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Experimental study on separating reinforced concrete infill walls from steel moment frames

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ABSTRACT

In a multistory building frame, stiff reinforced concrete (RC) infill walls may be terminated above the first story for architectural purposes, which may create a soft-first-story structure. To eliminate this detrimental situation, this paper proposes to separate the RC infill wall from the steel moment frame by slits. An experimental program of four one-bay-by-one-story steel moment frame specimens along with pushover analyses of multistory frame models were presented to validate the proposed idea. This study conducted cyclic loading tests on a total of four moment-resisting-frame specimens, which included one bare frame; one with ordinary RC infill wall; and two with side slits between RC wall and frame members. Furthermore, pushover analyses of multistory frame models with soft first story configurations were also conducted to illustrate the effect of RC infill walls with or without slit separation. Both experimental and analytical results showed that the stiff RC infill wall dominated the lateral resistance and drift capacity of the test specimens, and that by adding slit-separated features at the edges of infill walls improved the drift capacity. It is concluded that the slit-separated features can be a viable option to eliminate the soft-story problem caused by vertically irregular configuration of RC infill walls.

1. Introduction

In multistory moment resisting frame buildings, infill walls are usually made of masonry, reinforced concrete (RC), drywall, or lightweight panel filled with mortar. Apart from bearing walls or shear walls, most infill walls used for partition components within a building frame are regarded as non-structural elements, which are assumed to be vulnerable and excluded in structural analysis. This assumption seems reasonable as surrounding frame members are relatively strong with respect to the infill walls. However, from investigations [1–4] of several destructive earthquake disasters, the detrimental influence of infill walls on structural performance might be underestimated.

Prior researchers [5, 6] showed that infill masonry or RC wall could significantly increase the lateral stiffness and strength of RC moment frames. Due to rapid loss of strength and stiffness from shear failure of infill walls, the behavior of stiff-walls-infilled frame turned out to be relatively brittle as compared to the identical bare moment frame. Prior experimental study [7] further showed that a code-compliant RC moment resisting frame with minimum-reinforced concrete infill may result in a shear-critical failure even if its framing members are designed with ductile detailing. For steel structures, several researches [8–10] also showed that RC infill walls could provide significant lateral stiffness and strength as bracings. In general, additional lateral stiffness and strength from stiff infill walls could enhance a structure to resist most static loads. For earthquake-type loading, such stiff infill walls may attract unanticipated lateral forces and change load-transferring paths, leading to severe damage on the walls and adjacent frame members.

For a well-designed moment resisting frame, the plastic hinges should be developed at beam ends and distributed in many stories, as idealized in Fig. 1. If the RC infill walls cannot be placed continuously to the foundation, the soft first story may form, which is vulnerable to moderate or large magnitude earthquakes and prone to collapse, as those lessons we learned from past earthquakes [1–4].

Nowadays, the detrimental influence of the soft first story caused by stiff infill walls may be unavoidable for many urban multistory buildings. This is because many city multistory buildings provide residential apartments above commercial stores, open lobbies, or parking lots. Due to this kind of configuration, much fewer infill walls are placed in the first story as compared to the other stories. In addition, many public buildings, such as fire station, hospital, traffic

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