Analysis and Design of Sliding Isolation Pendulum Systems

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Summary

The paper discusses the analysis of curved surface sliders in accordance with EN 15129 (SIP i. e. Sliding Isolation Pendulum, single, double and triple variants) and compares their behavior with respect to isolation capacity and device displacements. The analysis is based on nonlinear transient dynamic analysis in the time domain using recorded accelerograms as well as synthetic earthquake records generated to match target response spectra. This method ensures that all nonlinear effects (stick-slip etc.) can be taken into account with full accuracy. Based on this analysis, a strategy for optimal design of SIP taking into account cost as well as conflicting safety targets is developed and applied to test cases.

Keywords: Structural dynamics; seismic protection; optimization; sliding isolation pendulum; nonlinear dynamics.

In order to ensure structural safety and integrity in earthquake conditions it may be useful or even necessary to equip structures with protective devices. One possible choice are seismic isolation devices allowing relative slip between the structure and the supports. Such devices consist of a combination of friction and spring element, in which the spring can also be replaced by a re-centering force due to gravity effects (so-called sliding isolation pendulum (SIP) systems, see e.g. [1]). A basic sketch of single and triple SIP is shown in Fig. 1. The so-called triple friction pendulum has been investigated and analyzed numerically before, see e.g. [2].

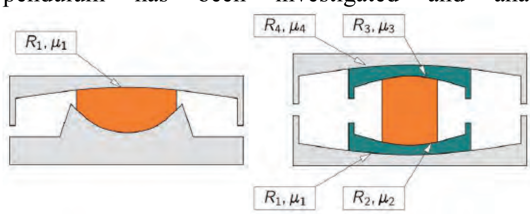

Fig. 1: Single and triple friction pendulum seismic isolation device

Both single and triple systems contain stoppers which limit the relative motion of the individual parts to specified displacement values (sliding limits) δ_i. Once a stopper becomes active, the transfer of forces is governed by the (large) stiffnesses k_0.

Two different buildings with different fundamental periods of vibration of 0.6 s and 1.6 s are analyes. Both structures are considered to vibrate mainly in their fundamental mode, so the analysis may effectively be reduced to a SDOF oscillator. The structures are subjected on one hand to a set of actually recorded ground accelerations (El Centro 1940, Tabas 1978, Gazli 1984, Kobe 1995, Bam 2003). On the other hand, the structures are subjected to a set to artificially generated accelerograms designed to match EC8 response spectra for a PGA of 5 m/s^2. The mean absolute maximum values of SIP displacement, relative structural displacement and absolute structural accelerations are shown in Fig. 2.

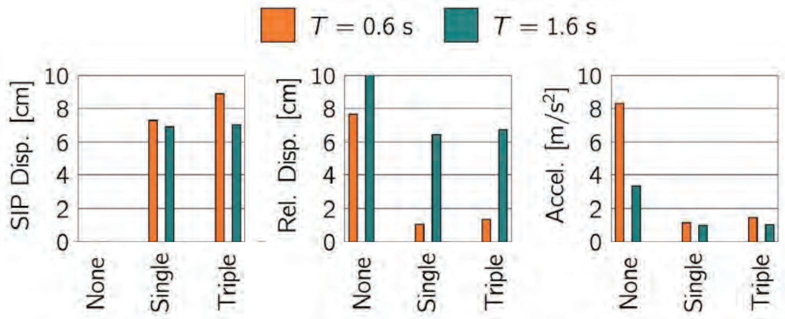

Fig. 2: Mean absolute maximum responses for different SIP systems under EC8-compatible synthetic earthquakes, PGA = 5 m/s^2

Apparently, both single and triple SIP system can effectively reduce the accelerations in the structure as well as the displacement relative to the foundation. The overall maximum values for the device displacement itself stays within the range of 10 cm for all scaled earthquake considered. It is interesting to note that there is no substantial difference in seismic performance between single and triple SIP systems. This has previously found for a different earthquake modes based on random process theory [3]. In order to compare the performance for smaller intensity earthquakes, another set of EC8-compatible accelerograms with a peak ground acceleration of 2 m/s^2 has been generated. The results of the analysis confirm that also in this case there is no substantial difference between single and triple systems. In the full paper, further studies regarding the optimal design of SIP systems are presented.

Acknowledgment

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