

Seismic Analysis of Telecommunication Tower Using Viscous Damper

Ashok Meti¹, Vinayak Vijapur²

¹PG student, Dept. of Civil Engineering, Government Engineering College, HAVERI, Karnataka, India

²Assistant Professor, Dept. of Civil Engineering, Government Engineering College, HAVERI, Karnataka, India

Abstract - The 4-legged self-supporting towers are very important in daily life for transformation of network singles, such as mobile singles, TV singles, radio antennas and wireless systems etc; nowadays these towers are used worldwide for the telecommunication purpose. In a recent year the importance of communication tower has tremendously increased and installation of large number of towers to increase converge area and net work consistency. The wireless telecommunication network plays an important role hence failure of such towers for natural disasters like wind and earthquake loads. Most of the researches have been studied for 3-legged triangular cross section and wind analysis for different heights and bracing systems. But in this dissertation have considered 4-legged self-supporting telecommunication tower with viscous fluid damper is incorporated for controlling the response of the tower structure and study includes 56m height of two tower models without and with damper was prepared using SAP2000 of version 18. Various analysis techniques such as static, response spectrum and time history analysis was done for different soil types and seismic zones, El-Centro data was used for time history analysis. After completion of analysis part, comparative study was made for without and with damper with respect to modal time periods, modal frequencies, base shear and joint displacement in static analysis whereas joint displacement in response spectrum and peak displacement and peak acceleration in time history by taking El-Centro earthquake data.

Key words: Telecommunication Tower, Damper, Equivalent Static Analysis, Response Spectrum, Time History Analysis, Modal Time Period & Frequency, Base Shear, Joint displacement & Acceleration.

1. INTRODUCTION

The telecommunication industry plays a great role in human society and thus much more attention is now being paid to telecommunication towers than it was in the past and also telecommunication masts are considered today as one of the basic infrastructures in the human society. Radio masts and communication towers are typically tall constructions specially designed to carry antennas for radio communication. Such radio communication includes television, radio, GSM and Internet traffic. Towers and masts are used in numerous applications in wireless networks from broadband point to point systems to LMR1 networks. Towers and masts The telecommunication

industry plays a great role in human society and thus much more attention is now being paid to telecommunication towers than it was in the past and also telecommunication masts are considered today as one of the basic infrastructures in the human society. Radio masts and communication towers are typically tall constructions specially designed to carry antennas for radio communication. Such radio communication includes television, radio, GSM and Internet traffic. In this study, seismic analysis of telecommunication tower with height of 56 m is performed with SAP2000 of version 14.2.4 software. The most of the researchers have did study on 3-legged lattice towers but in this study 4-leegeed self supporting tower has been considered for analysis with and without application of viscous damper and study was carried out only on earthquake analysis for different seismic zones and different soil conditions.

1.1 DAMPERS

A fluid viscous damper is a device which absorb or dissipates the energy from external excitation by applying resistive force over a finite displacement. Therefore damper reduces the builted strain energy and response of the structure, merely for resonance condition. The stiffness of damper is dependent on several factors such as amplitude of vibration, type of construction material and fundamental time period of vibration, mode shape and structural components.

Dampers are commonly used where

- It reduces the storey drifts for high rise buildings.
- Reduces the unplanned torosional motions of the tall structures.
- It reduces the large energy dissipation due to earthquake.
- Reduces the peak displacement of tall building structures.

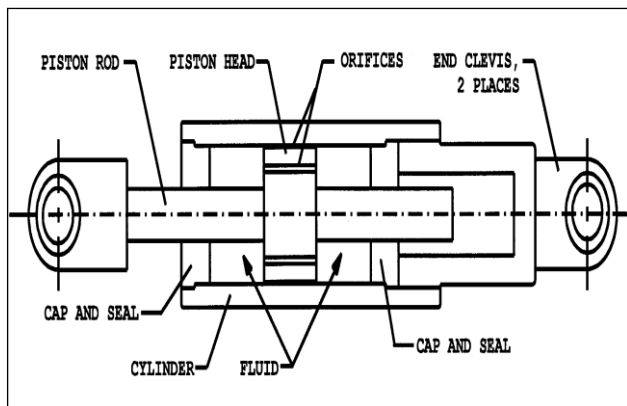


Fig-1: Fluid viscous damper arrangement

2. MODELLING AND ANALYSIS

Two framed Telecommunication Towers are modeled, with and Without Dampers were used in the analysis to know the realistic behavior of Tower during earthquake, using SAP2000 of version 14.2.4, the height of the tower was considered in the study is 56m and bottom plan dimension of the tower is 10mx10m and top plan dimension were considered is 2mx2m, with and without application of tower.

