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Out-of-plane behaviour of confined masonry walls

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ABSTRACT

This paper presents the results of a study on the behaviour of confined masonry walls subjected to out-of-plane uniform pressures. Six full scale confined masonry walls were tested in the laboratory. The variable studied was the wall support conditions; four-sided and three-sided simple supported walls were considered. Simplified analytical models were developed for predicting cracking and maximum pressure for the walls. The former was predicted using the finite element method and the latter using the yield line method, the failure line method, and the compressive strut method. This last method was modified to account for the stiffness of the confining elements and the observed failure mechanism. The observed maximum pressures and failure cracking pattern for the walls with three-side supports were similar to those with four-side supports. This was related to the strength and stiffness provided by the non-supported confining element, which acted as a fourth support. Based on the comparison of experimental and analytical results, it is concluded that both cracking and maximum pressure can be predicted with the analytical models developed in this work.

1. Introduction

The out-of-plane behaviour of masonry walls has not been studied as well as the corresponding in-plane behaviour; however, some research has been carried out on that out-of-plane behaviour, for example, Abrams et al. [1] studied the behaviour of unreinforced infill walls subjected to uniform pressures. Wall specimens were first subjected to a series of in-plane loads to crack the walls, and later to out-of-plane uniform pressures; the goal was to study the influence of damage due to in-plane loads in the out-of-plane strength of the masonry infill walls. A total of eight specimens were tested in the laboratory; the variables considered were the unit type, the wall slenderness ratio (height over thickness), and the mortar type. An analytical model based on an arching mechanism was developed to predict the out-of-plane strength of the walls; that model was developed for stiff concrete frames as typically found in infill masonry walls; crushing of masonry was assumed as the failure mechanism. One of the conclusions of that work is that the out-of-plane strength of the walls depends on the actual stiffness of the concrete frame around the masonry wall; as that stiffness decreases, the wall's strength also decreases. Drysdale and Essawy [2] tested 21 unreinforced masonry walls subjected to uniform pressures. Variables considered were aspect ratio (height over length), boundary conditions (simple supported), and axial loads. Cracking pressure was predicted using the finite element method; out-of-plane strength was predicted using the yield line method and the failure line method. The authors concluded that the yield line method tends to be slightly unconservative and that the failure line method slightly conservative, but both methods are recommended in that work to predict the out-of-plane strength of the walls. Griffith and Vaculik [3] studied the behaviour of eight unreinforced masonry walls subjected to uniform pressures; six of those walls were constructed with openings. Variables studied were the wall aspect ratio, boundary conditions (combined simple and fixed supports), and axial loads. Out-of-plane strength of the walls was predicted using the failure line method. Based on the results of that work it is concluded that the out-of-plane strength is not well-predicted using the failure line method; the main reason was that it is unlikely that the full moment capacity along diagonals and vertical crack lines will be reached simultaneously; a correction factor was proposed for those cases. Yi-Hsuan et al. [4] tested two existing two-story structures subjected to concentrated loads. The structures consisted of a series of reinforced concrete frames in two orthogonal directions with interior unreinforced masonry walls; the goal was to consider the out-of-plane contribution of the unreinforced infill walls in the in-plane lateral capacity of the structure. An analytical model based on an arching mechanism was developed to consider the out-of-plane strength of the walls; crushing of masonry was assumed as the failure mechanism. Because of the type of load, a single wall segment was considered in the model. It is concluded in that work that the out-of-plane strength of the walls increases as the compressive strength of the masonry increases, and decreases as the slenderness ratio increases. The analytical model based on an arching mechanism was in general conservative.

Based on the literature review conducted in this work it is concluded that few experimental studies have been carried out on

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