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OPTIMAL ACTIVE CONTROL OF ASYMMETRIC PLAN BUILDINGS WITH TORSIONAL EFFECT

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A lot of researches have been reported in the field of active control algorithms during the last 30 years, but almost all of the existing researches have been considered 2-dimensional structures in plane to implement and verify the active control algorithms. To simulate the behaviour of buildings more accurately, complex models should be used in the performance evaluation and design of controllers and their control algorithms. An LQR control algorithm is implemented to reduce the seismic responses of three-dimensional structures. The building is modelled as a structure composed of members connected by a rigid floor diaphragm such that it has three degrees of freedom at each floor, i.e., lateral displacements in two perpendicular directions and a rotation with respect to a vertical axis for the third dimension. An eight-story reinforced concrete building under earthquake excitations has been modelled three-dimensionally and seismic response of structures in the two orthogonal directions and rotation in z direction has been determined.

According to references (Lin et al., 2010; Yanik et al., 2014), each storey has three degrees of freedom. By assuming rigid diaphragm, total mass matrix of a building with n story is as equation (1).

$$M = \begin{bmatrix} m_1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & m_1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & I_{01} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & m_2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & m_2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & I_{02} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \dots \end{bmatrix} \tag{1}$$

where m_i and I_{0i} are transitional mass and torsional mass of each storey. For the formation of Stiffness matrix in two directions x, y and direction θ for each storey, equation (2) was used.

$$k_i = \begin{bmatrix} k_{xx} & 0 & k_{x\theta} \\ 0 & k_{yy} & k_{y\theta} \\ k_{\theta x} & k_{\theta y} & k_{\theta\theta} \end{bmatrix} \tag{2}$$

Finally, after obtaining the stiffness matrix of each storey (ki), as equation (3), the total stiffness matrix of the structure assembled. Each matrix ki is the index of the floor, is a 3 × 3 matrix.

$$K = \begin{bmatrix} k_1+k_2 & -k_2 & 0 & 0 \\ -k_2 & k_2+k_3 & -k_3 & 0 \\ 0 & -k_3 & \dots & -k_n \\ 0 & 0 & -k_n & k_n \end{bmatrix} \tag{3}$$

This three-dimensional building is idealized by a 3n-degree of freedom system. The three-dimensional building model is under earthquake ground motion and bidirectional control. The equation of motion of the structure can be described as

$$M\ddot{x} + C\dot{x} + Kx = -MR\ddot{x}_g + \Gamma u \tag{4}$$

As example for n=4;

$$\Gamma = \begin{bmatrix} -D & D & 0 & 0 \\ 0 & -D & D & 0 \\ 0 & 0 & -D & D \\ 0 & 0 & 0 & -D \end{bmatrix} \quad (5)$$

$$D = \begin{bmatrix} -1 & -1 & 0 & 0 \\ 0 & 0 & -1 & -1 \\ -By_1 & -By_2 & -Bx_1 & -Bx_2 \end{bmatrix} \quad (6)$$

where B is distance active tendons from center of mass with respect to x and y. Force of tendons obtained from equation (7) that R, Bu, P and z described in Yanik et al., (2014).

$$u = -R^{-1}Bu^{T}Pz(t)$$

where P is determined from riccati equation that need weighted matrix Q and R that the matrix obtained from genetic algorithm. Equation (4) solved by space state toolbox of MATLAB. The results has been showed in Figure 1 and a comparison of controlled and uncontrolled displacement of story 8 in the two orthogonal directions x and y, and rotation in z direction, was done. The results show a reduction in the both translational and torsional responses of the structure.

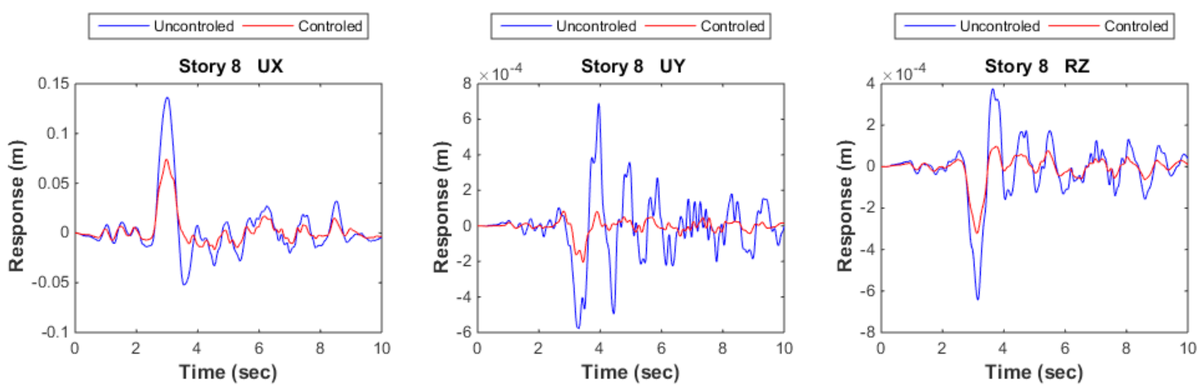

Figure 1. Comparison of controlled and uncontrolled displacement of story 8

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