The Dynamics of Rocking Isolation

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Abstract The uplifting and rocking of slender, free-standing structures when subjected to ground shaking may limit appreciably the seismic moments and shears that develop at their base. This high-performance seismic behavior is inherent in the design of ancient temples that consist of slender, free-standing columns which support freely heavy epistyles together with the even heavier frieze atop. While the ample seismic performance of rocking isolation has been documented with the through-the-centuries survival of several free-standing ancient temples; and careful post-earthquake observations in Japan during the 1940's suggested that the increasing size of slender free-standing tombstones enhances their seismic stability; it was Housner (1963) who ½ century ago elucidated a size-frequency scale effect and explained that there is a safety margin between uplifting and overturning and as the size of the column or the frequency of the excitation increases, this safety margin increases appreciably to the extent that large free-standing columns enjoy ample seismic stability. This article revisits the important implications of this post-uplift dynamic stability and explains that the enhanced seismic stability originates from the difficulty of mobilizing the rotational inertia of the free-standing column. As the size of the column increases the seismic resistance (rotational inertia) increases with the square of the column size; whereas, the seismic demand (overturning moment) increases linearly with size. The same result applies to the articulated rocking frame given that its dynamic rocking response is identical to the rocking response of a solitary free-standing column with the same slenderness; yet larger size. The article concludes that the concept of rocking isolation by intentionally designing a hinging mechanism that its seismic resistance originates primarily from the mobilization of the rotational inertia of its members is a unique seismic protection strategy for large, slender structures not just at the limit-state but also at the operational state.

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