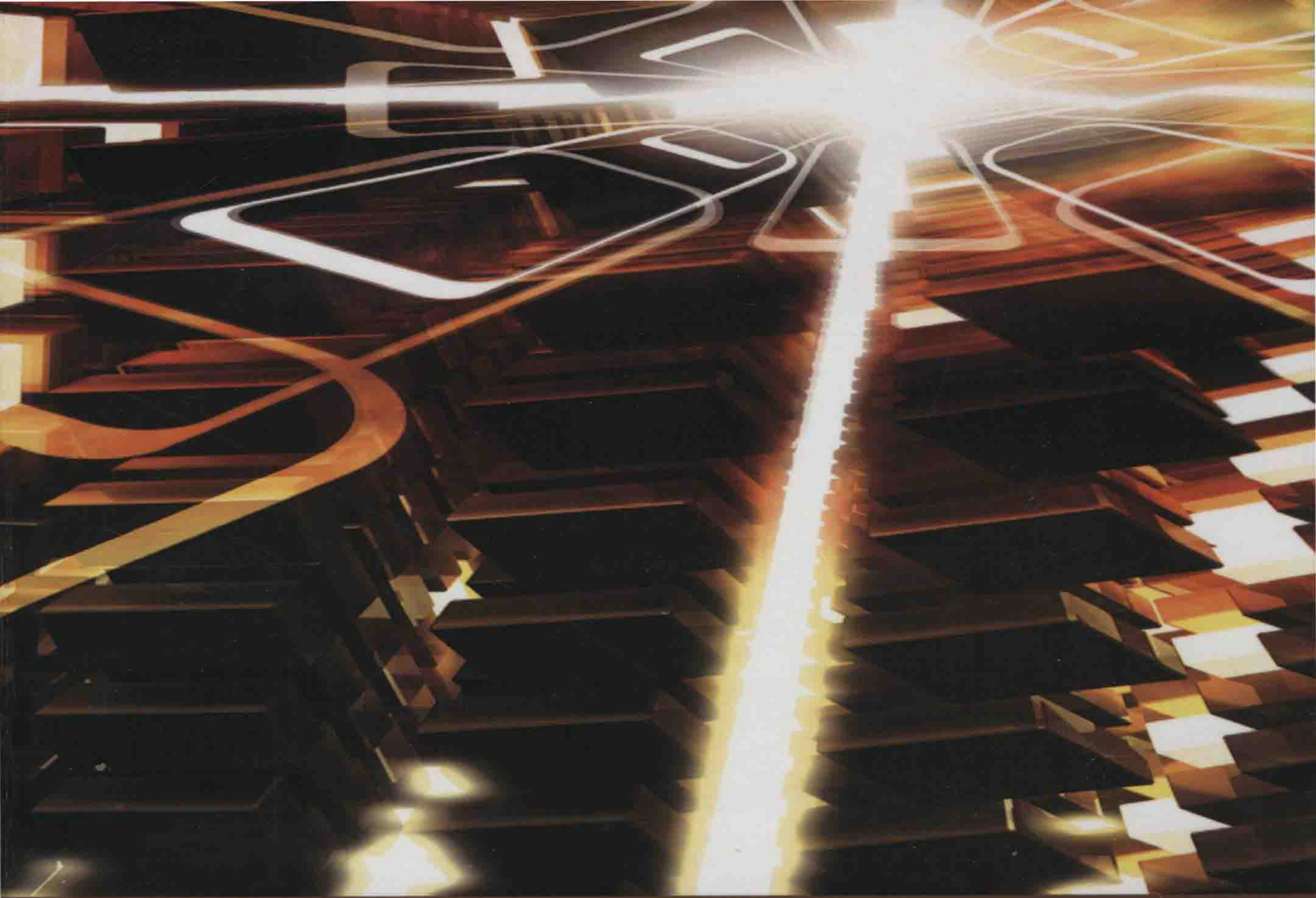

Advances in Dynamics, Vibration and Control

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PREFACE

The First International Conference on Advances in Dynamics, Vibration and Control (ICADVC 2016) was held at NIT Durgapur during February 25-27, 2016. This conference was organized jointly by the Department of Civil Engineering and Mechanical Engineering. The aim of ICADVC-2016 was to bring together the international leading scientists of dynamics, vibration and control communities, both theoreticians and experimentalists, and to present their original research work of very high quality. The themes of the conference were intended to be broad enough so as to cover most of the directions in dynamics, vibration and control, promoting wide interactions among different academic disciplines.

ICADVC 2016 received 129 full-length manuscripts to be considered for possible publication in the conference proceedings. All the papers were peer reviewed by two independent reviewers. Finally, 88 manuscripts have been included for presentation and publication in the conference proceedings. The presentations are planned in two parallel sessions (total of 15 technical sessions). Additionally two invited talks and two guest lectures are also planned. Prof. T. K. Datta, an eminent researcher enthralled the audience with his lecture on advances in structural dynamic control. Prof. G. Chakraborty, a leading researcher in MEMS and NEMS delivered an illuminating lecture on Dynamics and Vibration of MEMS and NEMS devices.

All in all, first ICADVC 2016 was very successful. This conference would not have been possible without the help and support of 75 reviewers of different parts of this country. We really thank them from bottom of our heart.

The advice and encouragement received from our Director, Deans and different administrative officers of NIT Durgapur, International scientific committee members were valuable in taking decisions at different stages of this conference.

