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Experimental Study of Seismic Behaviour of Multi-storied Framed Structure connected with Viscous Fluid dampers and Lumped masses

P. K. Deshpande, Vaibhav Shelar
College of Engineering, Karad 415124, Shivaji University, Kolhapur, Maharashtra, India
email: vaibhav2582@gmail.com

Abstract- ***Current trends in construction industry demands taller and lighter structures, which are also more flexible and having quite low damping value. This increases failure possibilities and also problems from serviceability point of view. The dynamic response of building structures due to earthquakes is very important to Civil engineers. Structures expose to earthquake excited vibrations are damaging to their structures components. Vibration control is having its roots primarily in aerospace related problems such as tracking and pointing, and in flexible space structures, the technology quickly moved into civil engineering and infrastructure-related issues, such as the protection of buildings and bridges from extreme loads of earthquakes and winds. The number of tall buildings being built is increasing day by day. Today we cannot have a count of number of low-rise or medium rise and high rise buildings existing in the world. Mostly these structures are having low natural damping. So increasing damping capacity of a structural system, or considering the need for other mechanical means to increase the damping capacity of a building, has become increasingly common in the new generation of tall and super tall buildings. But, it should be made a routine design practice to design the damping capacity into a structural system while designing the structural system. Now-a-days several techniques are available to minimize the vibration of the structure. The aim of the present work is to study the effect of Viscous Fluid damper and Lumped Masses on the dynamic response of multi-stored frame structures under earthquake excitations and the seismic response of frame structure model (one bay and three storied) for frequency, Amplification factor and lateral forces at different floor along X and Y direction for following cases (Experimental analysis).***
a) Analysis without damper and without lumped mass applied to the model
b) Analysis without damper and with lumped mass and
c) Analysis without lumped mass and with damper.

And the comparative study is made for above three conditions. The investigation is also carried out for effectiveness of the damping in terms of the percentage reduction in force of second & third floor with respect to first floor when dampers are connected diagonally.

Keywords Viscous Fluid Dampers, Lumped Masses, Amplification Factor, Lateral forces

1. Introduction

New civil engineering structures tend to be lighter, more slender and have smaller natural damping capacity than those of their older counterparts. This trend has increased the importance of damping technology to mitigate earthquake and wind-induced vibrations. The control of structural vibrations produced by earthquake or wind can be done by various means such as modifying rigidities, masses, damping, or shape, and by providing passive or active counter forces. To date, some methods of structural control have been used successfully and newly proposed methods offer the possibility of extending applications and improving efficiency.

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The selection of a particular type of vibration control device is governed by a number of factors which include efficiency, compactness and weight, capital cost, operating cost, maintenance requirements and safety.

2. Materials and Methods

2.1 Structural Model Details (Aluminum Structure)

Figure 2.1 Framed Structure

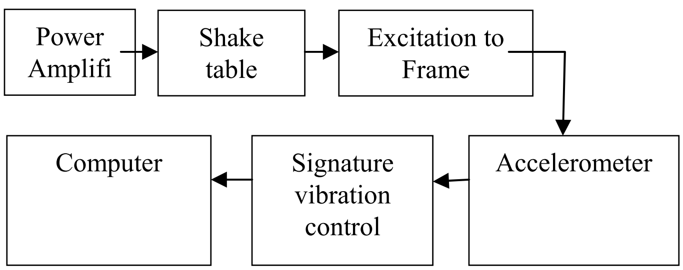
The physical properties of different sections are shown in table 2.1

Section	Material	Mass (m) Kg	Depth (D) mm	Width (B) mm	Length (L) mm	Material properties	
						Young's Modul	Mass Density (ρ)

						us (E) GPa	kg/m3
Column	Aluminum	0.269	10	25	400	69	2700
Slab	Aluminum	1.418	12	150	300	69	2700

The viscous fluid dampers which were used in the experimental work are of mass 0.211 kg , which contains viscous fluid SAE 90. Along with this for measuring acceleration at each floor level 1 D accelerometer was installed. A lumped mass of 500 gm (Calibrated) was installed as per the range of shake table

2.2. Experimental Setup



2.3 Methodology

Following methodology will be adopted for proposed work:

1. Literature Survey will be made through journals, reference books, technical magazines and also through internet & IS Codes.
2. Structural requirements will be finalized to follow technical concept of framed Structure and it will be compatible with existing shake table .

