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DISCRETE ELEMENT MODELING OF T-BAGS AND APPLICATIONS TO LOW-COST SEISMIC VIBRATION REDUCTION IN STRUCTURES

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Abstract

The T-BAGS system is a low-cost seismic isolation and vibration control technology that utilizes stacked layers of sandbags, which slide against each other through a high-performance polymer film sheet. The system's vibration reduction capabilities arise from the hysteretic shear behavior of the sandbags and their slippage against the film sheet. A numerical analysis of a T-BAGS-reinforced building involves modeling the building, the sandbags, and the sheet as a series of masses and springs. In our previous studies, the nonlinear stress-strain behavior of the sandbags was approximated by using the Ramberg-Osgood (R-O) model, with parameters that were rigorously tuned to laboratory test results. While this approach provides a reasonable prediction of the nonlinear behavior of the sandbags, it oversimplifies the granular nature of the sand within the bags, limiting its accuracy when the T-BAGS system is extended beyond the conditions tested in the laboratory experiments. In this study, we advance the modeling framework of the T-BAGS system by employing the discrete element method (DEM) to obtain the nonlinear macro-properties of a sandbag subjected to vertical and shearing loads. Since this approach derives the macro-properties of the sandbag from the contact interactions between individual representative particles of sand, it provides more realistic modeling of the sandbag in the T-BAGS system. This paper provides an overview of the application of T-BAGS to reduce the seismic vibration of a five-story building. The details of the discrete element modeling of the sandbag are then presented along with its validation by simulating and replicating simple shear tests. This study offers a physics-based modeling approach for the T-BAGS system, which complements phenomenological models and experimental calibration. By employing this approach, the behavior of T-BAGS can be more accurately understood, allowing for greater flexibility in modifying and optimizing the T-BAGS system for various applications.

Keywords: Discrete Element Method, Sandbag, Seismic Isolation, Seismic Vibration Control, Low-cost Construction Technology.