Experimental studies on seismic behaviour of RC frame with different configuration of infills

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Summary

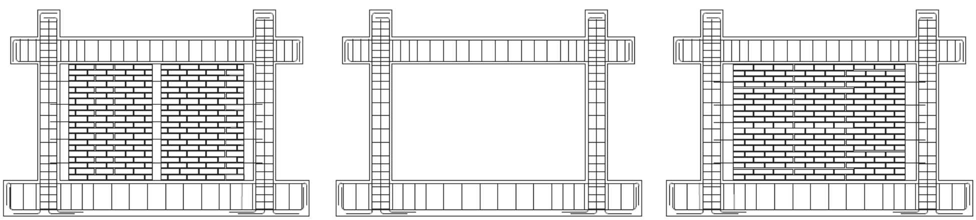
It is well known that the seismic effect of masonry infills is not fully considered on the reinforced concrete frame structures worldwide, though it has great influence on the overall structural behaviour during earthquakes. The purpose of this study is to investigate the effect of masonry-infilled walls on the RC frame response under reversed cyclic load. To pursue this goal, three large-scaled infilled RC frame specimens have been tested. Differences in results regarding stiffness, ductility and energy dissipation were obtained to evaluate the frame-to-infill interaction. These experiments focus especially on the enhancements gained by making use of masonry walls and failure modes, as compared to those of the bare frame. Conclusions are drawn by analysing hysteretic response and direct observation of the specimens.

1. Introduction

When ordinary low- to medium-rise structures are under seismic action, they may have different structural responses and modes of failure due to the interaction of frame and infill; the overall performance of the structure can be improved by the increasing strength brought from the non-structural elements. The RC frames can either be paired with fully or partially infilled masonry wall or kept empty as so called “bare frame”; the objective of this experimental research programme is thus to analyse the interaction between masonry infill and RC frame comparing the response of the bare frame, used as reference, with various infill configurations as slitted wall and isolated-columns system.

2. Experimental programme

The large-scale single bay reinforced concrete frame was designed to restrictions Eurocode8 for Ductility Class Medium (DCM). Based on this frame, three infilled frame specimens were constructed and tested with different configurations of infill: a bare frame (CB), slitted infill (CS) walls and column-isolated infill (CI).



(a) (b) (c)

Fig. 1: front view of different infill’s configuration for slitted wall (a), bare frame (b), and isolated column (c)

The lateral load was applied by means of a 460-kN servo actuator located at the left side of the specimen through a "push-and-pull" quasi-static action; the vertical load instead was constant and equal to 130 kN equally divided on the two columns.

3. Test results

The initial lateral load is almost the same for both specimens, around 110 kN but for the CS the value increases faster in the next few cycles, reaching 211 kN against 202 kN at 18 mm drift of the CI, starting level for the appearance of the first shear cracks; the higher stiffness of CI leads to a major concentration of stresses on the masonry wall and the premature shear failure was mainly due to the absence of stiffness for the frame CB.

The occurrence of flexural and shear cracks can be regarded as the serviceability and ultimate state designs. Hence, it can be concluded that the lateral drift ratio of the infilled frames equal to 1,24% marks the threshold between these two stages.,

The peak load of each specimen, as shown in Table 1, has been reached for the first two specimens at the drift level of 36 mm and 42 mm, while the isolated wall may achieve better result with a maximum peak load value of 246 kN at the 48-mm drift level.

Table 1: loading features

Speci-men	Peak load (kN)	Load at first stage (kN)	Ductility factor	Energy dissipation
CS	238	111,4	3,28	Medium
CB	215	68	2,81	Lower
CI	246	118,6	3,99	Higher

The specimen CS showed a non-linear behaviour with load capacity of more than 100 kN at the beginning of the test; the stiffness increased rapidly in the next two cycles, gaining around 70% before the drift level of 18 mm and the slope reduced after the early breakage of the masonry.

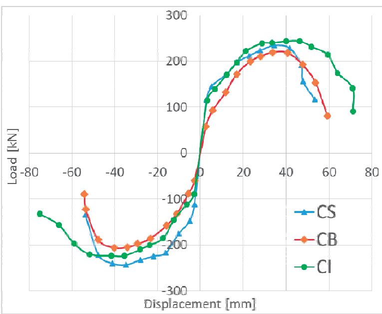


Fig. 2: comparison of backbone curve for different specimens

In the CI specimen the stiffness is higher but it suffers a constant slow decrease without any sudden failure. This behaviour can be noticed in the crack pattern since, after the formation of two triangular separate blocks in masonry, no further cracks occurred in the infill so the stiffness can be considered constant until the peak load reaches.

The trend of hysteresis loops of the column-isolate infilled frame is similar to that of the bare frame with constant grow of load resistance. The differences appear after the peak load when the first two frames were not able to carry further load and suffered a dramatic drop of resistance demonstrated by the appearance of great number of shear crack in both columns.

4. Conclusion

The test results illustrated by the curves in Fig.2 show the great enhancement obtained in the column-isolated (CI) specimen where the ductility factor increase by 21% respect to the slitted wall and 41% respect to the bare frame which leads to higher dissipation of energy.

Lateral steel connectors, bucked at an early stage for both specimens but in the latter case, the stronger bars permitted cracks to occur in the layer of mortar in corresponding to the bars, benefitting the formation of a shear surface on the wall which helps to dissipate energy.

Therefore some guidelines for the future work could be the providence of sliding surface on the masonry by using stronger connecting bars on the side while thinner layer of mortar on the upper bound in contact with the beam and on the lower one attached to the base since the material is weaker thus where the cracks are more likely diffusing through.