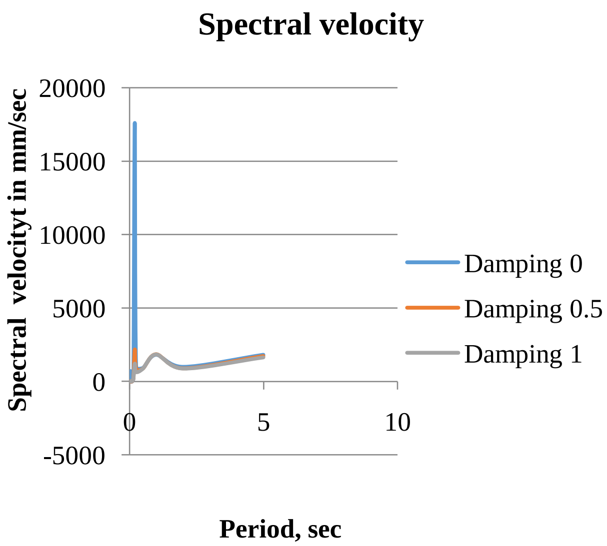

Chart 7: Base spectral velocity curve for model-2

Table-9: Base Spectral velocity for model-3

Period (sec)	Spectral velocity for model-3 in mm/sec		
	Damping 0	Damping 0.05	Damping 0.1
0.03	7.84	4.33	4.19
0.04	595.6	19.03	11.05
0.05	0	4.65	7.75
0.1	0	9.53	18.68
0.15	164.71	195.29	173.03
0.2	14889.97	1823.38	1016.31
0.25	833.38	740.28	537.72
0.5	770.29	738.08	726.8
1	1529.9	1558.32	1550.3
2	835.91	752.23	737.99
5	1526.97	1455	1379.58

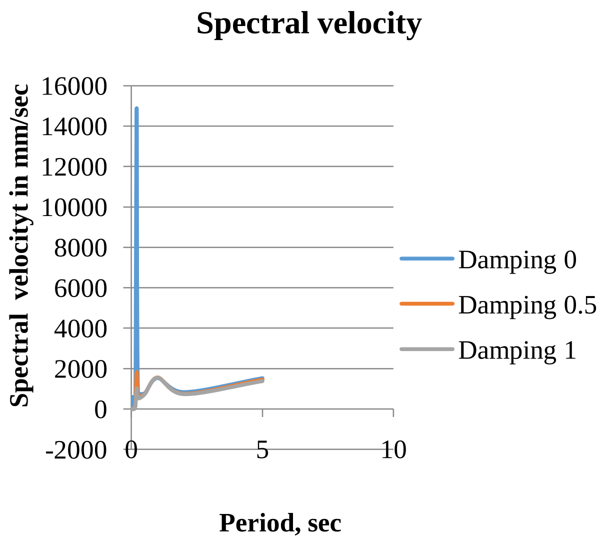

Chart 8: Base spectral velocity curve for model-3

3.5 Spectral Acceleration

Table-10: Base Spectral acceleration for model-1

Period (sec)	Spectral acceleration for model-1 in mm/sec^2		
	Damping 0	Damping 0.05	Damping 0.1
0.03	10037.15	10131.04	10369.24
0.04	10212.21	10461.24	10463.48
0.05	10212.21	10503.31	10515.62
0.1	10212.21	10504.05	10520.32
0.15	18851.37	16811.89	14896.48
0.2	10212.21	9794.56	9718.97
0.25	19946.09	16013.17	12276.17
0.5	10234.68	9967.52	9372.46
1	8467.21	7854.08	7844.29
2	4246.32	4261.77	4333.9
5	4304.17	4231.2	4189.42

