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VIBRATION CONTROL OF SEISMIC STRUCTURES USING FACADE MASS ISOLATION MODEL

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Since the development of the concept of base isolation, it has been fascinating to the researchers to adopt base isolation system in seismic protection for civil structures, due to its distinguished effectiveness. The base isolation system is to decouple the superstructure from the ground motion by changing the stiffness and therefore the natural frequency of the structure and consequently reflecting the energy of the earthquake. During the last century, a variety of ingenious isolation strategies and mechanisms have been proposed and implemented into structures, which has saved countless lives and great properties. Many research activities have been undertaken up to date internationally on the distribution of seismic isolation over the height of the building. The concept of partial mass isolation is proposed for the seismic design of structures in the range of medium height to tall buildings (Ziyaeifar et al., 1998). A partial isolation technique can be considered as an appropriate alternative for the base isolation technique in tall buildings or in situations in which isolating the whole structure is not cost-effective. In this technique, instead of isolating an entire building at the base, specific structural systems, components, floors or stories can be selectively isolated.

Development and implementation of Innovative facade systems to enhance seismic response of building structures have been a topic of debate for structural and architectural engineers. Due to these developments new types of facade systems, such as double skin facade system, have become popular to be used in building construction technology. The present paper studies a facade mass isolation technique in which a facade component is isolated from the primary building. This technique aims to reduce responses on the target components enhancing their seismic performance. A simplified scheme of an n-story that using facade mass isolation model is shown in Figure 1.

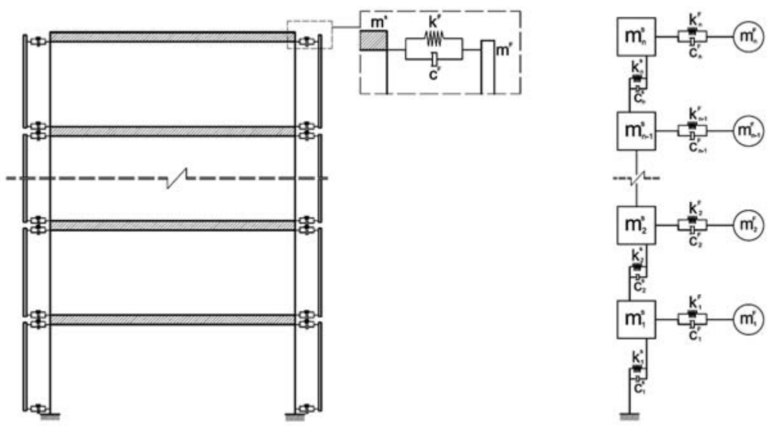

Figure 1. Simplified model for the analysis of a building structure with isolated facade system.

The primary structure is modelled as a shear-type two-dimensional frame having equal floor mass m_i^S, lateral stiffness k_i^S and the viscous damping ratio ξ_1^S that is assumed to be constant in all the modes of vibration. If the dynamic system is forced by unidirectional seismic ground acceleration, $\ddot{x}_g(t)$, the equation of motion of the building can be written as:

$$M\ddot{x}(t)+C\dot{x}(t)+Kx(t)=-Mr\ddot{x}_g(t) \quad (1)$$

where mass matrix, M, stiffness matrix, K, and damping matrix, C, are given by:

In this equation, $M=\begin{bmatrix} M_S & 0 \\ 0 & M_F \end{bmatrix}$, $K=\begin{bmatrix} K_S+K_F & -K_F \\ -K_F & K_F \end{bmatrix}$, $C=\begin{bmatrix} C_S+C_F & -C_F \\ -C_F & C_F \end{bmatrix}$

$$M^S=\begin{bmatrix} m_1^S & 0 & \cdots & 0 \\ 0 & \ddots & & \vdots \\ \vdots & \cdots & m_{n-1}^S & 0 \\ 0 & \cdots & 0 & m_n^S \end{bmatrix}, \quad K^S=\begin{bmatrix} k_1^S+k_2^S & -k_2^S & \cdots & 0 \\ -k_2^S & \ddots & & \vdots \\ \vdots & \cdots & k_{n-1}^S+k_n^S & -k_n^S \\ 0 & \cdots & -k_n^S & k_n^S \end{bmatrix}$$

$$M^F=\begin{bmatrix} m_1^F & 0 & \cdots & 0 \\ 0 & \ddots & & \vdots \\ \vdots & \cdots & m_{n-1}^F & 0 \\ 0 & \cdots & 0 & m_n^F \end{bmatrix}, \quad K^F=\begin{bmatrix} k_1^F & 0 & \cdots & 0 \\ 0 & \ddots & & \vdots \\ \vdots & \cdots & k_{n-1}^F & 0 \\ 0 & \cdots & 0 & k_n^F \end{bmatrix}$$

C^S, C^F take a form similar to K^S, K^F, respectively, that $c_i^s=2\xi_1^S\sqrt{k_i^S m_i^S}$, $c_i^F=2\xi_i^F\sqrt{k_i^F m_i^F}$. The superscripts S and F stand for the primary-structure and facade, respectively. In accordance with Figure 1, m_i^F represents in fact the mass of a facade panel, while k_i^F and c_i^F denote, respectively the stiffness and damping ratio of a single device and ξ_i^F is the damping ratio of the facade.

To examine the efficiency of the model in a wide structural frequency range, structural models with 5, 10, and 15 stories are selected. The story mass and the story stiffness coefficient are constant along the height of each story. Numerical results are presented for a case study, using facade with 5%, 10% and 20% mass ratio of structure. A dynamic analysis of the response by time history is used for four earthquakes include the El Centro, Hachinohe, San Fernando and Taft. To show the accuracy of the model to control vibration seismic structure, facade mass isolation model is investigated and compared with results available in non-isolated model and structure used tuned mass damper to control the vibration. Results show suitable behaviour of structure and also reduction of deformations in the facade components.

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