

TMD

Optimal design of tuned mass damper considering the friction between the moving mass and the rail

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Key Words : Tuned Mass Damper (), Friction Force(), Optimal Design ()

ABSTRACT

In this study, based on the results from the sinusoidal base excitation analyses of a single degree of freedom system with a tuned mass damper (TMD), it is verified that optimal friction force can improve the performance of a TMD like a linear viscous damper which has been usually used in general TMD. The magnitude of the optimal friction increases with increasing mass ratio of the TMD and decreases with increasing structural damping. Particularly, it is observed that the optimized friction force gives better control performance than the optimized viscous damping of the TMD. However, because the performance of the TMD considerably deteriorates when the friction force increases over the optimal value, it is required to keep the friction force from exceeding the optimal value.

1.

(Tuned mass damper, TMD), 가

(Active mass damper, AMD), TMD

가 (Hybrid mass damper, 가 가

HMD)가 (1). TMD(2), TMD

TMD가 가

,

(2). 가

가

TMD 가

가 가 TMD

TMD

가 ,

(Tuned liquid damper, TLD)

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TMD
TLD가 (3)

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

$$\omega_d$$

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

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 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)

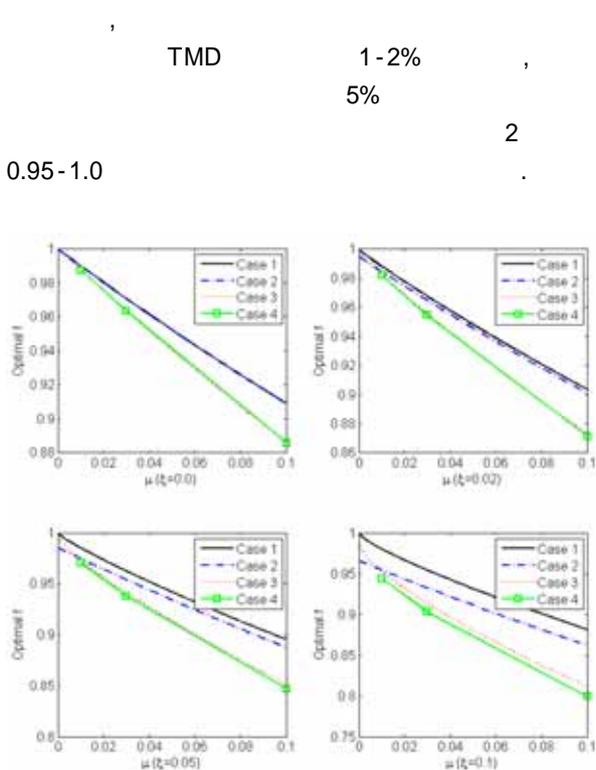


Figure 2. Optimal tuning frequency ratios by 4 previous studies

TMD 1-2% 5% 2 가 TMD 가 0.95-1.0 3. 가 가 TMD가 가 가 $\ddot{x}_g = p_0 \sin \omega t$, 가 ω_n $\beta (= \omega / \omega_n)$ $0.1 \leq \beta \leq 2.0$ 0.01 가 RMS , TMD $J_x = \int_{\omega_1}^{\omega_2} D(\omega) d\omega$ (5) 3 가 0.4 가 2% 2% 가 TMD가 3(a) TMD 0 가 3(b) 0 가

J_x
 J_x

가 TMD 가

가 , 가

가 가 가

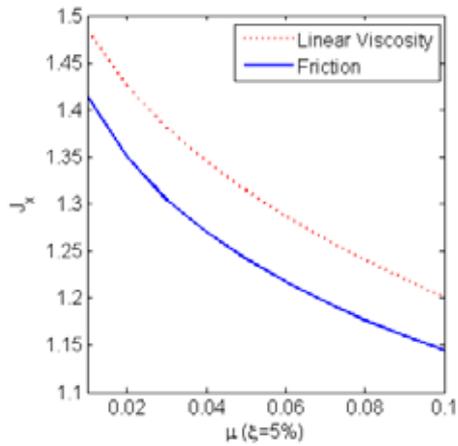
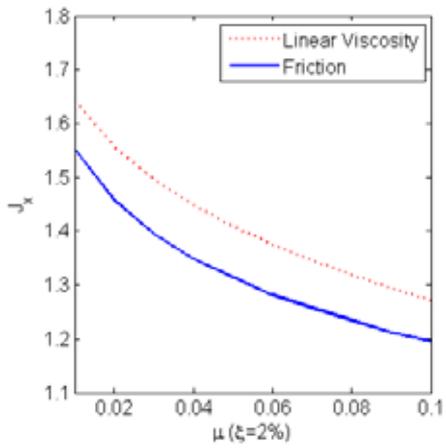


Figure 5. Comparison of minimized J_x by linear viscosity and friction

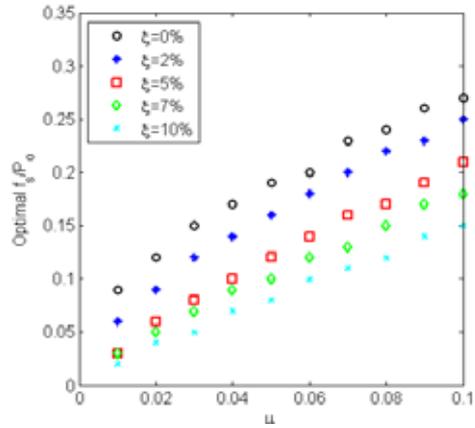


Figure 6. Optimal friction force

4.

가 TMD TMD
 가 TMD 가 가 가
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 가 TMD 가
 TMD 가
 가 가 가
 가 , 가

6 TMD

가 가
 가 가 , 가 가
 가 2%

2%-12% 가
 TMD
 2% TMD 가

가 (: 05- -D06)

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