2.1 Modelling details of tower

Table -1: Model description of tower

S	Parameters	Model
1	Tower	56m
2	Bottom	10x10
3	Top plan in	2x2
Material property		
4	Leg member	ISA-
5	Bracing	ISA-
6	Bracing type	Concentric and eccentric
7	Types of soil	Hard,

2.2 Tower model with and without damper

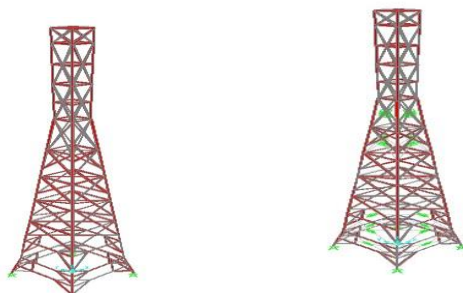


Fig.1: Tower without damper Fig.2: Tower with Damper

2.3 Loads considered for analysis

Loads considered are:

- Gravity loads includes dead load(DL) and live load(LL)
- Dead load → weight of platform at top of tower as 0.82 kN/m^2 and live load → 3 kN/m^2
- Earthquake load (EQ) as per provision of “Indian standard Criteria for Earthquake Resistant Design of Structures” IS: 1890-2002 (Part-1),
- Dead loads of towers:

Table-2: Antennas loads on tower

Sl. No.	Item	Quantity	Diameter (m)	Weight (kg)
1.	CDMA	8	0.26X2.5	20
2.	Microwave	2	1.2	77
3.	Microwave	3	0.6	45
4.	Microwave	4	0.3	25

3. RESULTS AND DISCUSSION

The results obtained from the static and dynamic analysis of different soil conditions and different seismic zones for without and with damper tower model.

3.1 EQUIVALENT STATIC ANALYSIS

3.1.1 **Modal time period:** In the static analysis modal time period and modal frequency was considered for 12 modes.

Table-3: Mode number v/s modal time period

Mode number	Time period in (Sec)	
	Without damper	With damper
1	0.92	0.87
2	0.90	0.86
3	0.78	0.55
4	0.68	0.49
5	0.65	0.47
6	0.29	0.25
7	0.27	0.23
8	0.27	0.22
9	0.24	0.21
10	0.22	0.18
11	0.20	0.17
12	0.20	0.16

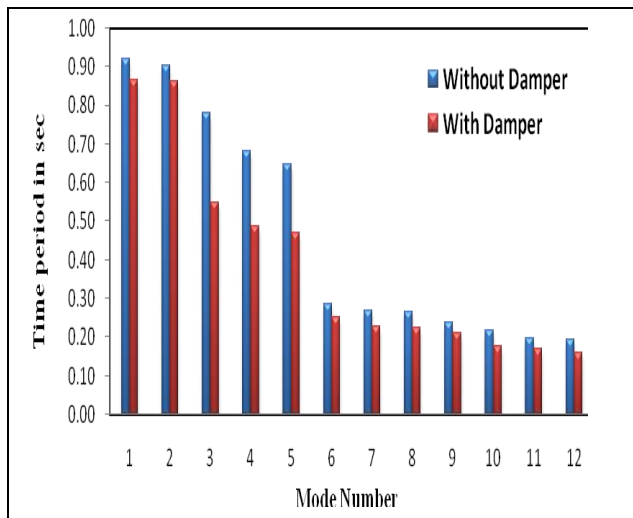


Chart-1: Comparison of mode number v/s. time period

The chart-1 shows the comparison of mode number versus time period, from this graph concluded that time period of vibration will reduce for without and with damper tower model and its value varies up to 5.43% for first mode and 20% for higher mode 12. For every higher mode vibration of time period goes decreases for both cases and its values varies up to 78.26% for first to higher mode 12 for without damper case.