We take this opportunity to thank organizing committee members for their enormous help and support. Financial supports extended by sponsors are duly acknowledged. It will be injustice if all delegates are not mentioned for their regards to this conference and participation. We also thank Narosa Publishing House, especially Mr. N. K. Mehra for publishing this proceeding in the Global Market. We thank our students Prasenjit, Buddhadeb, Prabas, Abhishek who worked hard to make this event in a presentable way.

Last but not the least we express our sincere thanks to family members for their encouragement and help to make this event successful.

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Atul Krishna Banik

CONTENTS

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MITIGATION OF SEISMIC RESPONSE OF FIVE STOREY BUILDING USING MULTIPLE TUNED MASS DAMPERS

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Abstract: The effectiveness of multiple tuned mass dampers (MTMD) to mitigate the vibration of building under real earthquake time history data is investigated in this paper. Different real earthquake data like Kobe, EL Centro, Uttar Kashi, Chamoli are considered. The multiple tuned mass damper (MTMDs) are installed at top of the building. The structure is tuned based on the fundamental frequency of building to the average frequency of dampers. Numerical study is performed to evaluate the effectiveness and robustness of MTMDs for real earthquake time history data. The structural responses like, displacement, acceleration, base shear and inter storey drift are evaluate using MTMDs and without damper also. It is investigated that the response reduction is more when MTMDs, configuration is 5 Nos. compare to MTMDs configuration is 3 Nos.
Keywords: Vibration Control, multiple tuned mass dampers, earthquake, time history.