4. Selection of material will be done from the recommendations of ARAI.
5. Fabrication of the framed structure of suitable size.
6. Examine the seismic behavior of model under excitation using shake table along X direction (longer side parallel to excitation) and Y direction (shorter side parallel to excitation). the model was tested for fixed base acceleration " g " with varying frequencies (in the range of 5 Hz to 60 Hz)
7. Comparison of lateral force for following cases
   a) Analysis without dampers and without lumped masses applied to the model,
   b) Analysis without dampers and with lumped masses and
   c) Analysis without lumped masses and with dampers.

2.4 Experimental Analysis

The experimental work was carried on multi storied aluminum frame model (one bay three storied) to study the behavior in terms of acceleration and lateral force at each story level along X direction and Y direction respectively. Total 30 cases were performed, with 15 cases along X direction and 15 cases along Y direction. Following is the list of different cases:

Table 2.4.1 Different types of conditions along X and Y Direction

Sr. No	**Different types of conditions**
1	Without dampers and without Lumped masses
2	Without dampers and with Lumped masses
i	Lumped masses on all floors
ii	Lumped masses on 2nd and 3rdfloor
iii	Lumped masses on 1st and 2nd floor
iv	Lumped masses on 1st and 3rd floor
v	Lumped masses only on 3rd floor
vi	Lumped mass only on 2nd floor
vii	Lumped mass only on 1st floor
3	Without Lumped masses and with dampers
i	Dampers connected at all floors
ii	Dampers connected at 2nd and 3rd floor
iii	Dampers connected at 1st and 2nd floor
iv	Dampers connected at 1st and 3rd floor
v	Damper connected only at 3rdfloor
vi	Dampers connected only at 2ndfloor
vii	Damper connected only at 1st floor

Graphical variation of Frequency and Amplification factor

Along X Direction:

1) Analysis without damper and without lumped mass applied to the model

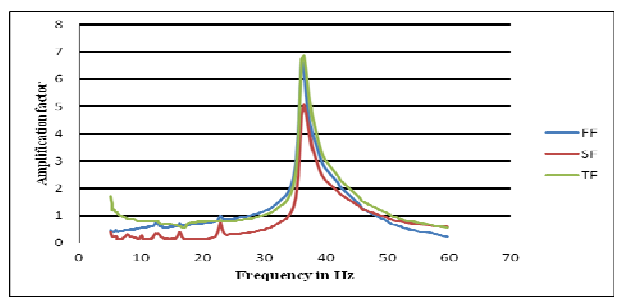


Figure 2.4.A.1 Graph Frequency Vs Amplification Factor

2.i) Lumped masses on all floors (500gm on each floor)

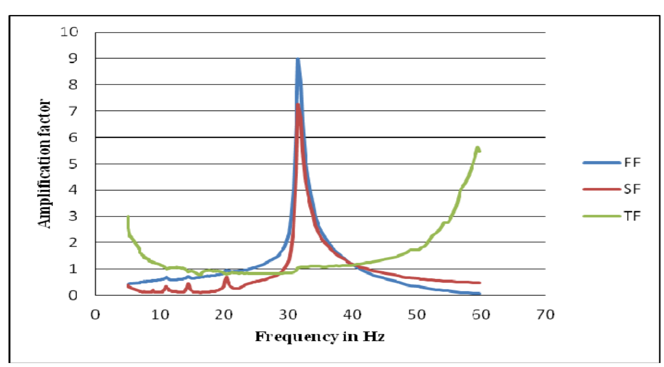


Figure 2.4.A.2 Graph Frequency Vs Amplification Factor

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3) Analysis without damper and without lumped mass applied to the model