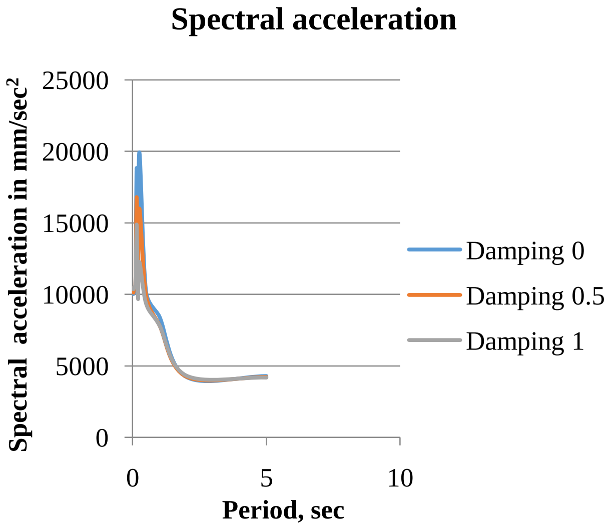

Chart 9: Base spectral acceleration curve for model-1

Table-11: Base Spectral acceleration for model-2

Period (sec)	Spectral acceleration for model-2 in mm/sec^2		
	Damping 0	Damping 0.05	Damping 0.1
0.03	20607.58	20800.34	21289.39
0.04	20966.99	21478.28	21482.87
0.05	20966.99	21564.66	21589.94
0.1	20966.99	21566.17	21599.59
0.15	38665.74	34595.98	30610.99
0.2	66675.27	18807.47	19593.11
0.25	40951.9	32877.1	25204.57
0.5	21013.12	20464.62	19242.88
1	17384.28	16125.44	16105.35
2	8718.24	8749.96	8898.05
5	8837.02	8687.19	8601.42

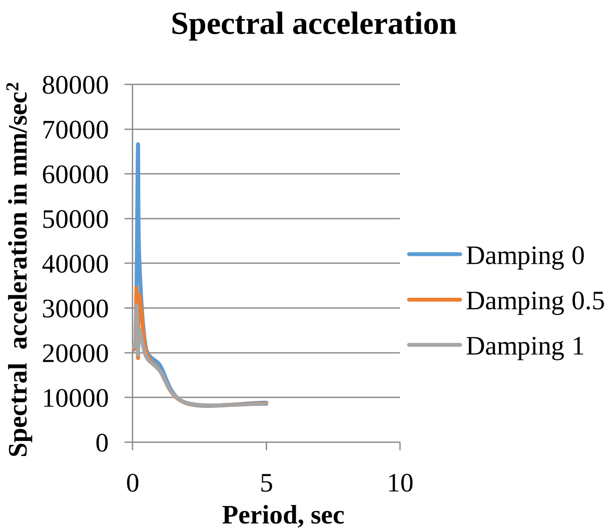

Chart 10: Base spectral acceleration curve for model-2

Table-12: Base Spectral acceleration for model-3

Period (sec)	Spectral acceleration for model-3 in mm/sec^2		
	Damping 0	**Damping 0.05**	**Damping 0.1**
0.03	17270.86	17432.41	17842.28
0.04	17572.08	18000.58	18004.43
0.05	17572.08	18072.97	18094.16
0.1	17572.08	18074.25	18102.25
0.15	32437.43	28928.11	25632.28
0.2	17572.08	16853.43	16723.37
0.25	34321.09	27553.75	21123.53
0.5	17610.74	17151.05	16127.14
1	14569.47	13514.46	13497.62
2	7306.61	7333.19	7457.31
5	7406.16	7280.59	7208.71

