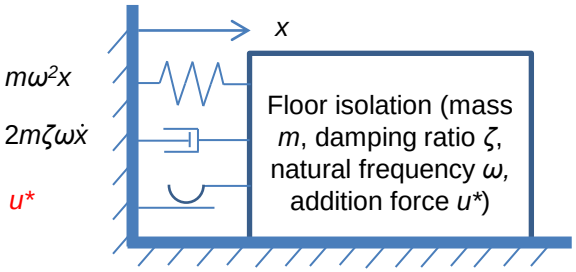
Semi-active controlled floor isolation system with new control algorithm

Background : Floor isolation systems are used to protect a group of valuable equipment from damage in earthquake events. To ensure that the semi-active control works more effectively under various types of excitations featuring different frequency characteristics, an LQR control with scheduled gain algorithm is developed.

Methodology : Simulation results show that the desired control gain for the traditional LQR depends on the dominant frequency of the excitation. The new developed method implements a feedforward loop to detect the excitation and analyzes the dominant frequency of the excitation with an FFT method. The control gain is then updated in real time. A series of shaking table tests are performed on a semi-active floor isolation system to validate the new proposed method for various types of excitations.



$$\ddot{x} + 2\zeta\omega\dot{x} + \omega^2 x + u^* / m = -\ddot{x}_{in};$$

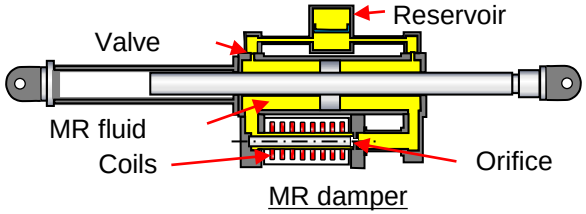
For traditional passive control with oil damper

$u^* = c\dot{x}$ c is damping coefficient

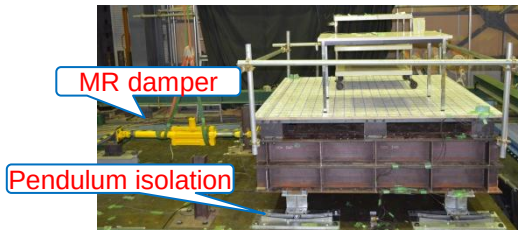
For semi-active control with MR fluid damper, u^* is controllable through control algorithm, such as LQR control

$$J = \int_0^t \left(\alpha\left(\ddot{x} + \ddot{x}_{in}\right)^2 + \beta x^2 + \gamma u^{*2}\right)dt \quad \min(J) \Rightarrow u^* = -\mathbf{G}\begin{bmatrix} x & \dot{x} \end{bmatrix}^T$$

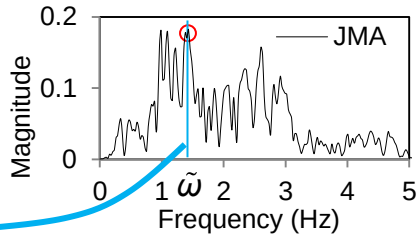
α, β and γ are constant $\Rightarrow$ **G** is constant	LQR
$\alpha = f(\tilde{\omega}); \mathbf{G} = g(\alpha); \beta, \gamma = const.$	New LQR



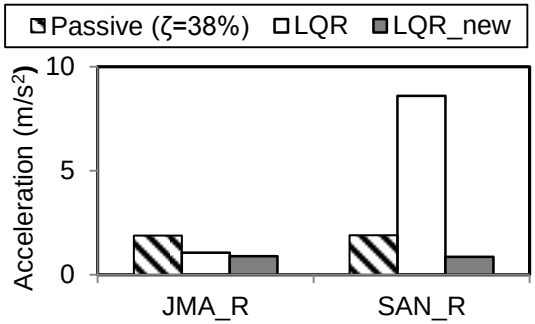
MR damper



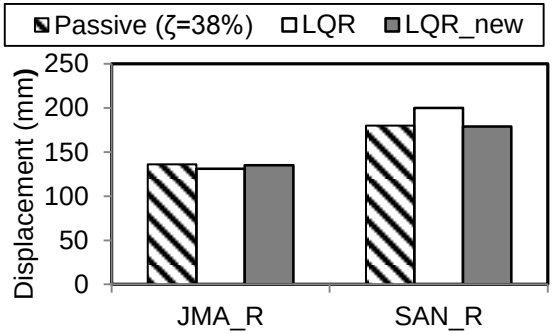
Test setup



FFT of acceleration



JMA_R: Short period motion
SAN_R: Long period motion



Test results

Conclusion : Test results show that among the three different control strategies including tradition LQR control, passive control and the new LQR, the newly developed method is most effective. It can suppress the acceleration response of the floor isolation system under different types of excitations, while maintaining the displacement below the safety level.