i) Dampers Connected at all floors

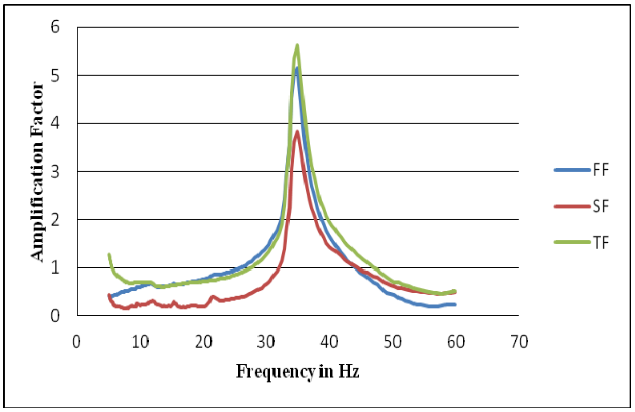

Figure 2.4.A.3 Graph Frequency Vs Amplification Factor

Along Y direction:

1) Analysis without damper and without lumped mass applied to the model

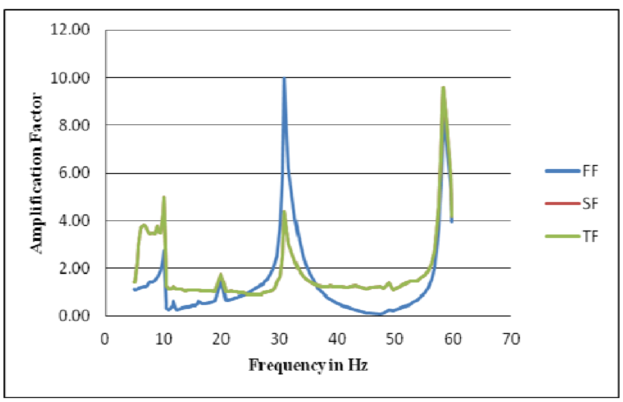

Figure 2.4.B.1 Graph Frequency Vs Amplification Factor

2. i) Lumped masses on all floors (500gm on each floor)