3.1.2 Modal frequency

Table-4: Mode number versus modal frequency

Mode number	Frequency in cyc/sec	
	Without damper	With damper
1	1.09	1.16
2	1.11	1.16
3	1.28	1.82
4	1.47	2.05
5	1.55	2.12
6	3.49	3.96
7	3.70	4.35
8	3.74	4.45
9	4.19	4.70
10	4.57	5.67
11	5.07	5.90
12	5.12	6.29

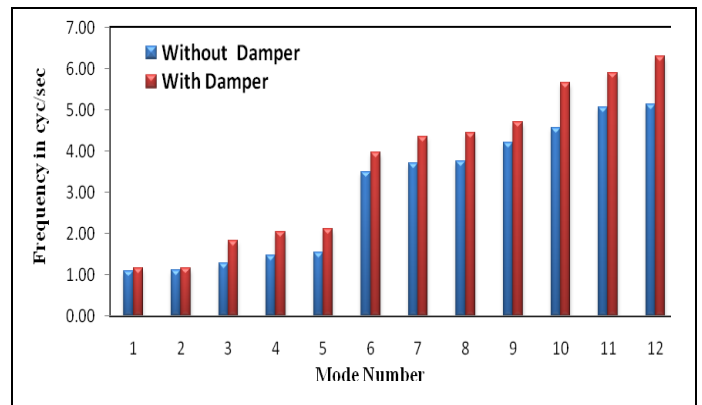


Chart-2: Comparison of mode number vs modal frequency

The chart-2 shows the comparison of mode number vs modal frequency, frequency of the first to higher modes goes on increases. Frequency of the tower without damper is less as compared to with damper, its value reduced to 6% for first mode and 18.60% for higher mode. This graph concluded that with the use damper frequency of the structure slightly increase in frequency of each mode number.

3.1.3 Base shear for different soil conditions

Table-5: Base shear for different soil condition

Sl.no	Types of soil	Base shear in kN	
		Without damper	With damper
1	Hard soil	20.36	20.77
2	Medium soil	27.69	28.25
3	Soft soil	34.00	34.69

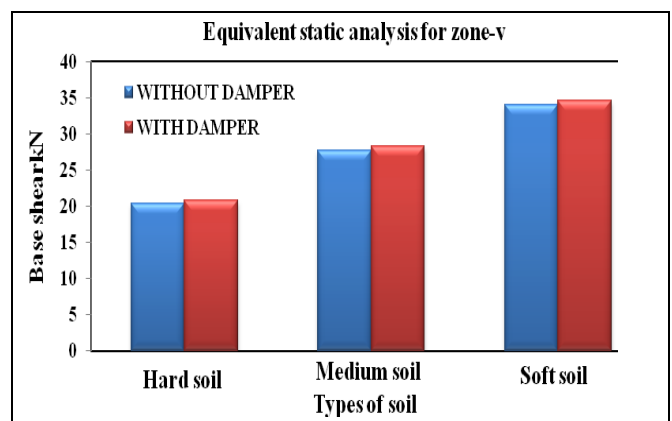


Chart-3: Base shear for different soil conditions

The chart-3 shows the base shear for different soil condition with considering severe earthquake i.e zone-V for without and with damper case. Maximum base shear value obtained for soft soil is 34 kN for without damper and 34.69 kN for with damper. With consideration of damper slightly increase in base shear due weight of damper considered in analysis and base shear values basically dependent on weight of the structure and soil condition. For hard soil to soft soil base shear values varies up to 40.11% it means that base shear largely depend on the type of soil.

