

TMD가

$$m_d(\ddot{u} + \ddot{u}_d) + k_d u_d + c_d \dot{u}_d + f_s \operatorname{sgn}(\dot{u}_d) = -m_d \ddot{x}_g \quad (1-b)$$

TMD

가 TMD

TMD

, u , u_d TMD

, m, c, k

. m_d TMD

, c_d, k_d TMD

가

가

. f_s

TMD

(slip-load)

, $\operatorname{sgn}(\cdot)$

가

-TMD

TMD

가

TMD

Hartog

TMD

. Den

. TMD

TMD

가

(4). Warburton

$$\mu = m_d / m \quad (2)$$

가

TMD

가

. Ioi Ikeda

가

가

가 2%

(1978), Tsai Lin(1993)

substructure TMD

. Feng

Mita

Mega-substructure TMD

가

(6-7). Sadek

TMD

10%

(9).

TMD

TMD가

(8).

TMD

가

TMD

TMD

가

가

$$\omega_d^2 = k_d / m_d \quad (3-a)$$

TMD

$$\xi_d = c_d / 2\omega_d m_d \quad (3-b)$$

TMD

TMD

가

TMD

$\omega (= \sqrt{k/m})$

TMD

ω_d

$$f = \omega_d / \omega \quad (4)$$

2.

1

TMD

($\xi = c/2\omega m$),

TMD

, 2

1

TMD가

2

가

TMD

가

가

$$m\ddot{u} + c\dot{u} + ku = -m\ddot{x}_g + k_d u_d + c_d \dot{u}_d + f_s \operatorname{sgn}(\dot{u}_d) \quad (1-a)$$

가 가
가

Table 1. Optimum tuning frequency ratio of TMD attached to damped structures

Case	Excitation	Optimization criteria	Optimal f	Researcher
1	Base	The first two modes of the structure with TMD has equal damping ratios	$\frac{1}{1+\mu} \left[1 - \xi \sqrt{\frac{\mu}{1+\mu}} \right]$	Sadek et al. (1997)
2	Structure	Minimization of the higher of the two peaks in the displacement amplification curves	$\frac{1}{1+\mu} - (0.241 + 1.7\mu - 2.6\mu^2)\xi$ $- (1.0 - 1.9\mu + \mu^2)\xi^2$	loi and Ikeda (1978)
3	Structure	Maximization of the effective damping of the structure-TMD system	$\left(\frac{\sqrt{1-0.5\mu}}{1+\mu} + \sqrt{1-2\xi^2} - 1 \right) -$ $(2.375 - 1.034\sqrt{\mu} - 0.426\mu)\xi\sqrt{\mu} -$ $(3.730 - 16.903\sqrt{\mu} + 20.496\mu)\xi^2\sqrt{\mu}$	Tsai and Lin(1993)
4	Base	Minimization of RMS displacement of main structure	$\frac{1}{1+\mu} \sqrt{\frac{2-\mu}{2}}$ (for $\xi = 0$) Numerical values (for $\xi \neq 0$)	Warburton (1982)

