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Comparative Study on the Influence of Masonry Infill Walls on Reinforced Concrete Frames

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ABSTRACT

In reinforced concrete frame building, masonry wall are generally used in as infills and specified by architects as partitions in such a way that they do not contribute to the vertical gravity load-bearing capacity of the structure. Infill walls protect the inside of the buildings from the environment hazards and create separation insides. In addition to this infills have a considerable strength and stiffness. In the present study, it is attempt to highlights the performance of masonry infilled reinforced concrete (RC) frames with and without openings to ultimate loads.

Introduction

Reinforced concrete (RC) frame structures with brick masonry infill are extensively used in India. Brick masonry is the very common infill material in India because of its low cost, abundance, good sound and heat insulation properties, and the availability of skilled labour in this construction technique.

The use of masonry in construction industry has gained much popularity and the prime areas of its usage is, by far, as load-bearing walls in ordinary constructions and as infill material in high-rise reinforced concrete frame structures.

In multistory buildings, the ordinarily occurring vertical loads i.e. dead or alive, do not cause much of an effect, but the lateral loads due to wind or earthquake tremors are a matter of great concern and need special consideration in the design of buildings. These lateral forces can produce the critical stress in a structure, set up undesirable vibrations, and in addition, cause lateral sway of the structure which can reach a stage of discomfort to the occupants. In many countries situated in seismic regions, reinforced concrete frames are infilled fully or partially by brick masonry panels with or without openings. Although the infill panels significantly enhance both the stiffness and strength of the frame, their contribution is often not taken into account because of the lack of knowledge of the composite behavior of the frame and the infill. During the elastic response phase, the presence of brick infill walls increases in plane lateral stiffness of the structure and reduced its fundamental period, and as a result leads to larger shear forces.

In a routine based design procedure, the structure would be designed only for the structural members i.e. columns, beams, footings etc. whereas ignoring the presence of masonry units within the framing members of the structure. With the advancement in research in concrete members subjected to lateral load analysis, there ascended a new debate on the performance of the incorporation of these masonry units in the frame members as in Fig. 1. Gradually the engineers responsible for the design of structures adopted this fact that the use of masonry units as infill material influences the performance levels of the overall building especially whenever a masonry infill is provided in spaces present in between two columns.

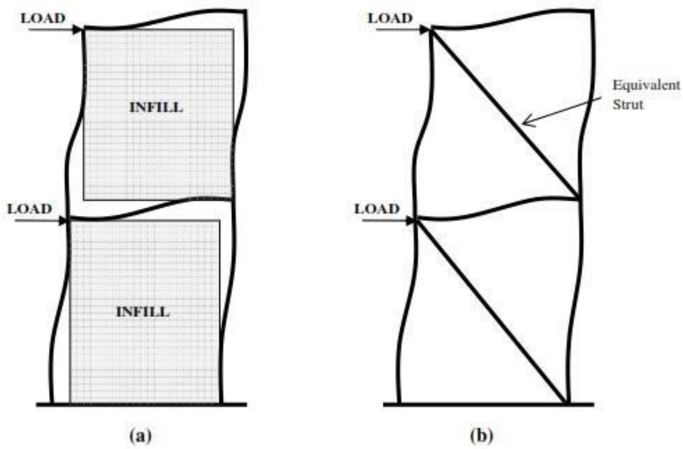

Figure 1. Laterally loaded infilled frame.

An attempt is made in this paper to study the effect of infill walls on reinforced concrete frames subjected to ultimate loads. The dimension of the framed specimens is 950mm x 950mm, with cross sectional dimension of 100mm x 100mm. nine concrete specimens with adequate reinforcement was prepared. Three was used as base specimen without infill wall (0% infill), three were used as 50% infill where the specimens were filled with brick work to 50% area leaving 50% open space and the last three were used as 100% infill where the inner surface was fully filled with brickwork. M20 grade concrete was used for casting the specimens.