3.1.4 Joint displacement for different soil conditions

Table-6: Displacement values for different soil conditions

Sl. No.	DISPLACEMENT (mm)		
	SOIL TYPE	WITHOUT AMPERS	WITH AMPERS
1	I (Hard soil)	14.86	13.57
2	II (medium soil)	20.21	18.46
3	III (soft soil)	24.82	22.66

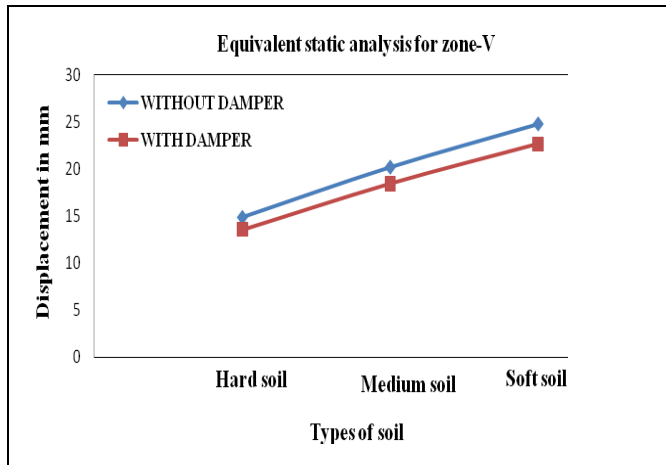


Chart-4: Joint displacement for different soil conditions

From the chart-4 concluded that joint displacement for hard soil is less compared to soft soil, its means that displacement of the structure largely dependent on type of soil in which the tower is going to construct. Displacement values vary from 8.68% to 8.75% for hard to soft soil for tower without and with damper. Variation of displacement values from hard soil to soft soil is 40.11% for both with and without damper application. Finally concluded that displacement of the tower significantly influence on the type of soil which is going to construct.

3.1.5 Base shear for different seismic zones

Table-7: Base shear for different zones

Sl. No.	ZONE	BASE SHEAR (KN)	
		WITHOUT DAMPERS	WITH DAMPERS
1	II	7.692	7.848
2	III	12.307	12.557
3	IV	18.460	18.835
4	V	27.690	28.253

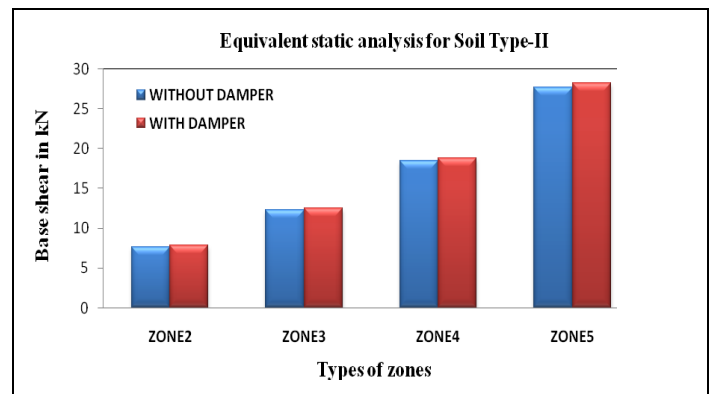


Chart-5: Comparison of base shear b/n different zones

The chart-5 shows base shear versus different seismic zones, base shear values slightly increases form 2% for without and with damper model. Since weight of damper included in analysis, base shear values varies from hard to soft soil is 72.22% for without damper. From this graph we concluded that base shear significantly dependent on type of soil.

3.1.6 Joint displacement values for different seismic zones.

Table-8: Displacement values for different zones

Sl. No.	DISPLACEMENT (mm)		
	ZONE TYPE	WITHOUT AMPERS	WITH AMPERS
1	II	5.16	5.12
2	III	8.98	8.20
3	IV	13.47	12.30
4	V	20.21	18.46

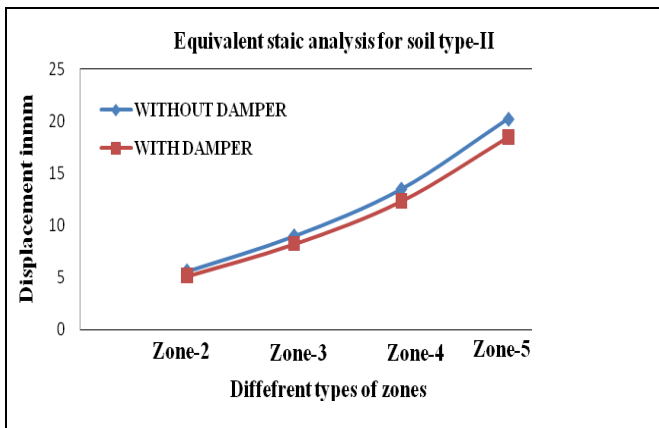


Chart-6: Joint displacement for different seismic zones

From the chart-6 observed that displacement values greatly influenced on different seismic zones and it varies from 75% to 72% for without and with damper tower model. In all zones it is observed that there is average reduction in 8.68% displacement with the application of dampers. From this analysis we concluded that joint displacement of the tower significantly depend upon the on which type of zone it is going to construct.

