Investigation of Strain in Infill Frames using Nastran Patran

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Abstract. Masonry infill is usually neglected in the design and it is treated as a non-structural element instead of its stiffness and lateral resistance capacity. Their presence in the RC frame could also affect the lateral load resistance. The interaction of infill presence in the RC frame will also depend on the aspect ratio of frame and openings presence in the infill. The infill collapse initiated disaster of RC Framed structures are mainly concerned by the researchers recently. Many researchers considered experimentation up to a single-story single bay frame may be due to constraints in their facilities. A 3-bay 3-Storey Frame is considered in the present study using finite element package using MSC Nastran for different frame such as bare frame, Infill frame with different openings provided in it, and meshing was done finally strains were taken at middle third distances on each member of the internal panel of the bare frame, Infill frame, Infill frame with window opening, Infill frame with door opening, Infill frame with window and door openings and a comparison was made with infill frame and presence of openings in the infilled frame.

1. INTRODUCTION

RC Frames alone may not satisfy the requirement of building functions such as space separation, protection from the environmental calamities like rain, dust, and security from outside. So, Masonry infills are commonly used as partitions in RC Frames and treated as a non-structural element. The effect of these infills usually neglected in the design, but recent researchers (Papatheocharis, Perdikaris, Asce, & Moretti, 2019)[4] have given evidence that the presence of Masonry infill in RC framed structure giving considerable in-plane stiffness, Ultimate strength, Energy dissipation, and little ductility. (Verderame et al., 2019)[7] Presented a numerical model for both non-conforming and conforming frames with and without infills by considering hallow clay bricks and found that nonconforming frames fail mainly due to shear failures involving infill panel and beam-column joints. (Huang, Asce, Burton, Asce, & Sattar, 2020)[1] developed empirical equations to predict the parameters of the backbone curve of infill panels which are modeled using equivalent struts which gives the axial response of the infill struts. (Misir, Ozcelik, Girgin, & Yucel, 2015)[3] studied with large scale RC frames using 3 single leaf, 2 double-leaf walls, bare frame and without and with Z-ties and are tested and resulted in doubled energy absorption capacity and initial stiffness of the all infill walls also 50% increased ultimate strength was observed, And due to presence of Z-ties integrity was maintained. (Singh & Yamini, 2018)[6] studied a numerical study to understand the behaviour of infilled RC frame and compared with the OGS frame and found that the stiffness of the infilled frame shows 1.12 times stiffer than a bare frame and
observed the failure was at the ground storey for both OGS and infilled ground storey. (Mbewe & Zijl, 2019)[2] given a new approach for developing geometric properties and equivalent strut material that incorporate within the infill that the behavior of dominant stress zones. The proposed strut was modeled as nonlinear springs with specific characteristics, and are represented by dominant stress zones, and are derived from the dominating stress and it connects these stress zones either parallel or series elements. Using numerical methods the proposed model was evaluated, and validated with the experimental data taken from literature and showed good correlation with the experimental data. (Schuller, Member, & Noland, 1996)[5] developed two types of frames i.e., single storey single-bay infill frames one is for wind loads and other for seismic loads and then tested and concluded that presence of infill panels improve the stiffness of the frames also strong frame strong infill panel shows high load resistance and energy dissipation capacity than weak frame weak panel.

In the present study to know the effect of the presence of infill in the 3-Bay, 3-Storey RC Frame and openings present in the RC Frame was studied using finite element package using MSC Nastran for different frame such as bare frame, Infill frame with different openings provided in it, and meshing was done finally strains were taken at middle third distances on each member of the internal panel of the bare frame, Infill frame, Infill frame with the window opening, Infill frame with door opening, Infill frame with window and door openings and a comparison was made with infill frame and presence of openings in the infilled frame.

2. Materials and Methods

2.1 Material Investigation
To perform analytical modeling in MSC NASTRAN, an experimental investigation of materials is needed. Analytical modeling in MSC NASTRAN requires certain properties such as Compressive strength of the material used (i.e. concrete, brick & steel), young’s modulus of materials, Poison’s ratio, etc. Hence these properties are to be found out from experimental investigation of materials.

