# Effect of Lintel Band on the Global Performance of Reinforced Concrete Masonry In-filled Frames

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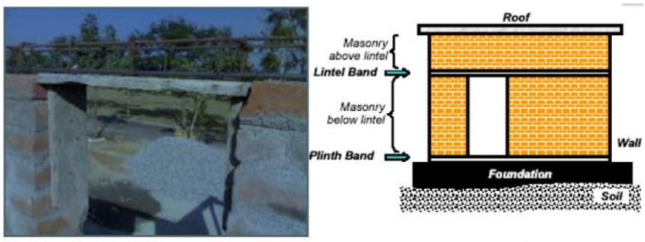
**I.** ***Abstract*— Entryway and window openings are unavoidable components in RC masonry in-filled frames because of functional and ventilation requirements. The presence of entryway and opening in RC masonry in-filled frames reduces the lateral stiffness and strength of the wall, which modifies the structural behavior of structure. If these open spaces are located in the critical zones like areas within middle two thirds of a wall panel, then the wall needs to be reinforced by providing necessary structural elements such as lintel bands (i.e., horizontal/vertical bands) around them. Lack of such strengthening techniques may cause the structure to undergo severe damage during the earthquake. In this paper, the change in structural response of RC masonry infilled frames due to the presence of horizontal bands above the openings is studied. For studying the behavior of the frames, static non-linear pushover analysis tool has been used [2].**

***Keywords—Unreinforced brick masonry infill walls, Lintel, Horizontal bands, Vertical bands and Static non-linear pushover analysis***

## II. INTRODUCTION

The use of reinforced concrete building is growing day by day due to various reasons like increase in demand to aesthetic appearance of a building also easy in fulfilling those demand through RC frame, partition wall requirements, and low cost. Among all the kinds masonry construction, brick masonry is one of the most commonly used materials till date in many parts of the world. Though these infill walls are essential component, they are considered as nonstructural elements according to the existing standard codes of practice in many countries. During ground motions, the infill brick wall may lose its stability, leading to change in seismic capacity of a building as a whole. Though there is presence of large article on effect of strong ground motion on RC frame, the effect of openings (i.e., Door(s) and window(s)) and presence of lintel bands above the openings are not much studied and are rather neglected in the analysis and design procedures. Lintel is a horizontal member just like beam made up either of stone, wood, steel or reinforced concrete (usually) or pre-tensioned concrete to support the masonry material present above the opening. These are responsible to transfer the load vertically to the supporting walls (Figure 1(a)). Horizontal bands (at sill and lintel) are provided in the masonry structure to keep the walls in place at the time of seismic events (Figure 1(b)). The presence of entry spaces, horizontal bands at the different positions in the wall panel changes the lateral load transfer mechanism in the structure and may lead to strength of infill wall. The presence of lintel beams and bands may lead to various effects especially the short column effect and change in the design forces on different structural elements[2].




(a) (b)

**Figure 1:** (a) Lintel Beam (b) Lintel Band

## III. LITERATURE REVIEW

From the review of past research work, it has been observed that the presence of infill wall may help to reduce the collapse of building by reducing storey displacement and increasing lateral load carrying capacity of frame[3]. Experimental study [12] carried out on RC frame with brick masonry infill has shown that the damage pattern of the structure depends on interaction between the frame and brick infill, and also on the relative strengths of RC frame and the infill panels. The combination of RC frame and brick infill ought to be in such a way that the energy given by the earthquake is dissipated by failure of infill wall, as it is nonstructural element, otherwise there might be failure of critical structural element which is serious matter for global performance of structure. In the case of RC frames with unreinforced brick masonry in-fills, introducing bare frame with brick infill material can lead to serious damage, also changes the relative capacities of beams and columns [5]. On the other hand, in the case of RC frames with reinforced brick masonry in-fills, the plaster thickness and reinforcement meshing in infill can also increase the lateral strength of frame provided that the frame members are designed for the additional forces due to the presence of brick infill [12]. The Indian Standards [2] provides sizes and details of the bands.