3.2. RESPONSE SPECTRUM ANALYSIS

The dynamic loads are applied on the tower structure using IS 1893: part 1, 2002. For the analysis was done on different seismic zones from II to V and with assuming different soil condition from hard to soft soil. The following parameters used for analysis of tower in response spectrum method are damping as 5%. The important factor (I) = 1.5 and response reduction factor (R) = 5.

3.2.1 Displacement values for different types of soil

Table-9: Joint displacement for different soil types

Sl. No.	DISPLACEMENT (mm)		
	SOIL TYPE	WITHOUT DAMPERS	WITH DAMPERS
1	I (Hard soil)	119.40	107.31
2	II (Medium soil)	161.12	145.98
3	III (Soft soil)	196.22	178.77

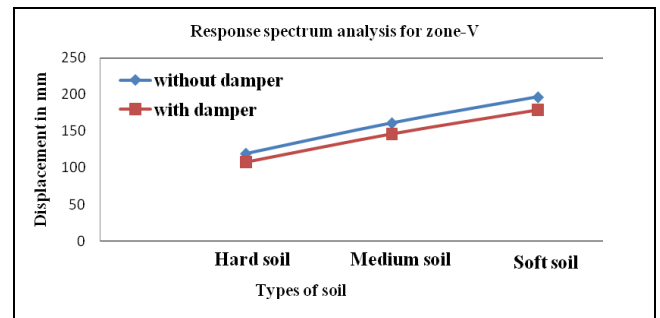


Chart-7: Displacement values for different types soil.

The above chart-7 plotted displacement versus type soils along vertical and horizontal direction respectively, displacement values varies lineally for different types of soil and maximum % of reduction in displacement from medium to hard soil is 40% for both with and without damper. Displacement values decrease for without damper compared to with damper & it varies 10% for hard soil.

3.2.2 Displacement values for different types of zones

Table-10: Displacement values for different zones

Sl. No.	DISPLACEMENT (mm)		
	TYPES F ZONES	WITHOUT DAMPERS	WITH DAMPERS
1	II	44.75	40.55
2	III	71.61	64.88
3	IV	107.41	97.32
4	V	161.12	145.98

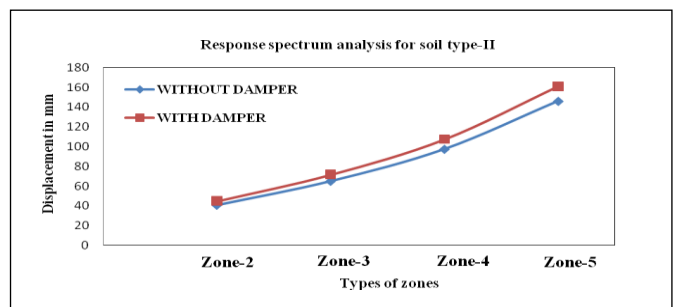


Chart-8: Displacement values for different seismic zones

From the above chart-8 shows the variation of displacement results for different types of zones varies parabolic. Maximum % of reduction in displacement is 72.22% from zone-II to zone-V and for all zones without and with damper values varies up to 9.4%.

3.2 TIME HISTORY ANALYSIS

The time history analysis is applicable for both elastic and inelastic analysis, in case of elastic stiffness characteristics are assumed to be constant for whole duration of earthquake. The modification to structural stiffness caused by cracking, formation of plastic hinges. El-Centro data have been used in this analysis.