The following materials were used in the investigating process:

- Fe 415 steel of 8mm diameter
- 53-Grade Cement
- Sand (Zone-II)
- Coarse aggregate of size 10mm
- Flyash bricks
- M20 Concrete

In the present work, the material of the model up to failure and beyond the initial yield surface is Perfectly Elastic

Elastic
Modulus of elasticity of Concrete = 22360 MPa
Poisson’s ratio = 0.151
Compressive Strength of bricks = 4.2 MPa
Modulus of elasticity of steel = 200 GPa
Poisson’s ratio = 0.3
Yield stress = 415 MPa

3. Methodology
Various stages of work involved in the present study, initially properties of materials were carried out. The results obtained from the material investigation were used in modeling the frame by FEA package MSC NASTRAN. Meshing is created with quadrilateral elements and finally, analysis is done for both vertical and horizontal load cases at all beam-column joints and the elemental strains for the bare frame, with infill, infill with the window opening, infill with door opening, and infill with both door and window openings are compared and conclusions were drawn.
3.1 Modeling using MSC NASTRAN

Key points are created at horizontal distances of 900mm and vertical distances of 700mm. The frame is modeled in such a way that a closed loop is formed at the center of size 900mm x 700mm. Four overhanging beams are formed in the frame each at the upper half and lower half of the frame. The frame is designed such that it is symmetrical about X-axis as well as Y-axis.

The following cases modeled using MSC Nastran package

1. Structure without infill
2. Structure with infill
3. Infill structure with a window opening
4. Infill structure with door opening
5. Infill structure with door and window openings.

![Figure 1. Bare frame modeled using Nastran.](image-url)
Frame with infill is modeled with three different materials i.e. concrete, steel, and brick. The corresponding properties are assigned in preprocessing mode and further analysis is done.

The following are the load cases
1. RC frame without infill is subjected to horizontal point loads applied at all beam-column joints
2. RC frame without infill is subjected to vertical point loads applied at all beam-column joints
3. RC frame with infill is subjected to horizontal point loads applied at all beam-column joints
4. RC frame with infill is subjected to vertical point loads applied at all beam-column joints
5. RC frame with infill and window opening is subjected to horizontal point loads applied at all beam-column joints
6. RC frame with infill and window opening is subjected to vertical point loads applied at all beam-column joints
7. RC frame with infill and door opening is subjected to horizontal point loads applied at all beam-column joints
8. RC frame with infill and door opening is subjected to vertical point loads applied at all beam-column joints
9. RC frame with infill and both window and door opening is subjected to horizontal point loads applied at all beam-column joints
10. RC frame with infill and both window and door opening is subjected to vertical point loads applied at all beam-column joints

4. Results and Discussions
After modeling the Frame using MSC NASTRAN strains at different nodes for each load case beginning from 1kN to 6KN are tabulated and graphs were drawn for all the cases. For structure without infill, with infill, Infill with the window opening, Infill with door opening, Infill with window and door openings, Four points at all beam-column joints as shown in Figure 1 Consider the top left corner as point-1, and apply a point load in the horizontal direction starting from 1kN up to 6kN note the strains for each load case at all eight points two on each member of the interior panel of the frame and comparison was made with the help of curves represented in the following Figures 4, 5, 6, 7.

**Horizontal Loading**

![Comparison of Bare Frame and Infill Frame](image)

**Figure 4.** Strain comparison between the bare frame and infill frame for horizontal loading.
Figure 5. Strain comparison between the bare frame and infill frame with window opening for horizontal loading.

Figure 6. Strain comparison between the bare frame and infill frame with door opening for horizontal loading.
In Figures 4, 5, 6 and 7 with horizontal loading a comparison made among the Frame without infill and with infill and openings provided were observed that the strains are high at 4th and 8th nodes in Bare Frame and they were reduced at all the points in Infill frames with openings provided.

**Vertical Loading**

![Figure 8. Strain comparison between the bare frame and infill frame for vertical loading.](image-url)
**Figure 9.** Strain comparison between the bare frame and infill frame with window opening for vertical loading.

**Figure 10.** Strain comparison between the bare frame and infill frame with door opening for vertical loading.
With vertical loading, a comparison made among the Frame without infill and with infill and openings provided were observed that the strains are increased at 1st, 3rd, and 4th nodes in Infill frames with openings provided compared to Bare Frame and are represented in the Figures 8, 9, 10, and 11.

5. Conclusions

For the frame, with infill for a load ranging from 1kN to 6kN in steps of 1kN applied in the horizontal and vertical direction the reduction in the strains when compared to the frame without infill is 75%.

For the frame, with infill and door opening for a load ranging from 1kN to 6kN in steps of 1kN applied in the horizontal and vertical direction the decrease in the strains when compared to the frame without infill is 45%.

For the frame, with infill and window opening for a load ranging from 1kN to 6kN in steps of 1kN applied in the horizontal and vertical direction the decrease in the strains when compared to the frame without infill is 38%.

For the frame, with infill and door and window openings for a load ranging from 1kN to 6kN in steps of 1kN applied in the horizontal and vertical direction the increase in the strains when compared to the frame without infill are 33%.

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