1 INTRODUCTION

Recently, due to shortage of land space, economic requirements and new developments of construction techniques have caused an increased presence of tall building. Due to growing use of high-strength materials and advanced construction techniques, these tall buildings have become relatively light, flexible and lightly damped. The structural vibration caused by earthquake and wind loadings. The occupants, especially in the top floor of buildings are feeling discomfort due to structural vibration. Thus, mitigating the seismic responses of such structures have gain tremendous interest to the structural engineering researchers. Various vibration control scheme like tuned mass damper (TMD), tuned liquid column damper (TLCD), Liquid column vibration absorber (LCVA) are capable to mitigate the structural vibration due to dynamic loadings. The TMD has been implemented as an effective passive control device to mitigate the seismic response. The TMD is a passive vibration control device consisting of a mass, damping and a spring; it is installed on top of building for suppressing undesirable vibrations induced by earthquakes. The natural frequency of the TMD is tuned in resonance with the fundamental frequency of the building. Multiple tuned mass dampers (MTMDs) are considered in the present study. MTMDs with distributed natural frequencies were proposed by Xu and Igusa (1992) and also studied by Janjid and Datta (1995). Bergmam et al. (1989, 1991) investigated the performance of MTMDs, spatially distributed in a primary system. The effectiveness and robustness of MTMDS under dynamic load were studied by Yamaguchi and Harnpornchai (1993) Chen and Wu (2003) studied the seismic response of a three storey building by experimentally with some scaled earthquake data and found multiple dampers substantially superior to a single tuned mass damper to mitigate the floor acceleration. Daniel and Lavan (2013) using MTMDs tuned to various frequencies can efficiently reduce total accelerations within the structure and bring them to a desired level. Numerical example is taken to obtain the effectiveness of MTMDs considering various real earthquake time history data and overall safety.

2 THE EQUATION OF MOTION OF STRUCTURE AND MTMD SYSTEM

The equation of motion of a mdof system attached with MTMD (as shown in Fig.1) can be expressed as,

$$\mathbf{M}\mathbf{Y}+\mathbf{C}\mathbf{Y}+\mathbf{K}\mathbf{Y}=-\mathbf{M}\bar{\mathbf{r}}z_b \qquad (1)$$

Where, $\mathbf{Y}=[x_s,x_1,x_2,.........,x_n]^T$ is the relative displacement vector, and $\bar{\mathbf{r}}=[0 \quad \mathbf{I}]^T$, where I is an nx1 unit vector. M, C and K represent the mass, damping and stiffness matrix of the combined system. The natural frequencies of the MTMD are uniformly distributed around their average frequency. The natural frequency, $\omega_j\left(\mathrm{i,e}\sqrt{k_j/m_j}\right)$ of the jth

TMD expressed by

$$\omega_j=\omega_T\left[1+\left(j-\frac{n+1}{2}\right)\frac{\beta}{n-1}\right] \text{ and } \qquad \omega_T=\sum_{j=1}^{n}\omega_j/n,\ \beta=\frac{\omega_n-\omega_1}{\omega_T} \qquad (2)$$

Where, ω_T is the average frequency of all MTMD and β is the non-dimensional frequency bandwith of MTMD system.

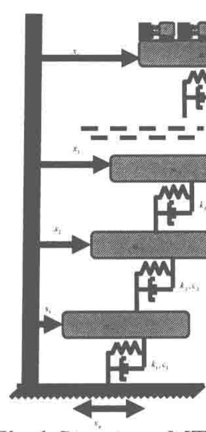

Fig.1 Structure-MTMD system.

The damping constant of the jth TMD is expressed as

$$c_j=2m_j\xi_T\omega_j \qquad (3)$$

Where, ξ_T is the damping ratio kept constant for all TMD. Total mass of the MTMD system is expressed by the mass ratio defined as,

$$\mu=\frac{\sum_{j=1}^{n}m_j}{m_s},\ f=\frac{\omega_T}{\omega_S} \qquad (4)$$

Where, μ is the mass ratio of the MTMD system and is the tuning frequency ratio of the MTMD system.

3 NUMERICAL STUDY

The A five storey building with MTMD subjected to real earthquake time history data is undertaken to study the performance of the proposed MTMD. The MTMDs are installed at top storey. The building has the following mass and stiffness values:

$m_1 = m_2 = m_3 = m_4 = 136.2\times10^3$ kg, m_5=126.40×10^3 kg, $k_1 = k_2 = 415.46\times10^6$ N/m

$k_3 = k_4 = k_5 = 415.46\times10^6$ N/m. Unless mentioned otherwise, following nominal values are assumed for various parameters: damping ratio of structures, $\xi_s = 5\%$, mass ratio, $\mu = 5\%$ & frequency ratio, $\beta = 0.30$. The fundamental natural frequency of the building (f_1 = 1.46055 hz) is tuned by frequency of MTMD, which is determined by the equation 2. All four records with their two components are normalized to a maximum acceleration level of 0.6 g.