**Fardis (1996)** investigated the seismic response of an infilled frame which had weak frames with strong infill material. It was found that the strong infill which was considered as non-structural is responsible for earthquake resistance of weak reinforced concrete frames. However, since the behaviour of infill is unpredictable, with the likelihood of failing in a brittle manner, it was recommended to treat infill as a non-structural component by isolating it from frames. On the contrary, since infill is extensively used, it would be cost effective if the positive effects of infill are utilized.

**Polyakov (1956)** the study of the complicated behaviour of masonry infill by suggested that the infill and frame disparate excluding at two compression corners. He established the idea of the equivalent diagonal strut and proposed that transformation of stresses from the frame to infill occurs only in the compression zone of the infill.

**Nasratullah Zahir, Dr Vivek Garg [9]** paper present static and dynamic analysis of R.C building frame with infill The results obtained from the analysis indicates that story shear increase for infill frame models compare to bare frame model by equivalent static method and response spectrum method. This increase in the ratio is found to be more at the roof compared to the base of the structure. The story shear values obtained by Smith and Holmes models are found to be more compared to Paulay and infill panel models**.**

**Rahul P. Rathi, Dr P.S. Pajgade [14]** in this paper actual building such as college building (G+3) is considered by modelling of frame and Infills. Modelling of infills is done as per the actual size of openings with the help of equivalent diagonal strut method for the various model such as bare frame, infill frame and infill frame with the centre and corner opening. Results indicate that infill panels have a large effect on the behaviour of frames under earthquake excitation. In general, infill panels increase the stiffness of the structure. The increase in the opening percentage leads to a decrease in the lateral stiffness of the infilled frame.

**Murty, C.V.R., and Nagar, A., (1996) [12]** In this paper there is mention about hybrid load transfer mechanism i.e. from the both wall and frame structure in such structures, there is a large concentration of ductility demand in a few members of the structure. For instance, the *soft-storey effect* (when a storey has no or relatively lesser infills than the adjacent storey), the *short-column effect* (when infills are raised only up to a partial height of the columns), and *plan-torsion effect* (when infills are unsymmetrically located in-plan), cause excessive ductility demands on frame columns and significantly alter the collapse mechanism. Another serious concern with such buildings is the out-of-plane collapse of the infills which can be life threatening. Even when the infills are structurally separated from the RC frame, the separation may not be adequate to prevent the frame from coming in contact with the infills after some lateral displacement; the compression struts may be formed and the stiffness of the building may increase

This paper aims in understanding the effect of lintel band above the central opening in RC framed structure. A Case study is carried out by considering a single bay single storey RC structure with brick infill, a central opening and lintel band.

Static nonlinear analysis is performed on the RC frame considering brick infill under different condition viz., (a) frame with masonry infill without opening (Figure 2(a)) (b) frame with opening but without lintel and lintel band (Figure 2(b)) (c) frame with lintel above the central opening (Figure 2(c)) and interpretations are derived. .

## IV. MODELING

In this study, a single bay single storey non-ductile RC infilled frame is considered and four different types of infill frames were considered (i) RC in-filled frame with no openings (Figure 2(a)) (ii) RC infilled frame with central opening but without lintel band (Figure 2(b)) and (iii) RC infilled frame with lintel band above the opening (Figure 2(c)). The material properties and the structural details are given in Table 1 and Table 2 [2] respectively.

**Table 1: Material Properties**

| | |
|---|---|
| Compressive strength of concrete (fck) in RC frame | 25 MPa |
| Compressive strength of concrete (fck) in Lintel Beam and Band | 20MPa |
| Yield stress in steel (fy) | 415 MPa |
| Poisson's ratio of concrete (γ) | 0.2 |
| Compressive strength of brick masonry (fb) | 10 MPa |
| Mortar Type (Cement and Sand ratio 1:5) | M1 |
| Basic compressive stresses for masonry after 28 days (IS 1905-1987) | 0.96 N/mm2 |
| Compressive strength of masonry fm' (IS 1905, Appendix B-2) | 0.96/0.25 = 3.84 N/mm2 |
| Young's modulus of brick masonry Em ( IS 1905, Clause 3.3.2) | 550*3.84 = 2112 N/mm2 |
| Poisson's ratio for brick masonry | 0.3 |