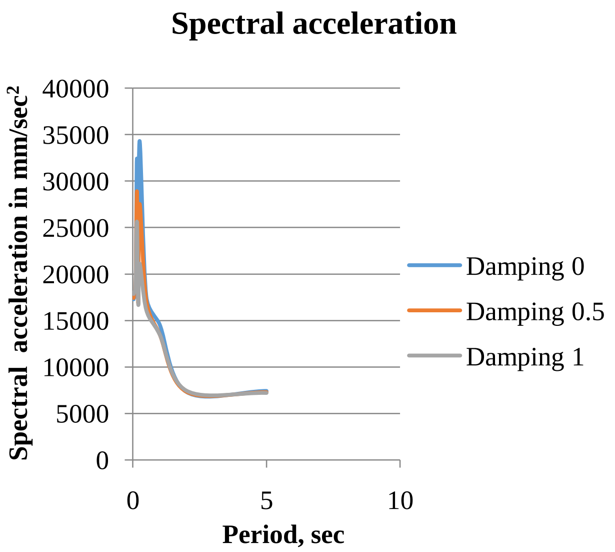

Chart 11: Storey acceleration curve for model-3

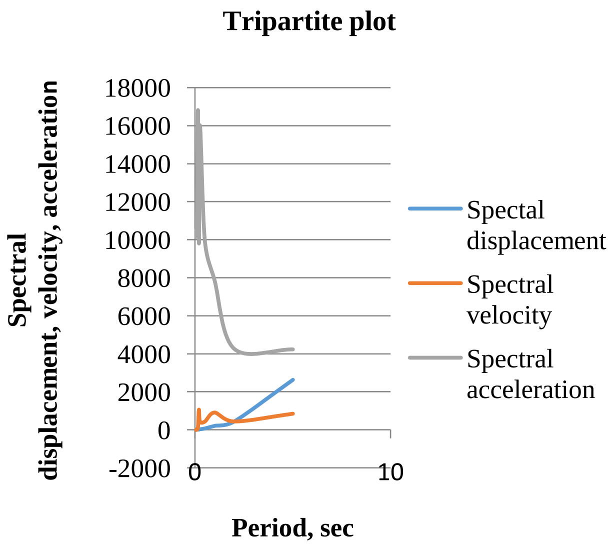

Chart 12: Tripartite plot for model-1

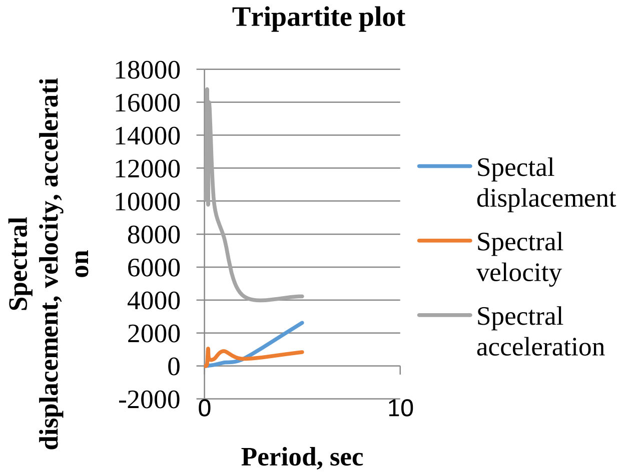

Chart 13: Tripartite plot for model-2

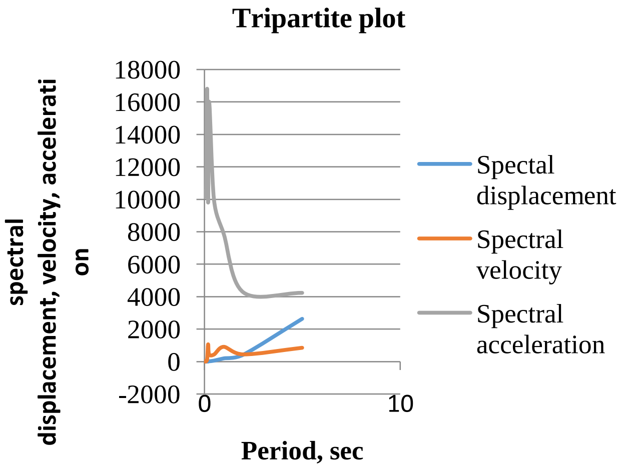

Chart 14: Tripartite for model-3

3.3 Time Period and Frequency

Table 13: Time period and Frequency of all models

Storey no	Time period (sec)	Frequency (cycle/sec)
1	1.689	0.592
2	1.605	0.623
3	1.512	0.661
4	0.554	1.804
5	0.524	1.907
6	0.497	2.013
7	0.32	3.122
8	0.302	3.311
9	0.289	3.46
10	0.222	4.503
11	0.206	4.843
12	0.2	5.002
13	0.167	5.981
14	0.153	6.529
15	0.15	6.662
16	0.133	7.528
17	0.12	8.348
18	0.119	8.415
19	0.11	9.108

20	0.098	10.22
21	0.098	10.254
22	0.094	10.648
23	0.083	11.996
24	0.083	12.055
25	0.082	12.163
26	0.076	13.206
27	0.073	13.633
28	0.072	13.95
29	0.072	13.971
30	0.067	14.983
31	0.065	15.443
32	0.063	15.884
33	0.061	16.449