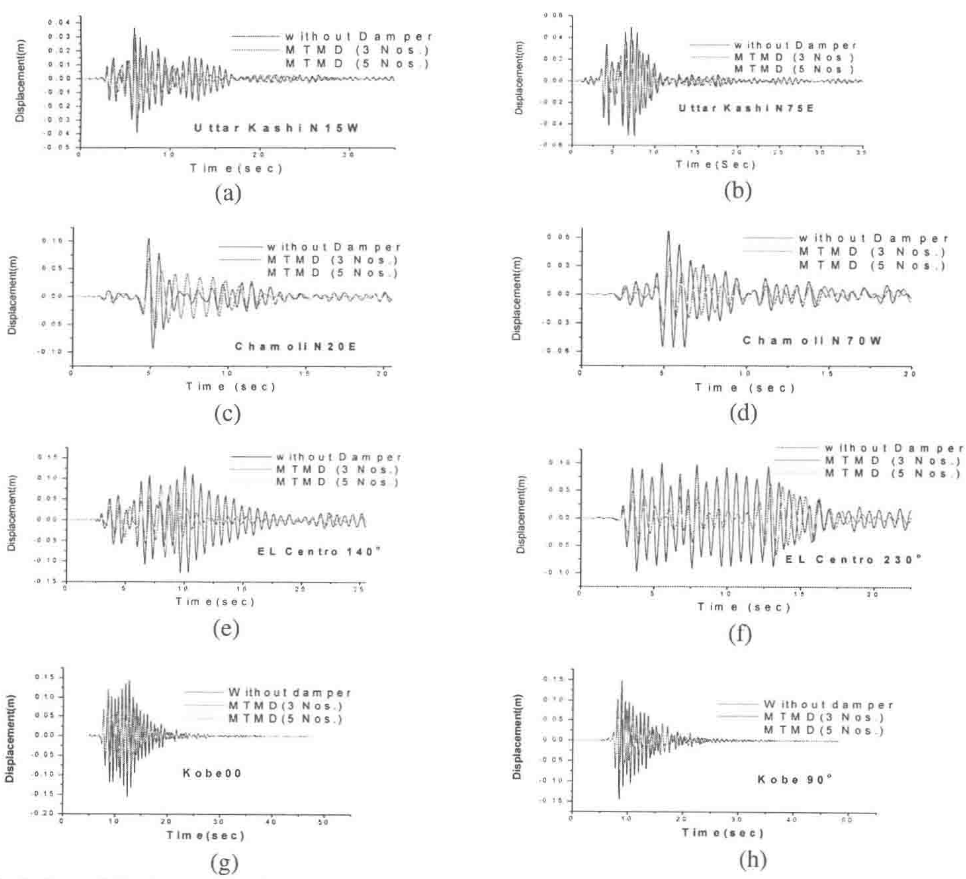

Fig.2 Variation of displacement of structures (a) Uttar kasha N15W (b) Uttar kasha N75E (c) Chamoli N20E, (d) Chamoli N70W (e) El Centro 140° (f) El Cento 230° (g) Kobe 00° (h) Kobe 90°

The variation of displacements of structures with time considering time history data of Uttar kashi, Chamoli and Kobe, EL Centro earthquake, using MTMD and with dampers are shown in Fig. 2. It is observed that the MTMD is more effective (when Nos. are more) to reduce the displacement of building. The reduction of the maximum displacement at top storey considering different earthquake ranges 50-65% using MTMD (when Nos. are five). The reductions are found 20-45% for 3 Nos. MTMD used. The variation of accelerations at top storey of building with time history data of different earthquake, using MTMD and with damper are shown in Fig. 3. It is observed that the MTMD (when 5 Nos.) is more effective to reduce the accelerations at top storey of building with compare to MTMD (3Nos.). The acceleration reductions at top are observed 60-75% using MTMD when Nos. are five, but the same was observed 25-50% for 3 Nos. of MTMD cases.

