ANALOGY OF RIGID BLOCK ROCKING PHENOMENON UNDER GROUND MOTIONS RELATED TO DIFFERENT SOIL TYPES

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Over the past 30 years, extensive research has been conducted to derive deeper understand on the role of uplifting of structures and rocking response. The seismic design codes assume that during earthquakes the foundation maintains full contact with the supporting soil. However, in some recent earthquakes such as Chile 1960, Alaska 1964, San Fernando 1971, Northridge1994 and Kobe 1995, it has been observed that uplifting from the supporting soil is often practically inevitable. These phenomena have been widely studied with reference to a single rigid body or rigid building structures such as industrial equipments, obelisks and storage tanks. In these cases the uplift is generated by the rotation of the structure around one side of its foundation. George Housner (1963) investigated the minimum acceleration amplitude of a half-sine pulse required to overturn the rigid block. Using an energy approach, the role of the excitation frequency and block size on the overturning potential was uncovered which explain that why the geometrically larger blocks could survive the excitation while the smaller ones topple. Makris (1998, 1999) focused on the transient rocking response of rigid blocks subjected to trigonometric pulses under near-source ground motions and derived the acceleration amplitude needed for overturning. According to these studies a rocking block subjected to one-cycle trigonometric pulse may overturn either in a rollback movement after one impact or without any rollback. Apostolou (2007) studied the effect of aspect ratio and block size on overturning block structures and revealed that structures with higher aspect ratio have greater safety against earthquakes.

In this paper, rocking response of rigid blocks with foundation uplift under seismic ground motions corresponding to four types of soil stratum based on Iranian seismic code is investigated. The response spectrum of each artificially generated record is set to be compatible with target spectrum for every soil type, separately. The dynamic analysis of the rocking response is implemented with a finite element discretization using Abaqus software. Figure 1 shows the model details and related parameters. The rigid block and the underlying rigid base are represented with plane-strain elements with consideration of geometric nonlinearities (uplifting and P-delta effects). Special interface algorithm has been adopted to prevent slipping and incorporate potential uplifting of the foundation.

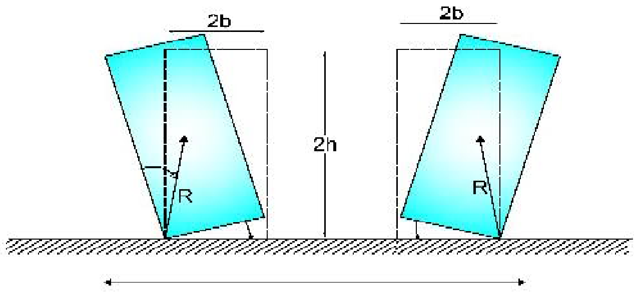

Figure 1. Schematic view of uplifting rigid block

Here in Figure 2, as a sample, the rocking response of a slender block with h/b=5 supported on the rigid base is presented, using two different high-frequency record, corresponding to Soil type I spectrum, and low-frequency record, corresponding to soil type IV spectrum. Both ground motions are scaled to have 0.3g peak ground acceleration. The input motions and corresponding responses are plotted together. Evidently, it can be seen that the high-frequency record tends to reduce the rocking angle and hence under such base motion, the block is more stable.

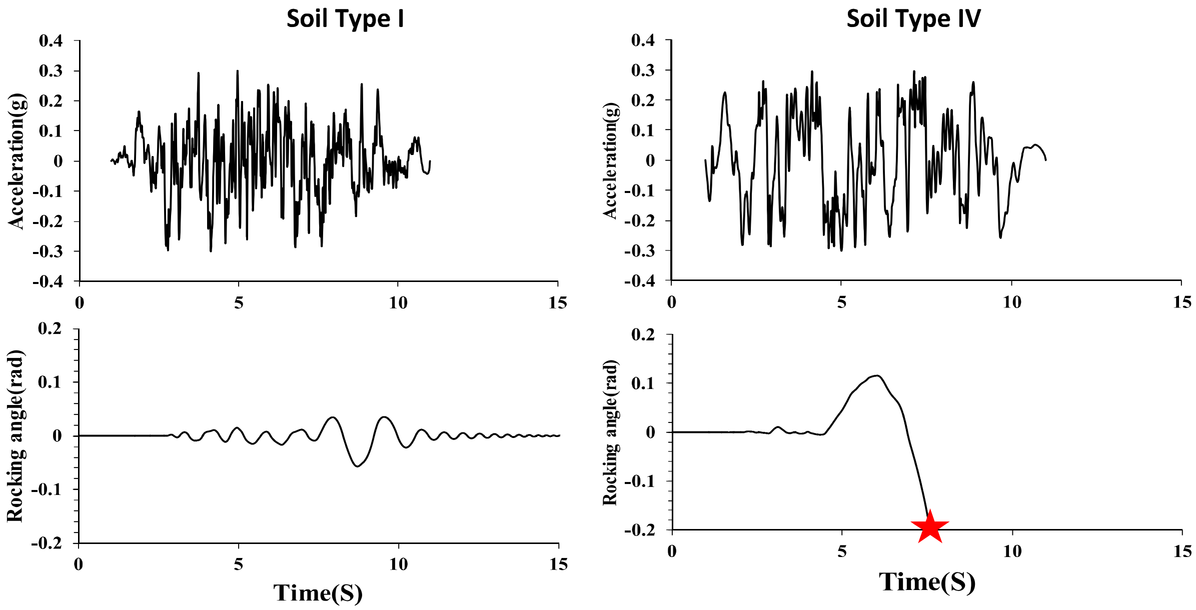

Figure 2. Time-histories of the rocking response for a rectangular block with h/b=5 and 2b=1 m subjected to a couple of ground motions corresponding to soil Type I and IV

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