Development of Sensor Embedded Oil Damper for Structural Control System

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Summary

With the recent increase of strong seismic activities worldwide, the evaluation of the seismic risks and improvement of seismic safety of infrastructures have gained critical importance. There have been many researches on monitoring and control of large structures. Many damping devices have been proposed and developed in order to mitigate the seismic responses of the structures. Besides, the introduction of monitoring systems in important structures is today recognized as part of the design and construction processes. However, most of control systems and monitoring systems are applied independently. It is also noteworthy that monitoring systems focus essentially on the health of the structure itself while disregarding the operational state of the control system. Therefore, combining these two systems into an integrated system which enables measuring and controlling the structural responses simultaneously could be more efficient and natural. In this study, we have developed a new damping system combining a conventional viscoelastic damper and a displacement sensor. In the proposed damping system, the measured dynamic responses are transferred and collected wirelessly to the data acquisition system using a sensor node attached to the device. Under seismic event, the developed damping system provides additional damping forces to the structures and measures the structural responses simultaneously. In addition, by tuning the sensor node appropriately, ambient vibrations of the structures are measured at relatively low frequency rates. Two full-size damper systems with capacity of 100 kN are manufactured and loading tests are performed in order to verify the operational status of the system under various loading conditions. Long-term outdoor test on a simple structure is also conducted to examine the efficiency of the system under real conditions. Test results are presented and indicate the validity of the developed smart damping system for the seismic response control and monitoring of the structures.

Keywords: oil damper; sensor node; loading test; monitoring.

1. Introduction

Research on seismic devices has regained large interest with the recent increase of seismic activities worldwide. Many damping devices have been proposed and developed in order to mitigate the seismic responses of the structures [1, 2]. The philosophy in conventional seismic design is that the structure should resist small earthquakes by its elastic action and is permitted to damage but not collapse under moderate or severe seismic events. This can be realized through the introduction of plastic hinges in the structure so as to dissipate the seismic energy.

Besides, structural passive control systems have been developed with a design philosophy diverging from such conventional seismic design method. These control systems include seismic isolation systems and energy dissipation systems. Various energy dissipation systems have been proposed and developed in the past decades such as friction dampers, metallic dampers, viscoelastic dampers and viscous dampers. The addition of such dampers in the structure allows the structure to dissipate the seismic energy without relying on plastic hinging by concentrating the energy dissipation on the dampers. Energy dissipation systems have gained large applications in long-span bridges since such structures should maintain their functions and remain serviceable after seismic event.

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