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Investigation on the behavior of brick-infilled steel frames with openings, experimental and analytical approaches

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ABSTRACT

This article deals with an experimental program to investigate the in-plane seismic behavior of steel frames with clay brick masonry infills having openings. Six large-scale, single-story, single-bay frame specimens were tested under in-plane cyclic loading applied at roof level. The infill panel specimens included masonry infills having central openings of various dimensions. The experimental results indicate that infill panels with and without openings can improve the seismic performance of steel frames and the amount of cumulative dissipated energy of the infill panels with openings, at ultimate state are almost identical. Furthermore, contrary to the literature, the results indicate that infilled frames with openings are not always more ductile than the ones with solid infill. It seems that the ductility of such frames depends on the failure mode of infill piers. This experimental investigation shows that infilled frames with openings experienced pier diagonal tension or toe crushing failure and have smaller ductility factors than those frames with solid infill. Furthermore, a simple analytical method is proposed to estimate the maximum shear capacity of masonry infilled steel frames with window and door openings.

1. Introduction

Steel and reinforced concrete framed structures in urban areas are usually infilled with masonry walls as interior and exterior walls. The resulting system is referred to as an infilled frame, which has high in-plane stiffness and strength. At low levels of lateral forces, the frame and infill wall act in a fully composite fashion. However, as the lateral force level increases, the frame attempts to deform in a flexural mode while the infill attempts to deform in a shear mode. Interaction between frame and infill panel significantly increases the infilled frame lateral stiffness and drastically alters the expected dynamic response of the structure. However, the effect of masonry-infill panels is often neglected in the analysis of infilled frames by structural engineers in current practice. Such an assumption may lead to substantial inaccuracy in predicting the lateral stiffness, strength, and ductility of the frame.

Since the 1950s extensive studies have been performed on lateral load behavior of masonry-infilled frames both experimentally and analytically. Stafford-Smith [1,2], has conducted experimental investigations on the lateral stiffness and strength of steel frames infilled with masonry panels. In order to model the infill frames, an equivalent diagonal strut was proposed by Stafford-Smith [2] to be substituted for the infill panel. A complete review of research studies on infilled frames through 1987 was reported by Moghadam and Dowling [3]. The results of the most intensive experimental program conducted on masonry-infilled steel frames were reported by Dawe and Seah [4]. Mosalam et al. [5] reported the results of a series of experiments on two-bay single-story concrete block masonry infilled steel frames tested under quasi-static loading. Moghadam presented the results of an experimental program on retrofitting brick masonry infilled steel frames [6]. El-Dakhakhni et al. conducted an experimental investigation to study the effect of retrofitting unreinforced concrete masonry-infilled steel frame structures using GFRP laminates [7]. Moghadam et al. [8] reported the results of an experimental investigation on small and medium scale masonry and concrete infilled frames with and without horizontal reinforcement as well as bond beams under in-plane cyclic loading. Doudoumis [9] proposed and used a precise linear finite element model to investigate the effects of interface conditions, mesh density, relative beam to column stiffness and orthotropy of the infill panels. Puglisi et al. [10,11] modified the conventional diagonal strut model (two independent struts in two opposite loading directions) by the inclusion of a new concept called "plastic concentrator". The plastic concentrator links the two diagonal struts and produces a transfer of effects from one strut to the other. They have shown that the use of plastic concentrators leads to a more realistic representation of

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