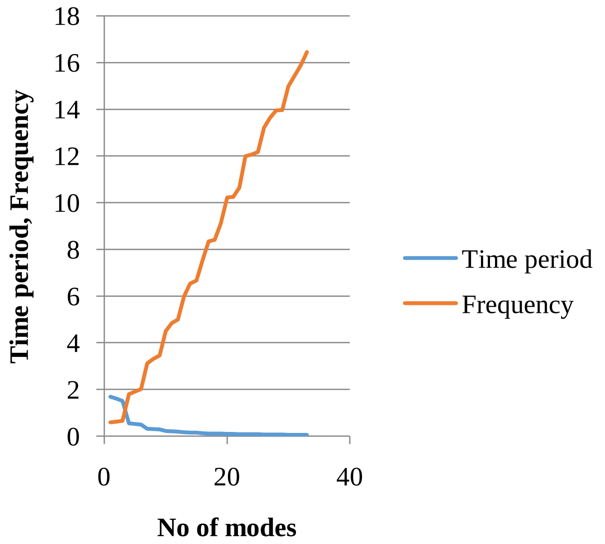

Chart 1: Time period and frequency curve for all models

3.6 Mode Shapes

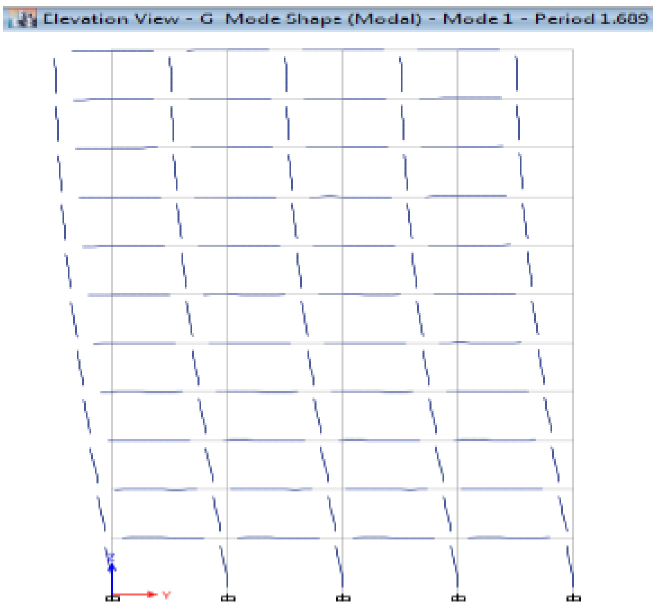

Fig 3: Mode shape for 1st mode from ETABS-2015

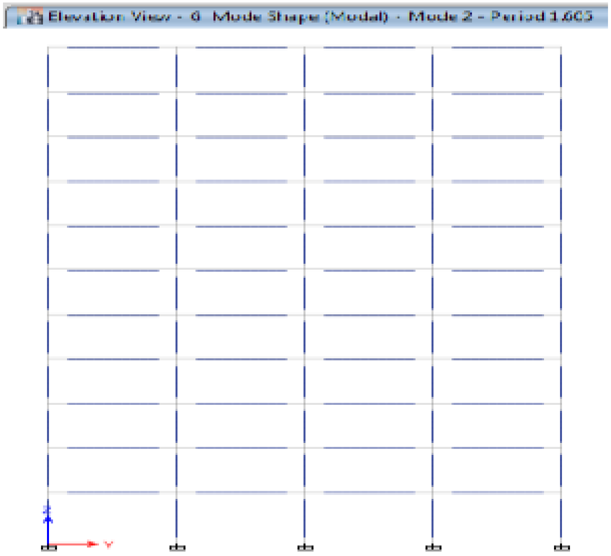

Fig 4: Mode shape for 2nd mode from ETABS-2015

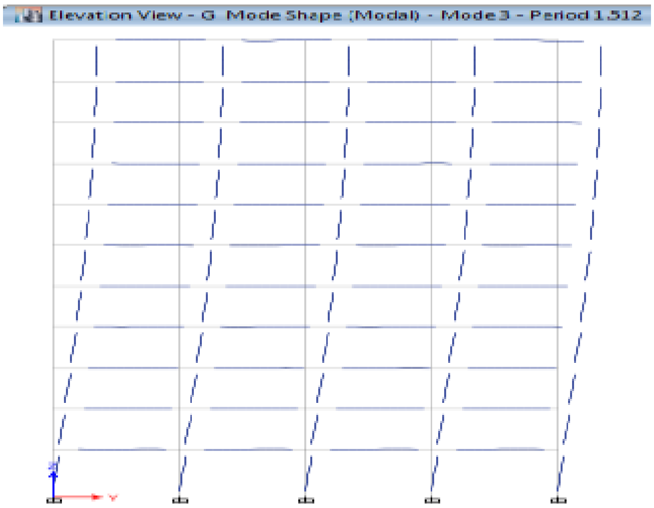

Fig 5: Mode shape for 3rd mode from ETABS-2015

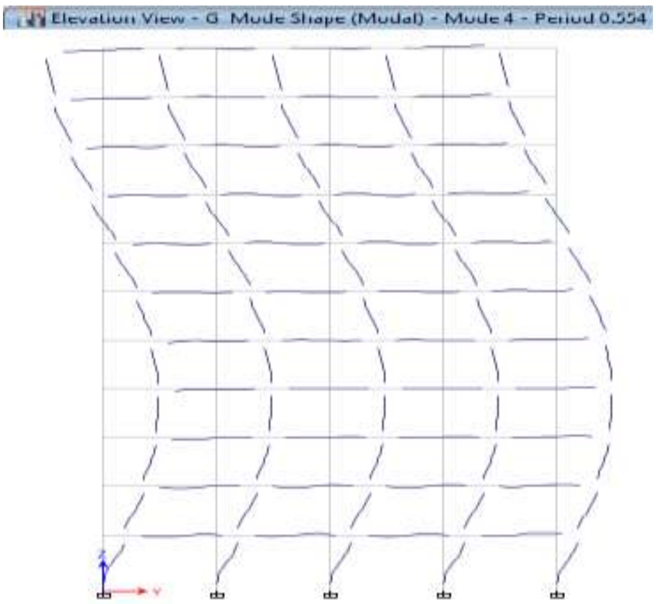

Fig 6: Mode shape for 4th mode from ETABS-2015

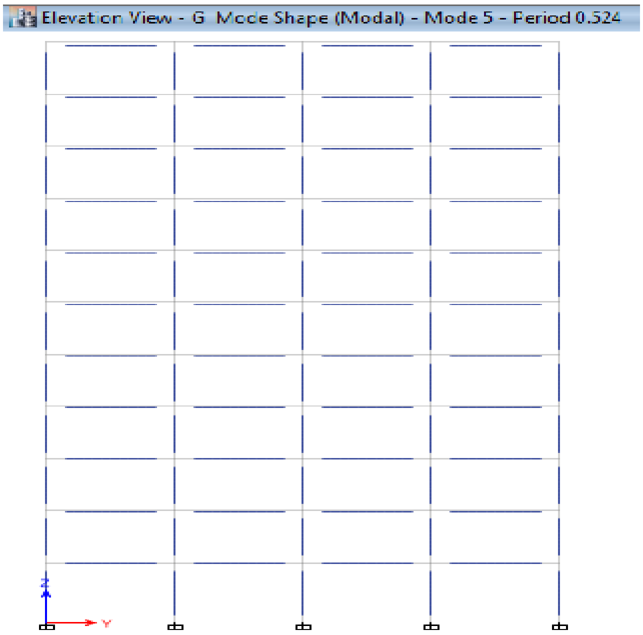

Fig 7: Mode shape for 5th mode from ETABS-2015

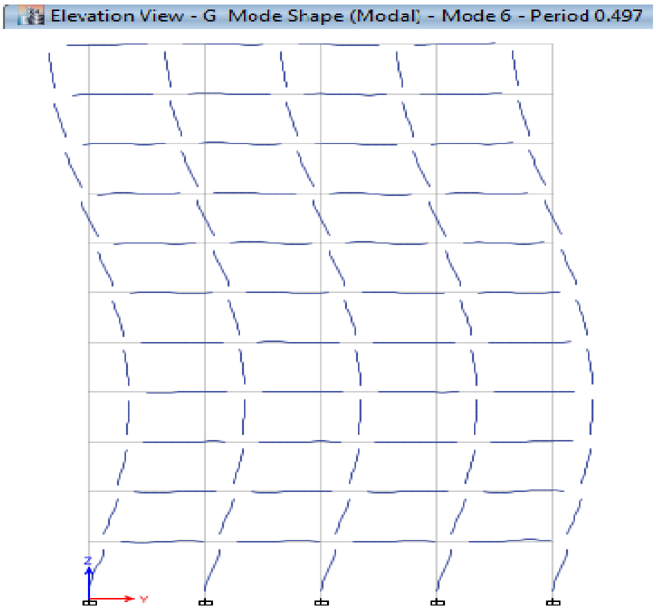

Fig 8: Mode shape for 6th mode from ETABS-2015

4. CONCLUSION

- The storey displacement, storey drift for DCON-3 load combination is greater than storey displacement, storey drift of DCON-2 load combination for equivalent linear static analysis, obtained for the models under consideration.
- The linear dynamic response spectrum method of analysis is performed and results yields that the model (model-2) with material damping properties is displaced less rather than the time dependent model (model-3) and bare frame model (model-1).
- The various response spectrum results like spectral displacement, spectral velocity and spectral acceleration are obtained for various percentage of damping with respect to period.
- The results like time period, frequency and mode shapes are same for all the three models are tabulated and graph are plotted.
- The results such as frequency is inversely proportional to time period, i.e., as the time period goes on decreases the corresponding frequency goes on increases.
- It is seen that the model-2 with the material damping properties yields better response and results in comparison with all other models.

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BIOGRAPHIES

Latha H R, Post graduate student, Ghousia college of engineering, Ramanagaram-562159, Karnataka, India.

Syed Ahamed, Assistant Professor, Ghousia college of engineering, Ramanagram-562159, Karnataka, India.