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Evaluation of Non-structural Partition Walls and Hanging Ceiling Systems through a Shake Table Study

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Abstract

The structural engineering community has seen a significant amount of effort placed on the evaluation and improvement of the lateral load resisting system in building structures during a seismic event. However, the behavior of non-structural elements is becoming increasingly more critical under performance-based seismic design as damage to these elements can result in significant economic losses or loss of life. In order to address this issue, a unique full-scale non-structural study was undertaken where the specimen consisted of gypsum board partition walls and a typical hanging ceiling system. The partition walls created an enclosed space allowing for the effects of perpendicular walls framed into each other to be evaluated. The effects of discontinuities in the partition walls were studied through the placement of a large opening in one of the walls and a door frame in the opposite wall. Unlike past studies, the setup also allowed for the evaluation of any interaction between the walls and ceiling system. A steel loading frame was designed to provide the inertial loads to the non-structural system as a result of sine wave inputs provided by the shake table at the Disaster Prevention Research Institute of Kyoto University. The amplitudes of the input were increased with subsequent tests such that the behavior and damage could be correlated with particular drift levels. The non-structural walls underwent a rocking behavior as a result of the presence of a perpendicular wall, which caused early damage at the corners of the gypsum board. More significant damage was seen as drift levels reached 1/28 radians with most of this damage concentrated around the door frame and at the corners of the partition walls. Stiffness and damping values degraded significantly after initial cycles at each drift level due to the accumulation of residual damage. Only minimal damage was imparted to the ceiling system as it performed to design standards. However, the small ceiling area and the lack of a vertical motion input may have played a large role in the performance of the ceiling system. The results of this test provided important preliminary data for the future full-scale test of a four-story steel moment frame to be tested at E-defense in Japan, which will incorporate these non-structural systems.