**Table 2: Structural Details**

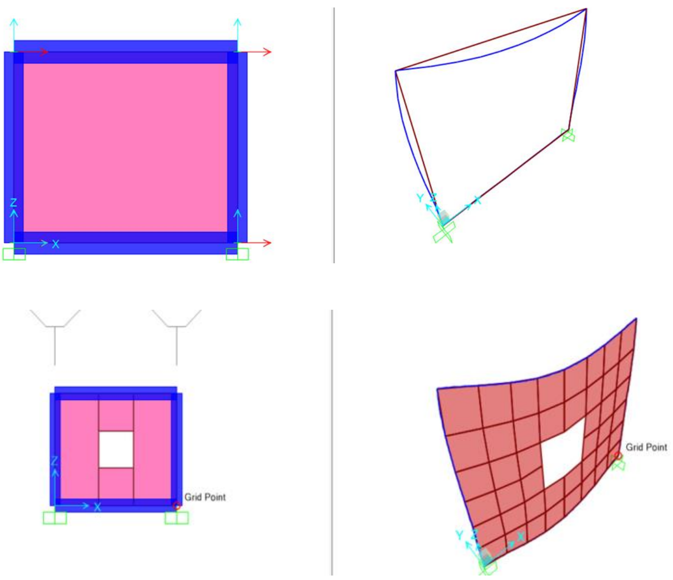
| | |
|---|---|
| Bay width | 3.5 m |
| Height | 3.0 m |
| No of bays | 1 |
| Opening Size | 1m x 1m |
| Column size | 0.3 m x 0.3 m |
| Lintel Beam | 0.075 m x 0.230 m |
| Lintel Beam Length | 3.5 m |
| Lintel Band | 0.23 m x 0.075 m |
| Beam size | 0.23 m x 0.35 m |

According to code provision only those walls with an opening area of less than 10% of the gross panel area are considered as resisting seismic loads. In this study opening area of 9% of the gross panel area is considered. The frame is designed in all four models according to IS: 456-2000 [10]. 75mm thick R.C.C. lintels and lintel bands are considered over the 2m high brick walls.

The space frame is modelled using a standard software SAP 2000, Version 16. Infill brick masonry walls are modelled as a wall shell element. First Static linear analysis of building is carried using the program calculated fundamental time period along x and y direction which is followed by push over analysis respectively. The following load combination as given in NBC 105:1994 are considered for the working stress method

DL+LL+E

0.7DL+E



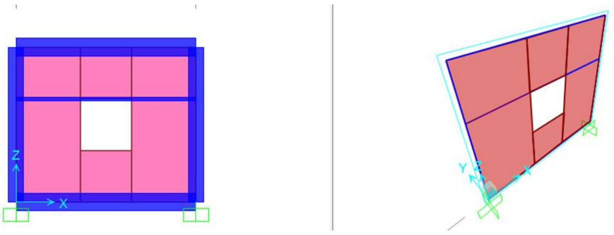



Figure 2: (a) Frame with masonry infill without opening (b) Frame with opening but without lintel beam and lintel band (c) Frame with lintel beam above the central opening

## V. Methodology

In this methodology, the brick masonry is considered as combination of brick units and mortar units. The interaction between the brick units and the masonry units could be established with the help of assumed virtual pair of springs in two directions; one normal and the other shear. But in our case for finding the effect of lintel band on global performance, macro modeling of masonry element was done where masonry element is assumed as the shell element with properties mentioned in above table 2 and 1 then first static linear analysis was performed which is followed by Nonlinear static analysis [1]. Nonlinear static pushover analysis is used to know the performance and collapse pattern of infill frame. It is an incremental static analysis used to determine the force displacement relationship, or the capacity curve for a structure. The analysis involves applying horizontal loads, in a prescribed pattern, onto the structure incrementally; pushing the structure and plotting the total applied lateral force and associated lateral displacement at each interval, until the structure achieves collapse condition. . A plot of the total base shear vs. roof displacement in a structure is obtained by this analysis that would indicate any premature failure or weakness. Displacement controlled pushover analysis is performed on all the four RC infilled frames which are modeled using macro level modeling. A target displacement of 254mm is applied on to the structure in positive x direction to all three models.

