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INVESTIGATION OF OUT-OF-PLANE SEISMIC BEHAVIOUR OF EXISTING MASONRY INFILLS

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The importance of accurate seismic assessment of masonry infills has been recognized after their high seismic vulnerability led to severe damages during past earthquakes. In this study, the out-of-plane behaviour of an existing masonry infill typology is characterized through experimental and numerical investigations with the aim of proposing improved formulations to assess its out-of-plane capacity and seismic demand parameters. The experimental program consisted of pseudo static in-plane cyclic tests and out-of-plane dynamic shake table tests on full scale single storey single bay infill specimens. Based on the experimental results, a numerical model is developed and validated to conduct parametric studies.

1. Introduction

The seismic behaviour of masonry infills has been extensively studied in the last decades [1, 2] to improve their detrimental response observed during many past earthquakes. The out-of-plane failure of infills is critical regarding life safety, especially when the out-of-plane capacity is impaired by in-plane damage. The out-of-plane capacity of infills is attributed to the arching action [3] owing to the presence of the surrounding frame, influenced by many factors such as infill properties, boundary conditions, slenderness ratio, and the stiffness of frame elements. In the current seismic codes, infills are assessed as non-structural elements and their safety is verified without giving special consideration to infill typology or structural configuration. Therefore, a better understanding of the out-of-plane behaviour of masonry infills is crucial to develop improved guidelines to minimize damage and prevent out-of-plane collapse. In this context, an experimental campaign was implemented to investigate the seismic behaviour of an existing masonry infill typology which was used in the 1960s-1980s in Italy as enclosures and partitions in reinforced concrete frame structures. The first phase of the experimental campaign involved five infill panels constructed surrounded by steel/concrete composite frames. Four specimens were fully adhered to the frame, and subjected to in-plane, out-of-plane, and successive in-plane and out-of-plane loading. The remaining specimen had free vertical edges and was tested in the out-of-plane direction. From experimental results, the influence of the boundary conditions and the level of in-plane damage on the out-of-plane behaviour was substantiated. Following the experiment, numerical simulations will be carried out to further investigate the influence of parameters such as infill properties, different geometries, frame properties and openings, on the out-of-plane behaviour of infills.

2. Experiment

Five infill specimens (T1-T5) were constructed with 12 cm thick 25x25 cm horizontally perforated clay units and 10 mm thick mortar joints. The panels were 3.5 m in length, 2.75 m in height and 13 cm in thickness including a 10 mm plaster layer on one side, built within steel/concrete composite frames. Four specimens (T1-T4) were fully bonded to the frame with a mortar layer. The remaining specimen T5 was connected to the frame at the top and bottom edges only. In-plane pseudo static cyclic tests on specimens T1, T2 and T3 were performed in displacement control and out-of-plane dynamic tests were conducted on specimens T2, T3, T4 and T5 on a shaking table. Specimens T2 and T3 were first subjected to in-plane nominal drifts of 0.3 and 0.65%, respectively, and then to out-of-plane motion until failure.

Figure 1. a) Units; b) Specimen with full adherence; c) Specimen with vertical gap

3. Preliminary results

From the pure-in-plane tests on T1, the in-plane drift capacity was found as 0.9%. In combined tests, the collapse was reached for specimens T2 and T3 at 2.5g and 1.5g nominal peak floor acceleration (PFA), respectively. In pure out-of-plane tests, the fully connected T4 did not show any significant damage or reach failure at PFA of 1.8g where the test was stopped. Specimen T5 exhibited vertical arching mechanism with horizontal cracks at boundaries and around mid-height, and the capacity was reached at a nominal PFA of 0.6g. The reduction of the out-of-plane capacity of the panel T3 with respect to T2 was 42% in terms of maximum acceleration at the centre of the panel. The out-of-plane response of specimen T5 completely differed to that of T4 with a higher flexibility and a lower capacity. Furthermore, the acceleration profiles observed in the infills were triangular between two supported opposite edges (for fully supported infills, along length and height, for T5 along height) inferring that the applied out-of-plane load on the panel is not uniform but close to triangular.

4. Conclusions and future work

1. An undamaged infill possesses considerable out-of-plane capacity, which drastically reduces with the presence of previous damage due to in-plane loading.

2. The boundary conditions of the panel significantly influence the out-of-plane response. The vertically spanning infill had a lower stiffness and capacity compared to the fully supported undamaged infill.

3. Effectuating the next phases of the experiment involving specimens with a gap on the top and specimens with openings, implementing numerical analyses, and finally proposing capacity and demand evaluation formulations are envisaged as future work.

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