3.3.1 Maximum peak displacement for time analysis

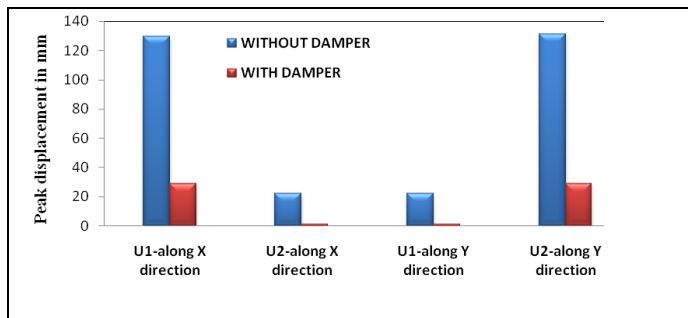


Chart-9: Maximum peak displacement at joint 115.

From the above chart-9 shows peak displacement for both without and with damper for time history analysis the displacement is more towers without damper compared to with damper. Along X-direction displacement reduces to 100.46mm and along Y-direction is reduced 21.3mm.

3.3.2 Maximum peak acceleration (m/s²) for time history analysis:

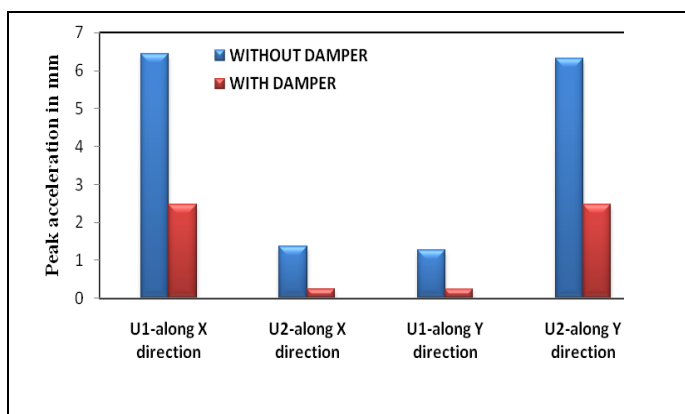


Chart-10: Maximum peak acceleration at joint 115.

From the above chart-10 maximum peak acceleration values are more for without damper compared to with damper and maximum reduction of peak displacement values along Y-direction compared to X-direction is about 82%. Hence it can be concluded that with damper in tower model values for both displacement as well as acceleration decreases compared to without damper.

4. CONCLUSIONS

- From the modal analysis it can be concluded that tower will have more stiffness with the introduction of damper since there will be reduction in time period between 5% to 20%.
- From the equivalent static analysis it can be concluded that, the type of soils and Zones in which tower is located influence the base shear of the tower. For soft soil base shear will be 40.11% more compared to hard rock. With the introduction of dampers variation of base shear values for both different types of soils and different seismic zones is 2%. Hence it can be concluded that with the use of damper base shear values will not be very much.
- From ESA Dampers will have more effective in controlling the displacement of the tower, maximum displacement has increased merely up to 40.12% from hard soil to soft soil for without and with damper. With the introduction of damper there will be a significant reduction of displacement 8.70% for all type of soil.
- With the introduction of damper in tower model displacement values for different zones will be reduced up to 8 to 10%. Hence due to application of damper there can be control the displacement in seismic regions.
- From response spectrum analysis variation of displacement results for different soils is 8% to 10% for all type of soils with comparison of without and with damper. For different seismic zones displacement results also vary the same from 8 to 10% compared to without and with damper. Hence it can be concluding that displacement values will not vary much for types of soil and seismic zones due to use of damper.
- From time history analysis, it can be concluded that 77% of maximum peak displacement can be reduced with the introduction of dampers and there will be reduction in acceleration up to 62% with the effective use of dampers in the towers which is allowable.
- Dampers will have more effects on dynamic analysis compared to Equivalent static analysis.
- Hence from the present study, it can be concluded that the overall performance and stability of the telecommunication tower can be increased with the introduction of the damping system.

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BIOGRAPHIES



Ashok N Meti, Perusing his M.Tech. in Structural Engineering, Civil Engineering Department, Government Engineering College HAVERI-581 110. And he obtained his B E in Civil Engineering from Basaveshwar College of Engg. Bagalkot affiliated to VTU, Belagavi



Mr. Vinayak Vijapur presently working as Assistant Professor, Dept of Civil Engineering, Government Engineering College, HAVERI-581 110. He has obtained his M.Tech. [CADSS] from University B.D.T. College of Engineering, Davangere-577004, Karnataka state, affiliated to Kuvempu University.