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Failure Modes

The failure modes of masonry infilled material in reinforced concrete (RC) frame structures depends greatly on the properties of the frame and the masonry infill material used. In order to quantify the amount of enhancement of lateral stiffness of frame members is of utmost importance to study the various modes of failure occurring in frame-masonry interface as a result of lateral loads.

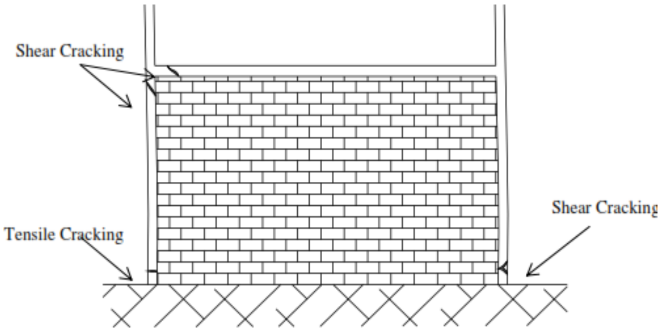

Figure 2. Failure mode of RC frame

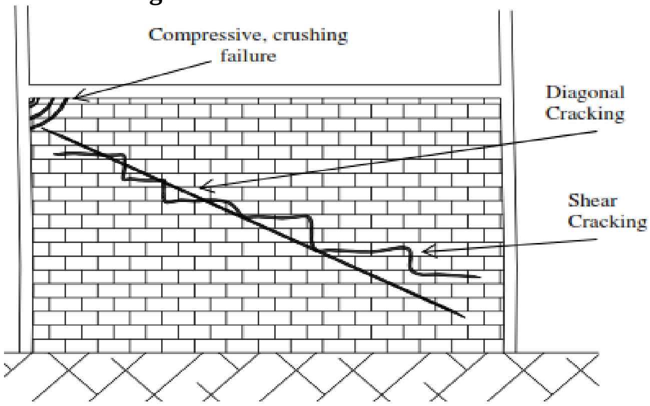

Figure 3. Failure mode of Infill

The modes of failure of the masonry units and that of the adjoining concrete frame member are presented in Fig. 2 and 3. The failure of columns in the frame is primarily a tension failure that initiates as a result of the applied overturning moments. This mode of failure can be of a great concern for the designers.

Literature Review

Haroon Rasheed Tamboli et al(2014) presented a paper on “Seismic Analysis Of RC Frame Structure With And Without Masonry Infill Walls”. This paper deals with the frames with three different infill configurations subjected to dynamic loading. The seismic analysis is performed using equivalent lateral force method and equivalent strut method using E-TABS software. The parameters discussed were time period, natural frequency base shear and storey drift. This paper results that the in-filled frames increases the storey drift and also infill frame increases the strength and stiffness of the structure.

Ozgur Anil et al (2007) performed a study on “An Experimental Study On Reinforced Concrete Partially In-filled Frames”. This paper studies the behavior of partially in-filled reinforced concrete frames subjected to lateral cyclic loading. And also it investigates the behavior of ductile reinforced concrete frames strengthened by introducing partial in-fills. The test results that partially in-filled RC frame exhibits significantly higher ultimate strength and higher initial stiffness than bare frame. And also it is observed that the aspect ratio of infill wall was increased, the lateral strength and rigidity were also increased. And it shows that the partial infill walls both connected to the column and beam of the frame showed the most successful behavior.

Objectives of the present Work

Methodology

Materials

Portland Pozolana Cement 53 grade was used for the investigation. Locally available fine and coarse aggregates were used. Frame specimens were prepared with concrete of grade M20 for which mix proportion was prepared as shown in table 1 using IS method. Basic tests were conducted as per IS standards on the materials used for concrete, such as specific gravity, fineness, consistency, and initial setting time for cement. For fine and coarse aggregates tests such as sieve analysis, specific gravity, impact value and crushing value were conducted as per standards and results are tabulated in table 2. Light weight fly ash bricks were used for making the infill wall.

Mix Design

Concrete used for the investigation is designed in accordance with IS 10262-2009.

