E05

Impedances for the Adoption of Isolated High-Rise Building in the US

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In Japan roughly eighty isolated high-rise buildings, ranging from 60 to 150 meters tall, have already been constructed. The most common implementation is for concrete residential condominium buildings. While tall buildings, due to their long periods, already have reduced response levels compared to low or mid-rise buildings, the addition of base isolation is meant to further increase the performance, limiting maximum floor accelerations to below 0.2 g to avoid overturning of furniture, which is more likely to be unbraced in residential homes than in office buildings.

Use of isolation in the United States has been seriously limited. One of the main factors is extra complexity in the design code for isolated buildings resulting in both time and cost spent on a project. Thus, the majority of isolation use has remained within mainly essential, public buildings such as hospitals, city halls or 911 centers. Isolation has not spread to use in typical office or residential buildings.

Perhaps due to limited use of isolation projects in the US, most practitioners see the use of isolation for high-rise buildings impractical and unfeasible. These views are clearly at odds with the state-of-practice in the Japanese design community. A major issue of concern to the US community is: Are there benefits to adding isolation to an already very flexible structure?

This issue derives from the underlying idea of period separation in isolation theory. In traditional base isolation, the period of the isolation system is typically 3+ times longer than the period of the fixed base building. This large period separation results in the majority of the deformation being limited to the isolation level and little higher-mode contributions. In Japan, isolated high-rise buildings typically have fixed base first mode periods from 2.5 to 4.5 s. The isolation systems range from 4 to 7 s. The ratio of the isolation period to the fixed base period is typically below 2 and thus, less benefit from the added isolation is expected. As isolation in the US is seen as a costly investment, a large increase in behavior is expected.

To investigate this issue the performance of an isolated high-rise building was compared to a fixed base counterpart. The model comes from the design of an already constructed isolated high-rise in Japan. The building is 100 m tall with a fixed base period of 2.67 s. The isolation system is non-linear with a period of 5.24 s at 0.2 m displacement. The fixed base counterpart has a fundamental period of 2.03 s. Rather than a lumped-mass model, used for design in Japan, a 2D frame model was used to investigate the behavior. The Japanese “golden set” of Taft, El Centro and Hachinohe were used for the comparison. While decreases in story drifts were small, from less than 0.3% in the fixed base building to less than 0.2% in the isolated ones, a major decrease in the roof response spectra was found (Figure 1). This shows a marked improvement for the behavior of furniture.

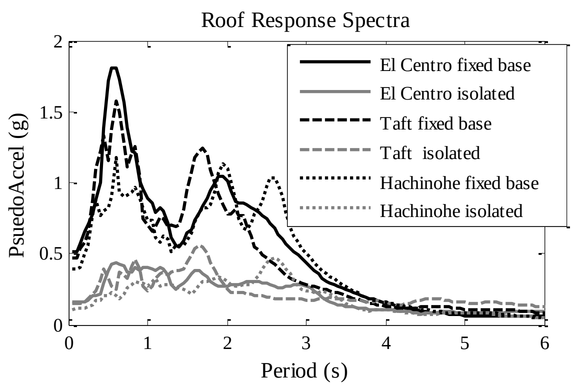

Figure 1: Roof response spectra