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Behavior of reinforced concrete frame with masonry infill wall subjected to vertical load

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ABSTRACT

The effectiveness of masonry infill wall on behavior of a Reinforced Concrete (RC) frame subjected to a column failure is studied experimentally. For this reason, one full scale RC frame designed according to Eurocode is statically tested to investigate the behavior of the frame with and without masonry infill wall. The obtained results show that infill wall can significantly increase the load carrying capacity of RC frame and thus serve as an important robustness reserve in the case of unpredictable extreme events (i.e. local impact, blast or earthquake). A photogrammetry analysis is carried out to study the behavior of the structure. Results give valuable information about the alternative load path, transfer of the applied load to the column and beams, and interaction forces between RC frame and infill wall. At the end, the experimental program is simulated by the OpenSees software to study the behavior of the frame. After having demonstrated that this model can predict the load deflection with good accuracy, a parametric study is conducted to evaluate the effect of the percentage of longitudinal reinforcement ratio of beams and columns on the load carrying capacity of the infilled RC frame.

1. Introduction

Progressive collapse means failure of a primary structural element that can resulting in the failure of adjoining structural elements, which in turn causes further structural failure [1]. Progressive collapse of multistory buildings can occur after local failure of a key structural member, typically originated by extreme unforeseen events, such as: earthquake, different types of natural disasters, man-caused accidents, and terrorist attacks. In Ronan Point, London [2], a gas explosion on the 18th floor of a residential building blew out a wall element causing a progressive collapse of the building. In the Bad Reichnhall arena, Germany [2], due to a design error and undetected deterioration, a progressive collapse occurred under snow load, and led to the total collapse of the roof of the structure. These are clearly some examples of non-robust structures and the observed types of failure that may be seen as the result of the incapacity of the structures to develop alternative load paths after local damage of a member [3].

To avoid disproportionate failure, robustness must be ensured, i.e. the structure must develop alternative load paths after loss of a key-member. For instance, after sudden failure of a column, the connecting beams and infill panels must be able to transfer the redistributed loads to the adjacent columns [4]. This scenario highlights the importance of robustness. Robustness has been recognized as a desirable property of structural systems which mitigates their susceptibility of progressive disproportionate collapse [5]. In general, robustness is defined as the insensitivity of a structure to local failure. In a robust structure, no damage disproportionate to the initial failure will occur. Thus, an appropriate assessment of the structural behavior requires accounting for alternative load bearing scenarios that contribute to the overall resistance. Among the fundamental mechanisms of arrest, shear deformation of infill panels can provide significant enhancement of the resistance against collapse in frame RC structures [4].

The influence of the masonry infill panels is not generally considered in the design process of RC frames subjected to lateral loads, due to early brittle failure and consequently formation of soft-story mechanism and column shear failure. In reality, masonry walls are often arranged non-uniformly in different floors for functional reasons that cause the RC buildings have vertical irregularity, such as stiffness irregularity (soft story), strength irregularity (weak story), mass irregularity, and short-column effects. However, it is generally accepted that these elements have a significant influence on the structural behavior. They increase initial stiffness and decrease the natural period of

