SI-06840373

8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

EARTHQUAKE RESPONSE OF INELASTIC BASE-ISOLATED STRUCTURES SUBJECTED TO POUNDING

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Keywords: Base-isolation, Pounding, Near-field pulse-like motion, Non-linear response, Gap size

Despite conservative existing code requirements (American Society of Civil Engineers, 2017; CEN Technical Committee 250, 2004) regarding clear seismic gap distance of base-isolated (BI) structures to surrounding moat walls, seismic performance of these structures is still ambiguous under severe earthquake ground motions that may push the base-slab of the isolation system to collide to the surrounding moat walls. Moreover, the temptation of reducing seismic gaps in congested urban areas significantly exacerbates the risk of pounding. Excessive horizontal displacement response of these long-period structures under near-field motion of a rare earthquake event may lead to pounding to adjacent structures and subsequently, severe and uncontrolled damage or even the total collapse of the superstructure despite all the code requirements are met in the design and construction process (Hall et al., 1995). Additionally, it is well understood that increasing the damping of the isolation system to reduce the system displacement may not be a reasonable solution due to its adverse effect on inertial and the base shear demand (Alhan and Öncü-Davas, 2016). However, in a previous study (Masoudi and Ghalehnoy, 2018) on linear elastic response of BI structures it was revealed that it is possible to minimize the damaging consequences of collision to the moat wall if the dynamic characteristics of a BI structure and its moat wall system are carefully selected and adjusted against the dominant period of expected near-field pulse-like motions. Present study aims to examine the aforementioned findings for inelastic superstructures supporting by an isolated base-slab that do not comply with the codified gap size requirements.

In this study, the most basic impact model, i.e. the stereo mechanical approach has been adopted. In this impact simulation model, collision is assumed to be instantaneous and pounding forces are calculated based on the principle of conservation of energy and momentum with an energy loss factor. The global superstructure ductility demands have been calculated for a wide range of BI systems under different near-field analytical pulse-like motions. To do this, the superstructure is represented with an equivalent elastoplastic single-degree-of-freedom (SDOF) oscillator as shown in Figure 1. This type of modeling has been widely used to assess the most fundamental aspects of seismic responses of seismically isolated structures (Kelly, 1990). In order to develop a general understanding of the nonlinear response of BI structures in the risk of pounding to moat/stop walls, effects of most influential parameters including gap size, pulse motion period, isolated and superstructure periods, moat wall frequency were investigated.

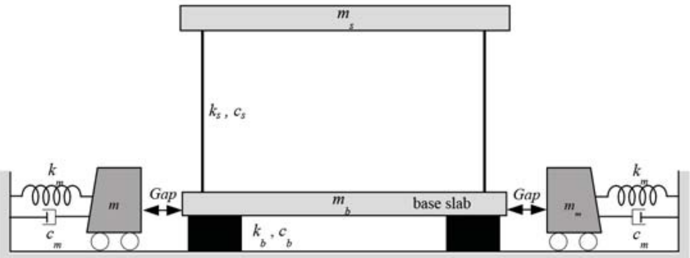
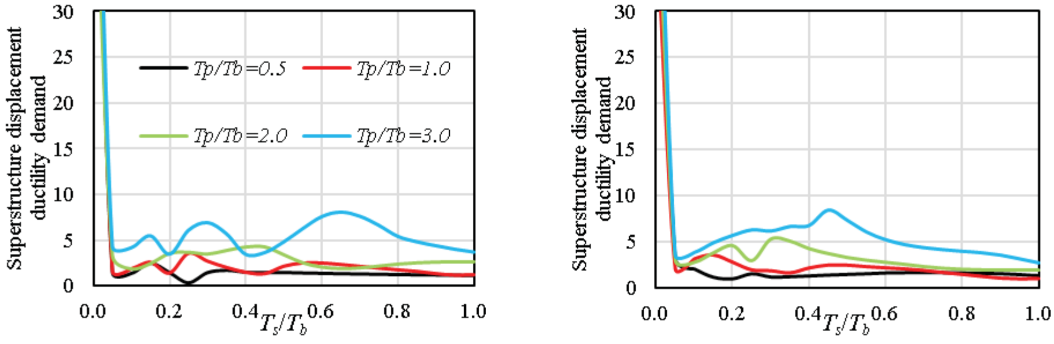


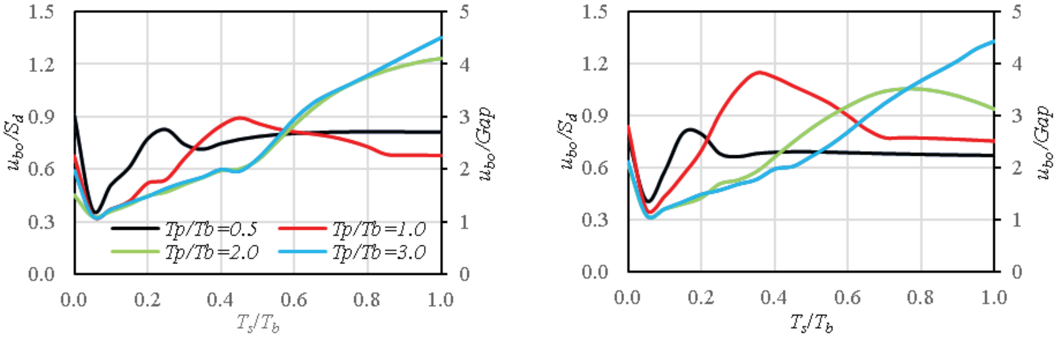
Figure 1. Parameters of the general two-degree-of-freedom base-isolated structure with moat/stop walls.

Results of the parametric study were plotted in Figures 2 and 3 for elasto-plastic superstructures with a response modification factor of R = 2. The results indicate that if the dynamic properties of the system are carefully selected, the superstructure displacement ductility demand remains in the code-required (American Society of Civil Engineers, 2017) reserved deformation capacity range of the BI building structures. Additionally, it is possible to limit the base-slab maximum displacement demand by selecting a proper gap size in accordance with the other system parameters and the ratio of the dominant period of the pulse-like excitation to the isolated period.



(a) (b)

Figure 2. Superstructure displacement ductility demand spectra for inelastic two-degree-of-freedom base-isolated structures for different T_p/T_b, and different analytical pulse-like excitations, $T_m/T_s = 1.0$, $Gap/S_d = 0.3$, $\zeta_b = 0.2$, $\zeta_m = 0.01$, $\zeta_s = 0.02$, $\gamma_m = 0.5$, $\gamma_s = 0.5$;(a) antisymmetric Küpper; (b) symmetric Küpper.



(a) (b)

Figure 3. Isolation layer displacement spectra for inelastic two-degree-of-freedom base-isolated structures for different T_p/T_b, and different analytical pulse-like excitations, $T_m/T_s = 1.0$, $Gap/S_d = 0.3$, $\zeta_b = 0.2$, $\zeta_m = 0.01$, $\zeta_s = 0.02$, $\gamma_m = 0.5$, $\gamma_s = 0.5$;(a) antisymmetric Küpper;(b) symmetric Küpper.

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