Then on application of displacement up to 254mm the changes on performance level, changes on base shear and also stages of structure on different phase i.e. formation of hinges and types of hinges were observed which are shown in result section [4].

## VI. Result and Interpretation

After analysis of structure the changes on performance level, Base shear, stages of building (i.e. Hinge formation), based on displacement controlled pushover analysis along x direction up to 254mm and then comparison is down between three different model (i.e. Wall only, wall with central opening and wall with lintel band above opening)

### A. *Performance level*

After carrying out nonlinear static analysis [1] on model containing wall only the performance level was (V, D) =(8.316KN,1.89E-05m), similarly for model containing central opening (V, D) =(11.170KN,3.97E-05m) and for model including lintel band above central opening (V, D) =(11.619KN,4.08E-05m) which shows increase in performance level of structure.

### *B. Hinge state*

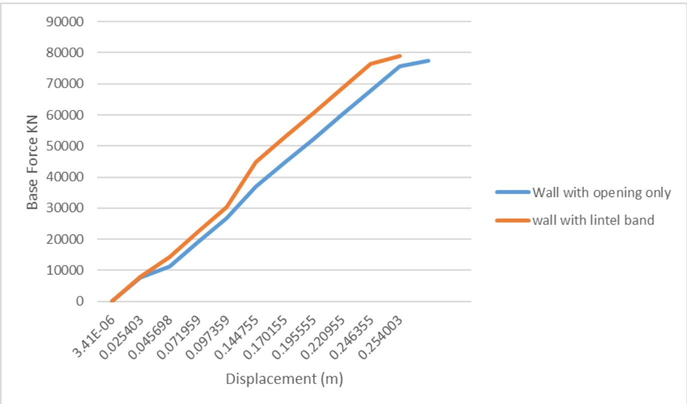
| Hinge State( Wall with opening only) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Step | AtoB | BtoIO | IOtoLS | LStoCP | CPtoC | CtoD | DtoE | BeyondE | Total |
| 8 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 4 |
| 9 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 4 |
| 10 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 4 |
| 11 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 4 |

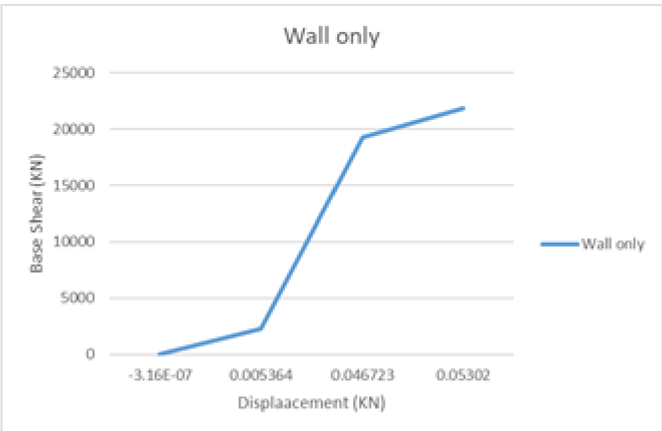
| Hinge State( Wall with Lintel above opening ) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Step | AtoB | BtoIO | IOtoLS | LStoCP | CPtoC | CtoD | DtoE | BeyondE | Total |
| 8 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 9 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 10 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |

On carrying out push over analysis of model containing opening only the hinge state was in life safety state but after applying the lintel band above the opening the hinge state were found to be in immediate occupancy state which shows the increase in safety of structure.

### *C. Base shear Vs Displacment*

On Plotting the graph between base shear and displacement for three model, following graphs were




obtained.

## VII. CONCLUSION

In this paper three brick infilled masonry frames (Full wall, with opening without lintel and opening with lintel band) have been considered. Displacement based pushover is conducted on these frame to understand the effect of lintel on overall performance of the frame. Base shear, hinge state and deformation capacities have been studied. It was observed that there was increase in stiffness of structure, reduction on top storey drift by 1.2% and also improvement in hinge state from Life safety state to immediate occupancy on adding lintel band. Hence lintel bands increase seismic strength, stiffness and reduce top displacement of structure. Therefore, in higher seismic zone areas, providing lintel bands is suggested. The conclusions should not be generalized because the numerical experiments were conducted on only one frame.

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