Experimental vibration analysis of seismic isolation system using inertial mass damper

Ryo Masano, Nanako Miura and Akira Sone

June 25, 2019

Experimental vibration analysis of seismic isolation system using inertial mass damper

Ryo Masano[1], Nanako Miura[1], and Akira Sone[1]

[1]Kyoto Institute of Technology, Matsugasaki, Sakyo-ku, Kyoto, 606-8585, Japan
*m8623027@edu.kit.ac.jp

Keywords: Inertial mass damper, Seismic isolation device, Experiment

Nowadays, there are a lot of damages in structures (bridge, building, road, etc.) which are caused by earthquakes in Japan. In addition, the damage of computers leads to losing important information. There is a seismic isolation system installed, but it is reported that computers fall over. Because of some reasons including the seismic isolation system resonates and the displacement response increases, the range of motion is exceeded. Also, in the case of active seismic isolation, there is a problem that the active control system does not work when the power supply is stopped by the earthquake.
In fact, in Tohoku earthquake in 2011, it was reported that power was cut off due to a large-scale blackout and active seismic isolation did not work (K. Nakajima et al., 2012). Recently, the dependence of information systems has been rapidly expanding in all fields. Thus, the earthquake countermeasures for computers should be improved.
Therefore, we improve a new design of seismic isolation system using power generation function installed under a large computer as earthquake countermeasure. In this research, an inertial mass damper is applied for this seismic isolation system.
An inertial mass damper gives a reaction force proportional to relative acceleration. Until now, there are some researches about using inertial mass damper to control the vibration. The application of inertial mass damper in seismic isolation has not considered and performed much in experiment (Y. Nakamura et al., 2013), (K. Sugimoto et al., 2018). Based on combining the inertial mass damper using the power generation function, we propose the seismic isolation system with a generator.
First, we analyze the effectiveness of the seismic isolation system in simulation. The simulation model is shown in Fig.1;

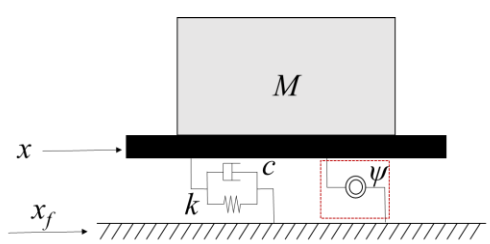
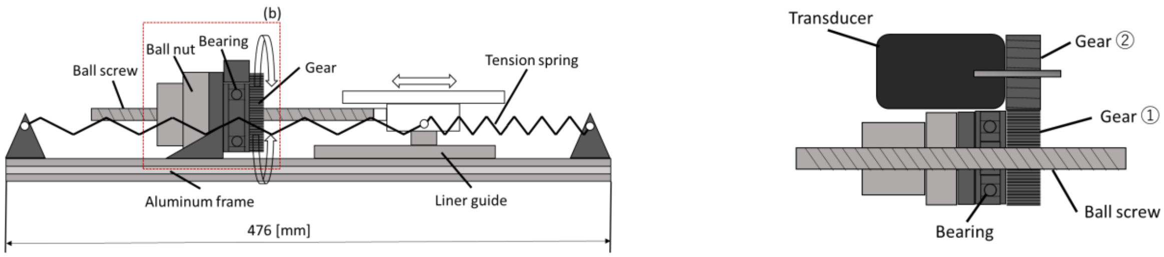


Fig.1 Analysis model

where, M represents the mass of the computer, c represents the damping, k represents the stiffness, ψ represents the inertial mass, x represents the displacement of the isolation device, and x_f represents the relative displacement to the ground. Second, we carried experiment and conducted a vibration test. The experimental model of seismic isolation system is shown in Fig.2. Figure 2(b) shows the constitution of power generation mechanism shown by the red line in Fig.1. Figure 3 shows the correspondence with the simulation parameters.



(a) Seismic isolation system (b) Power generation mechanism

Fig.2 Model of seismic isolation system using inertial mass damper

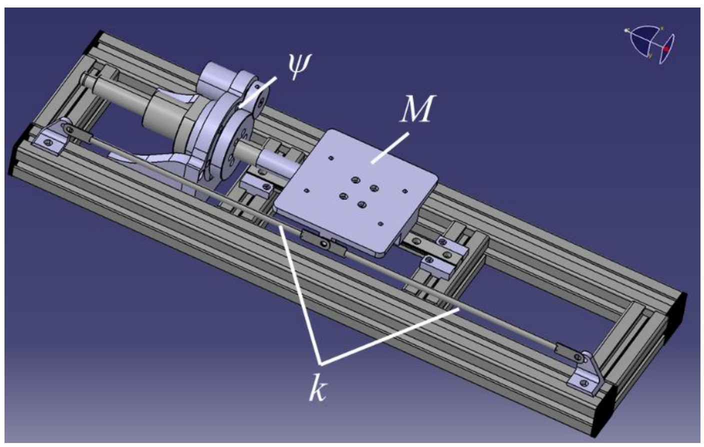


Fig.3 Correspondence with simulation parameters

A mechanism which can convert the displacement due to vibration into the rotation angle of the gear and charge the transducer, is designed. Tension springs were added from both ends. In addition, a weight was attached to the nut of the ball screw. By adjusting the weight M and changing inertia mass ψ, we tried to design to be able to conduct experiment by adjusting various parameters. Verifications using free vibration and sine wave were compared the effectiveness of the seismic isolation system using mass damper between experiment and simulation.

References

K. Nakajima, N. Giron, M. Kohiyama, K. Watanabe, M. Yoshida, M. Yamanaka, S. Inaba, and O.Yoshida, Seismic response analysis of a semi-active-controlled base-isolated building during the 2011 great east japan earthquake, *Proceedings of the International Symposium on Engineering Lessons Learned from the 2011 Great East Japan Earthquake, Tokyo, Japan,* 2012

Y. Nakamura, T. Hanzawa, and K. Isoda, Performance-based placement design of tuned inertial mass damper, *13th World Conference on Seismic Isolation, Energy Dissipation and Active Vibration Control of Structures*, *Sendai, Japan*, 2013

K. Sugimoto, A. Fukukita, T. Hanzawa, and M. Okamoto, Full-scale dynamic vibration test and dynamic model of inertial mass damper, J. Struct. Const. Eng., AIJ, Vol.83, No.749, (2018), 997-1007 (in Japanese)