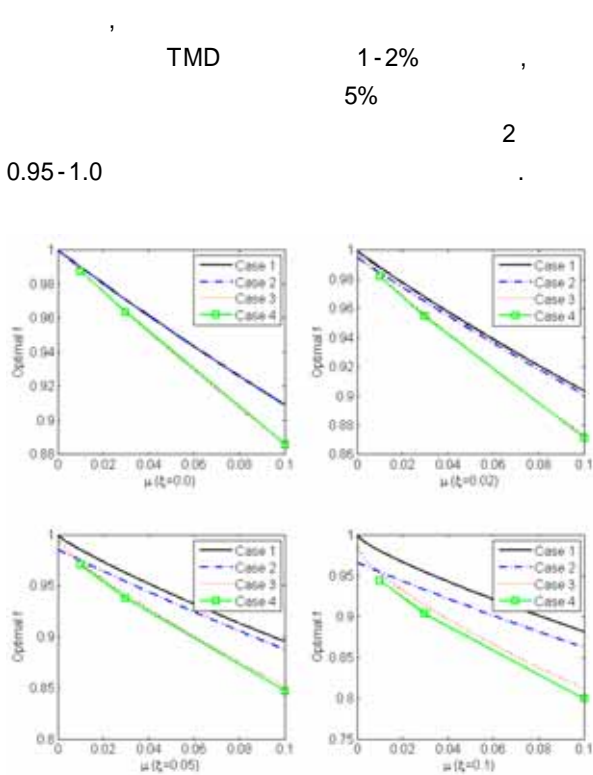


Figure 2. Optimal tuning frequency ratios by 4 previous studies

TMD 1-2% 5% 10% 20%

TMD 가 TMD 가 TMD 가 TMD 가

0.95-1.0 3. 가 가

가 TMD가 가 가

가 가 $\ddot{x}_g = p_0 \sin \omega t$, 가 ω

ω_n $\beta (= \omega / \omega_n)$ $0.1 \leq \beta \leq 2.0$

0.01 가 RMS

, TMD

$$J_x = \int_{\omega_1}^{\omega_2} D(\omega) d\omega \quad (5)$$

3 가 0.4 가 2% 2% 가 TMD가 3(a)