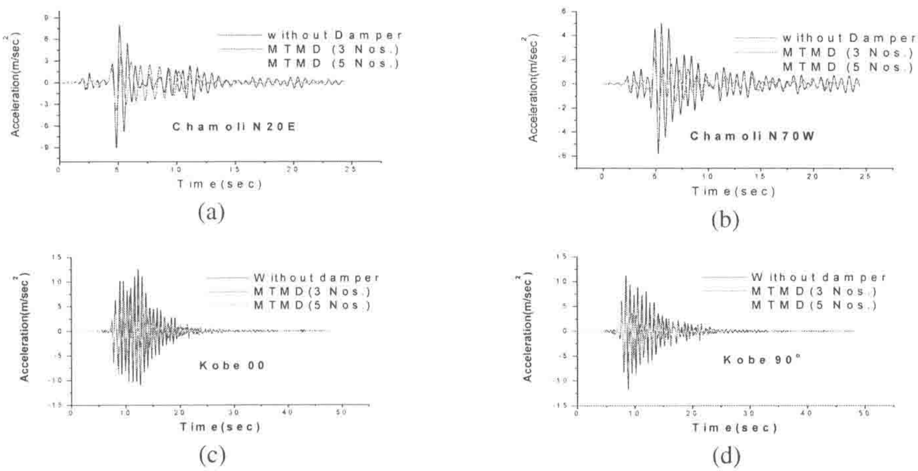

Fig.3 Variation of acceleration of structures (a) Chamoli N20E, (b) Chamoli N70W (c) Kobe 00° (d) Kobe 90°

The base shear of building with MTMD and without dampers is shown in Figs.4 for different real earthquake time history data. It is observed that the maximum reduction of base shear considering MTMD (5 Nos.) with compare to MTMD (3 Nos.). The variation of displacements at storey level of structures considering time history data of different earthquake using MTMD and without damper are shown in Fig 5. From these Figs, it can be seen that MTMDs (when Nos. 5) are more effective with compare to MTMDs configuration (3 Nos.).

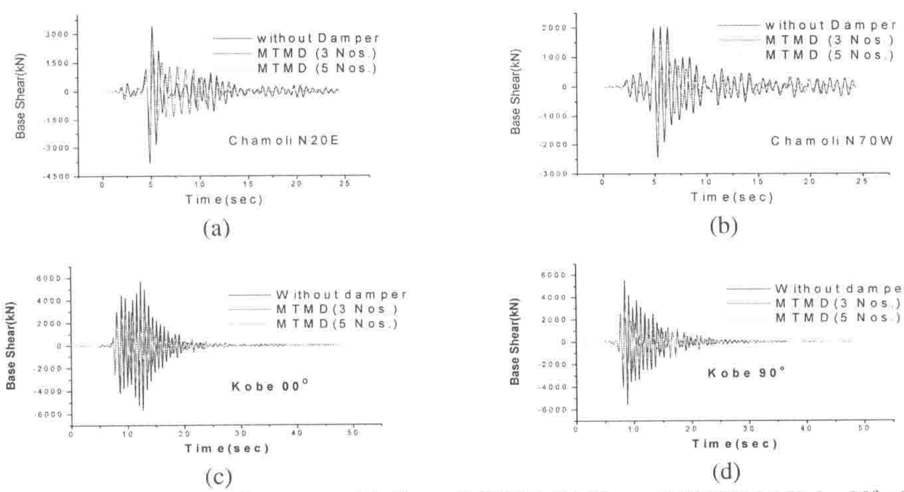

Fig.4 Variation of base shear of structures (a) Chamoli N20E, (b) Chamoli N70W (c) Kobe 00° (d) Kobe 90°

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