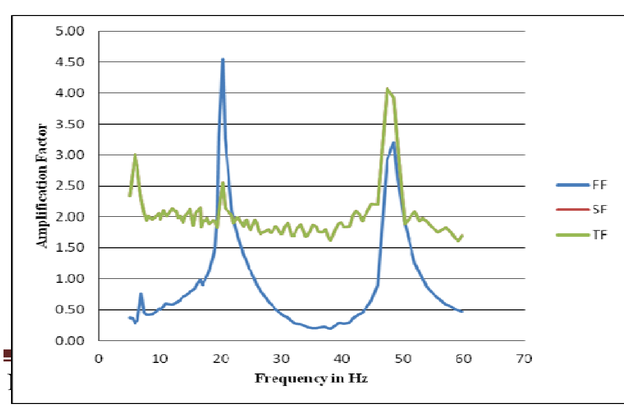

Figure 2.4.B.2 Graph Frequency Vs Amplification Factor

3) Analysis without damper and without lumped mass applied to the model

i) Dampers Connected at all floors

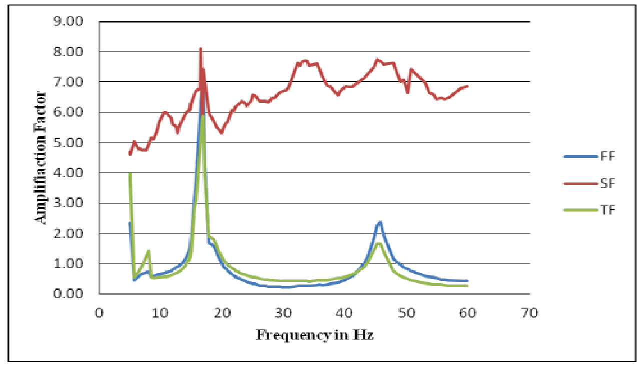

Figure 2.4.B.3 Graph Frequency Vs Amplification Factor

2.5 Experimental Results

Table 2.5.1: Percentage reduction in lateral force along X direction

Sr. No	Different types of conditions	% Reduction in Lateral Force	
		SF wrt FF	TF wrt SF
1	Without dampers and without Lumped masses	20.5↓	15.66↓
2	Without dampers and with Lumped masses		
i	Lumped masses on all floors	19.45↓	15.27↓
ii	Lumped masses on 2nd and 3rdfloor	0	0
iii	Lumped masses on 1st and 2ndfloor	29.33↓	19.79↓
iv	Lumped masses on 1st and 3rd floor	41.06↓	27.37↓
v	Lumped masses only on 3rd floor	27.1↓	17.26↓
vi	Lumped mass only on 2nd floor	9.93↓	4.29↓
vii	Lumped mass only on 1stfloor	40.25↓	45.68↓
3	Without Lumped masses and with dampers		
i	Dampers connected at all floors	22.89↓	15.92↓
ii	Dampers connected at 2nd and 3rdfloor	23.22↓	15.64↓
iii	Dampers connected at 1st and 2nd floor	39.86↓	20.45↓
iv	Dampers connected at 1st and 3rdfloor	25.18↓	14↓
v	Dampers connected only at 3rd floor	21.88↓	8.79↓
vi	Dampers connected only at 2ndfloor	28.42↓	24.41↓
vii	Dampers connected only at 1st floor	31.74↓	24.52↓

Table2.5.2 Percentage reduction in lateral force along Y direction

Sr. No	Different types of conditions	% Reduction in Lateral Force

		SF wrt FF	TF wrt SF
1	Without dampers and without Lumped masses	3.13↓	23.54↓
2	Without dampers and with Lumped masses		
i	Lumped masses on all floors	38.59↓	24.88↓
ii	Lumped masses on 2nd and 3rd floor	41.53↓	32.53↓
iii	Lumped masses on 1stand 2nd floor	60↓	28.93↓
iv	Lumped masses on 1st and 3rd floor	7.9↓	15.33↓
v	Lumped mass only on 3rd floor	13.43↓	18.45↓
vi	Lumped mass only on 2ndfloor	22.67 ↑	22.61↓
vii	Lumped mass only on 1st floor	58.16↓	34.99↓
3	Without Lumped masses and with dampers		
i	Dampers connected at all floors	15.94 ↑	37.54↓
ii	Dampers connected at 2nd and 3rd floor	22.59↓	22↓
iii	Dampers connected at 1stand 2nd floor	6.5↓	30.43↓
iv	Dampers connected at 1stand 3rd floor	15.2 ↑	24.14↓
v	Dampers connected only at 3rd floor	45.52↓	13.52↓
vi	Dampers connected only at 2nd floor	17.21↑	26.65↓
vii	Dampers connected only at 1st floor	3.84↓	31.89↓

As per the results obtained, following points were observed.

1. Due to presence of lumped masses and viscous fluid dampers, there is significant increase in amplification factor along X direction and reduction in amplification factor along Y direction.
2. Due to presence of lumped masses, there is increase in lateral force along X direction and Y direction.
3. Due to presence of viscous fluid dampers, there is significant reduction in lateral force along Y direction

2.6 Equation

The force/velocity relationship for this kind of damper can be characterized as F= C.V. α where F is the output force, V the relative velocity across the damper, C is the damping coefficient and α is a constant exponent which is usually a value between 0.3 and 1.0. Fluid viscous dampers can operate over temperature fluctuations ranging from –40°C to +70°C.

3. Conclusion

Multistoried framed structure model (G+2) has been tested for the seismic behavior under excitation using shake table along X direction (longer side parallel to excitation) and Y direction (shorter side parallel to excitation). the model was tested for fixed base acceleration " g " with varying frequencies (in the range of 5 Hz to 60 Hz) . From the experimental study following conclusions can be drawn.

1) It is observed that there is reduction in lateral force due to presence of viscous fluid dampers. This will lead to improvement in performance level of the structure.
2) The location of dampers has significant effect on response of the framed structure. It is advisable to provide dampers on all floors.

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