TMD 0 가

3(b) 0 가

TMD TMD가 TMD TMD

TMD 가 TMD가 TMD가 J_x 0

peak 가 peak 가 J_x , J_x

TMD 가 가 가 가 가

가 가 J_x J_x 가 J_x

peak 가 가 J_x J_x

TMD 가 가 TMD J_x J_x

TMD 가 가 TMD 가

가 가 TMD 가

가 가 TMD 가

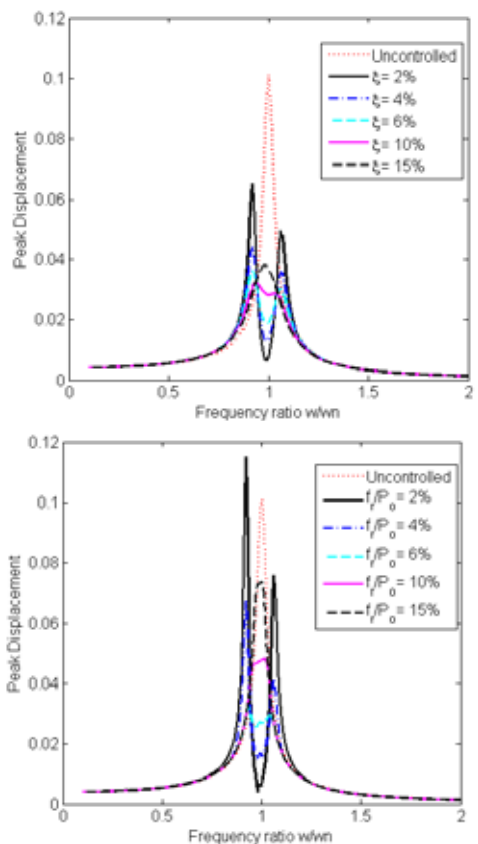


Figure 3. Peak displacement induced by sinusoidal base excitation

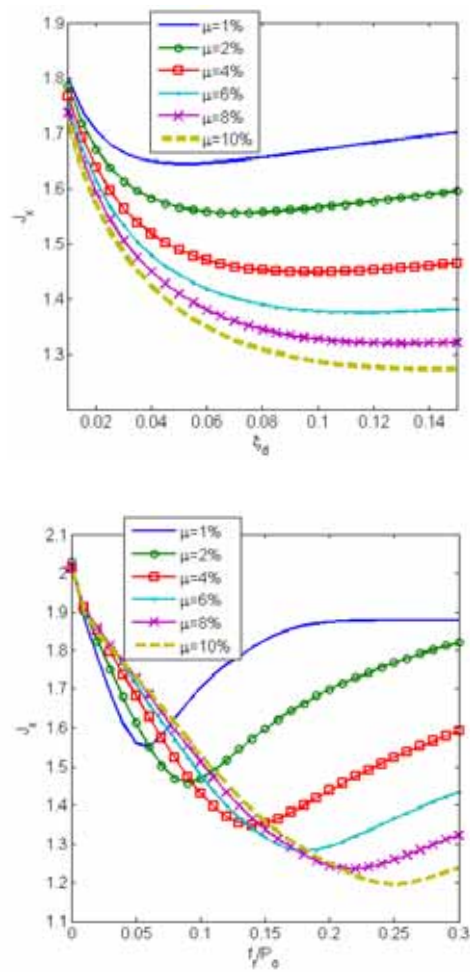


Figure 4. The variation of J_x

4 3 가 5 2% 5% 가 TMD

J_x
 J_x

가 TMD 가

가 , 가

가 가 가

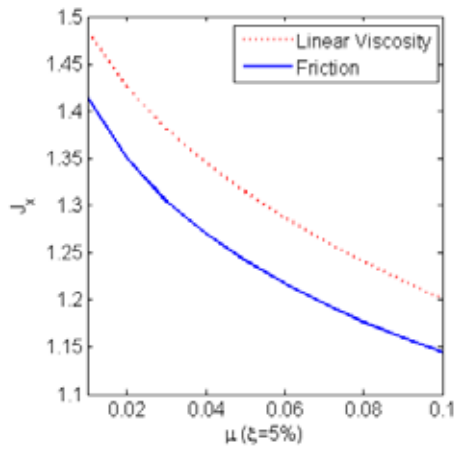
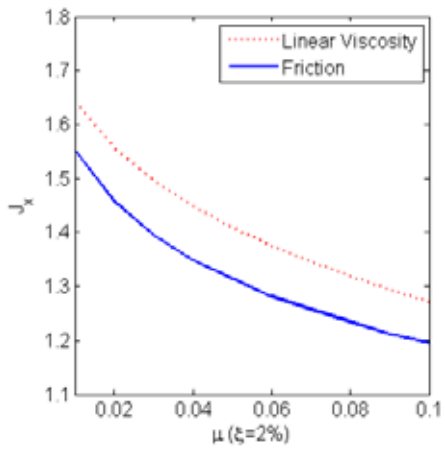


Figure 5. Comparison of minimized J_x by linear viscosity and friction

6 TMD

가 가
가 가 , 가 가
가 2%

2%-12% 가
TMD
2% TMD 가

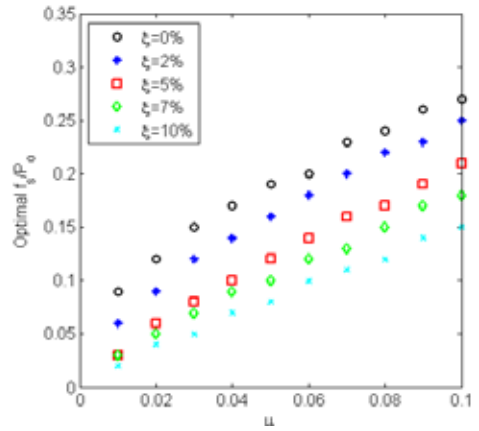


Figure 6. Optimal friction force

4.

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- (1) Chu S. Y., Soong T. T. and Reinhorn A. M., 2005, "Active, Hybrid and Semi-active Structural Control – A Design and Implementation Handbook", John Wiley & Sons, West Sussex, England, chap.1.
- (2) Choi S. J., Yoo M. S., Ahn S. G. and Park C. H., 2003, "Effective Vibration Control of Existing Footbridge Using Tuned Mass Damper", Proceedings of KSNVE Annual Autumn Conference, pp.263-269.
- (2) Soong T. T. and Dargush G. F., 1997, "Passive Energy Dissipation Systems in Structural Engineering", John Wiley & Sons, New York, chap.7.
- (3) Yalla S. K., 2001, "Liquid Dampers for mitigation of structural response: Theoretical Development and Experimental validation", Ph.D. Thesis, University of Notre Dame.
- (4) Den Hartog J. P., 1956, "Mechanical Vibrations, 4th Edition", McGraw-Hill, New York.
- (5) Warburton G. B., 1982, "Optimal Absorber Parameters for Various Combinations of Response and Excitation Parameters", Earthquake Engineering and Structural Dynamics, Vol.10, pp.381-401.
- (6) Ioi T. and Ikeda K., 1978, "On the Dynamic Vibration Damped Absorber of the Vibration System", Bulletin of Japanese Society of Mechanical Engineering, Vol.21, pp.64-71.
- (7) Tsai K. C. and Lin G. C., 1993, "Optimum Tuned-mass Dampers for Minimizing Steady-state Response of Support-excited and Damped Systems", Earthquake Engineering and Structural Dynamics, Vol.22, pp.957-973.
- (8) Sadek F., Mohraz B., Taylor A. W. and Chung R. M., 1997, "A Method of Estimating the Parameters of Tuned Mass Dampers for Seismic Applications", Earthquake Engineering and Structural Dynamics, Vol.26, pp.617-635.
- (9) Feng M. Q. and Mita A., 1995, "Vibration Control of Tall Buildings Using Mega Subconfiguration", Journal of Engineering Mechanics ASCE, Vol.121, pp.1082-1088.