Design Stipulations
Grade designation : M20
Type of cement : PPC
Max nominal size of agg. : 20 mm
Min cement content : 300 kg/m3
Max water-cement ratio : 0.55
Workability : 25–50mm Slump
Exposure condition : Mild
Method of concreting : Non-Pumping
Degree of supervision : Good
Type of aggregate : Crushed Angular
Chemical admixture type : Nil
Test Data for Materials:
Cement used : PPC (53Grade)
Specific gravity of cement : 3.13
Specific gravity of:
Coarse aggregate : 2.65
Fine aggregate : 2.6
Water absorption:
Coarse aggregate : 0.81%
Fine aggregate : 1.57%
Free (surface) moisture:
Coarse aggregate : 1%
Fine aggregate : Nil
Sieve analysis of Fine aggregate : ZONE II

Table 1. Mix proportion for M-20

w/c ratio	Cement	Fine Aggregate	Coarse Aggregate
0.47	1	1.69	2.88

Details of Beam-Column Joints Specimen

The outer to outer dimensions of the frame specimen is 950mm x 950mm, with the cross sectional dimension of 100mm x 100mm. The main reinforcement of 4 no. of 8mm diameter bars with stirrups of 6mm diameter are provided at a spacing of 100mm centre to centre.

The infill was done using fly ash bricks with full infill, 50% infill as shown in fig.5.

Figure 4. RC frame without infill wall.

Figure 5. RC frame with infill wall.

Experimental Setup and Testing

The self-straining load frame and the loading jack along with proving ring are arranged in such a way to apply the concentrated force diagonally on the specimen as shown in fig 6. Care is taken to avoid eccentricity during loading. The frames with no infill wall, and frames with infill walls were subjected to failure and hence the ultimate loads are determined. Visible crakes first appeared at the joints and propagated along the diagonals. The ultimate loads are tabulated in table 3. From the investigations it is observed that the failure patterns of no infill specimens are more ductile than that of specimens with infill wall.

Figure 6. Test setup of specimen in loading frame.

Results and Discussions

Table 3 shows the relation between the ultimate loads and the percentage of infill in the RC frame specimens. A bar chart is made between ultimate loads and percentage of infill in the RC frame specimens as shown in fig. 7.

Table 3. Ultimate load carrying capacity of RC frames

Percentage of infill	Ultimate Load Pu, kN (M20)			
(%)	(i)	(ii)	(iii)	average
0	13.73	14.15	13.87	13.92
50	29.14	29.47	31.04	23.44
100	43.64	42.94	43.87	33.14

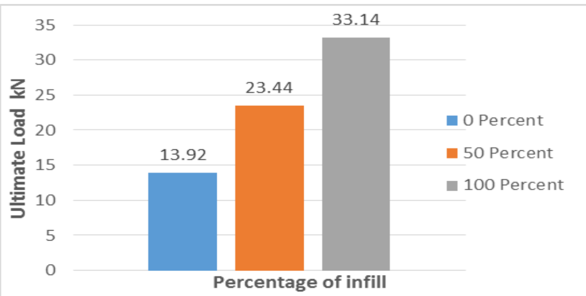

Figure 7. Relation between ultimate load and percentage of infill in the specimens.

Figure 8. Propagation of crack in the specimen.

Conclusions

The following conclusions are drawn from the test results.

1. The ultimate load carrying capacity of RC frame specimen with 50% infill increases by 68.39% to that of 0% infill RC frame specimen.
2. The ultimate load carrying capacity of RC frame specimen with 100% infill increases by 138.07% to that of 0% infill RC frame specimen.
3. The ultimate load carrying capacity of RC frame specimen with 100% infill increases by 41.38% to that of 50% infill RC frame specimen.
4. The presence of the in-fill wall increases the strength and stiffness of the structure.
5. The increase in the opening percentage leads to a decrease on the lateral stiffness of infilled frame.
6. From this present result it shows that, deflection is very large in case of bare frame as compare to that of infill frame with opening.
7. The propagation of cracks along the diagonals confirms shear failure.

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