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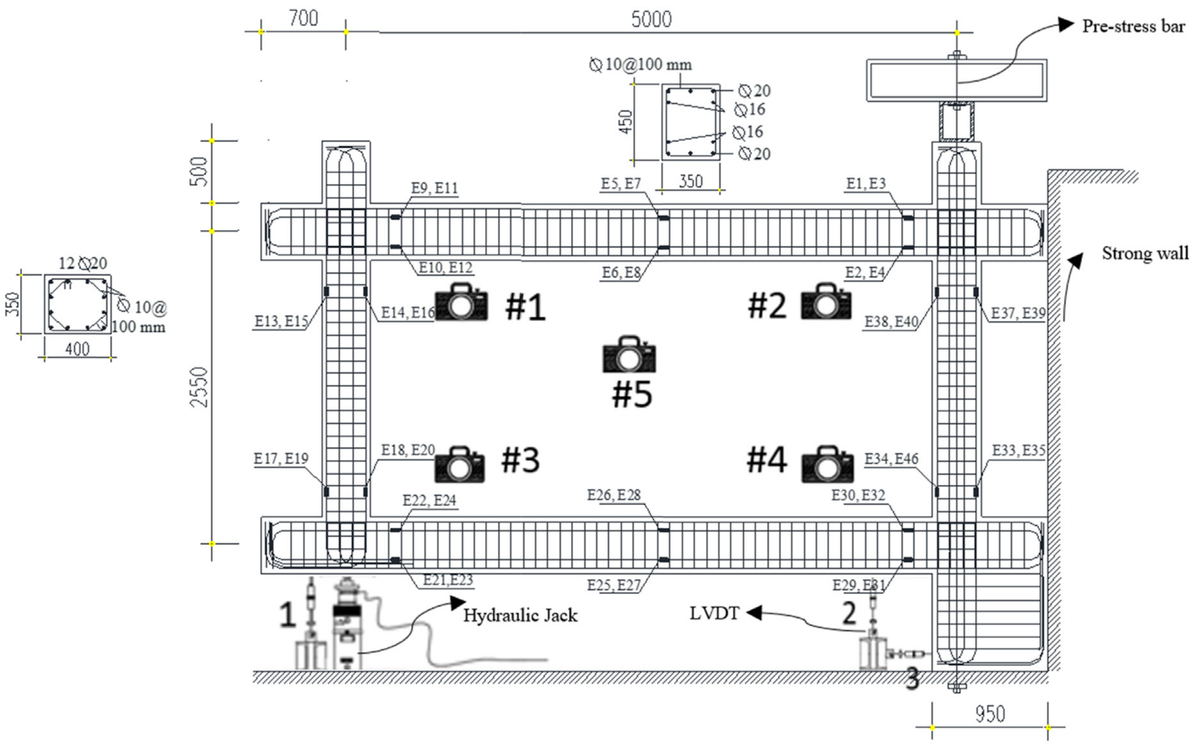
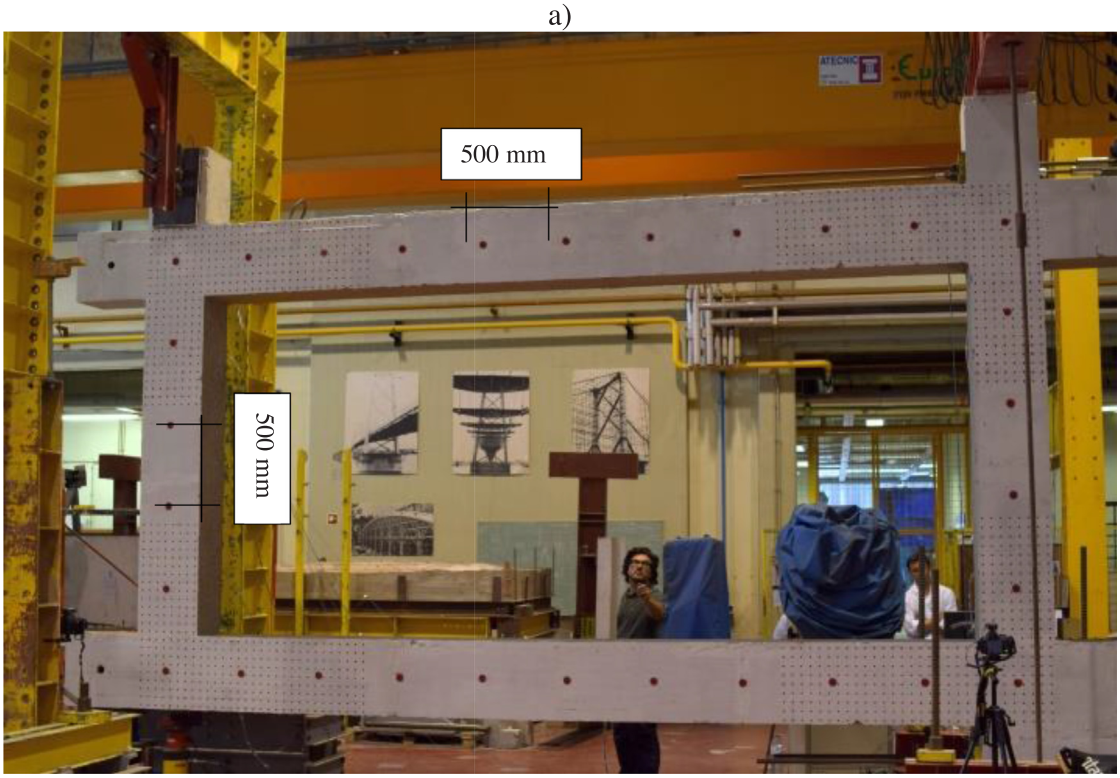


a)



b)

Fig. 1. (a) Details of the RC frame, LVDTs, Strain gages, and cameras; (b) location of the printed targets on bare frame.

the frame, which might be beneficial depending on the frequency of earthquake motion [6].

Shan et al. [7] studied experimentally the progressive collapse of a two-story four-bay RC frame with and without infill wall. The test results showed that the infill walls can provide alternative load paths for transferring the loads originally only supported by the beams, and thus, improve the collapse resistance capacity of the RC frame.

Tsai and Huang [8,9] studied the progressive collapse of RC frames numerically and showed the effect of infill walls on the structure's resistance capacities against progressive collapse. The results showed that the progressive collapse depends on the dimensions as well as the locations of infill wall. However, infill walls have slightly influence on the