NONLINEAR SEISMIC ANALYSIS OF STEEL MOMENT RESISTING BUILDING WITH DIFFRENT INFILL ARRANGEMENT

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Abstract: This paper presents a case study of seismic performance comparison of 9, 15, 21-story steel MRF designed with and without irregular infill arrangement. The seismic performance of MRF is evaluated under a suit of various ground motion representing high to medium seismicity using nonlinear time history analysis. The findings of evaluation study showed that the with infill MRF is significantly more efficient than the bare frame MRF.

Index Terms -Steel moment resisting frame, Nonlinear infill, Nonlinear time history analysis.

I. INTRODUCTION

Moment resisting steel frames comprise one of the most common forms used in modern building and industrial structures. Their main advantage for seismic resistance is that, they provide very ductile response. However, numerous moment resisting frames suffered beam to column connections and other failures in brittle manner during some recent earthquakes, particularly the 1994 Northridge and 1995 Kobe earthquakes. Although many experimental and analytical studies have been conducted to investigate the seismic behaviour of moment resisting frames for several decades, the lessons learned from recent earthquakes indicated that the current earthquake resistant design concept and methods could not prevent the failure of the frames subjected to severe earthquakes. To prevent the failures during severe earthquakes that can occur in the future, the seismic behaviour of moment-resisting frames should be investigated in a more rational manner and considering different types of irregular infill arrangements.

II. PROBLEM STATEMENT

Present research involves the study of with and without models of infill in steel moment resisting 9, 15, 21 story building for seismic analysis and effect of these modelling on different selected ground motion data.

III. NONLINEAR MODELLING OF INFILL WALL

It is micro level of modeling in which the nonlinearity is assigning by considering it as elements. In SAP 2000v15 shear wall is modeled as single layer shell element in which in plane behavior is kept as nonlinear and out plane behavior is linear The shell element is made up of single layers with uniform thickness and uniform material properties are assigned to single layer. During the finite element calculation, the axial strain and curvature of the layer can be obtained in element. Then according to the assumption that plane remains plane, the strains and the curvatures of the other layers can be calculated. And then the corresponding stress will be calculated through the constitutive relations of the material assigned to the layer. From the above principles, it is seen that the structural performance of the infill wall can be directly connected with the material constitutive law. For performance-based design, the recommendation of ACI 40 and FEMA 356 define the performance criteria for the steel members in terms of plastic rotations. Therefore, for practical engineering, further development of this model is needed.

IV. SEISMIC EVALUATION BY USING SAP2000

4.1 Nonlinear time history analysis

Non-linear structural analysis is becoming more important in earthquake resistant design, which requires more information about the drifts, displacements and inelastic deformations of a structure than traditional design procedures. In non-linear dynamic analysis, the non-linear properties of the structure are considered as part of a time domain analysis. This approach is the most rigorous and is required by some building codes for buildings of unusual configuration or of special importance. However, the calculated response can be very sensitive to the characteristics of the individual ground motion used as seismic input; therefore, several analyses are required using different ground motion records. The time history analysis is an actual dynamic analysis that can be done for both linear and nonlinear systems.

V. RESULTS AND DISCUSSION

5.1 Displacement profiles of 9 story structures

Following graph shows displacement profiles of 9 story structure with different irregular arrangements (bare frame, soft story, weak story, infill at center, and infill at corner, horizontal irregular arrangement and vertical irregular arrangement)

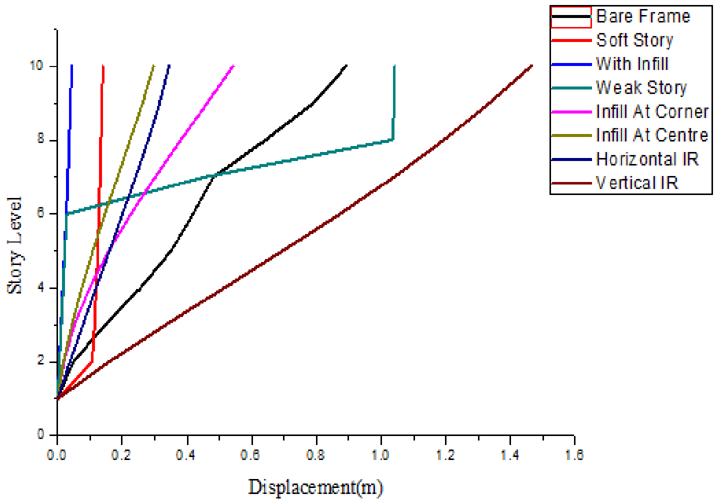

Figure 1: Displacement profiles of 9 Story with different irregular arrangements for Kobe Ground motion data.

As Kobe ground motion data is applied on different types of infill frames. It is observed that the vertical irregular arrangement frame has reached max displacement of 1.46 mm and structure with infill wall reached minimum displacement of 0.0429 mm. In weak story arrangement shows that it is slightly constant i.e. the displacement increases as the story of the building increases up to 1.04 mm. For bare frame initial increasing displacement is up to 0.8921 mm. Horizontal irregular arrangement, infill at center and infill at corner shows relatively similar behavior but less than that of bare frame.

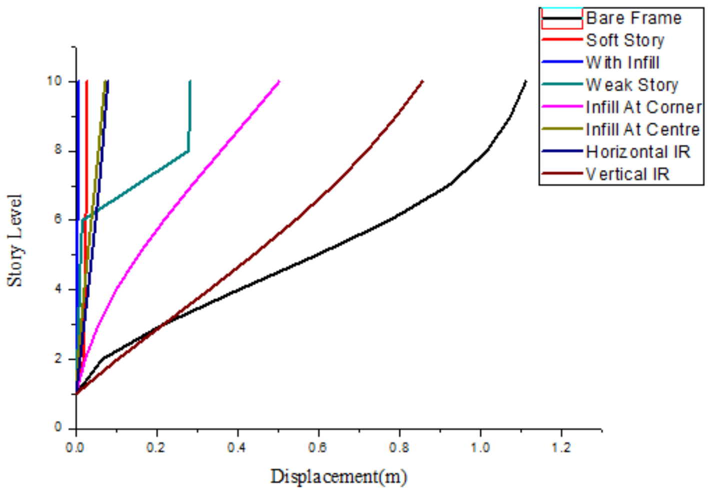

Figure 2: Displacement profiles of 9 Story with different irregular arrangements for Northridge Ground motion data.

As Northridge ground motion data is applied on different types of infill frames. It is observed that the bare frame has reached max displacement of 1.11 mm and structure with infill wall reached minimum displacement of 0.0061mm. In vertical irregular arrangement shows that it is slightly constant i.e. the displacement increases as the story of the building increases up to 0.855 mm. For weak story initial increasing displacement is less up to with infill present the story then it increases gradually up to 0.282 mm. Horizontal irregular arrangement, infill at center and infill at corner shows relatively similar behavior but less than that of vertical irregular arrangement.

5.2 Inter Story Drift of 9Story structures

Following graph shows inter story drift of 9Story structure with different irregular arrangements (bare frame, soft story, weak story, and infill at center, infill at corner, horizontal irregular arrangement and vertical irregular arrangement)

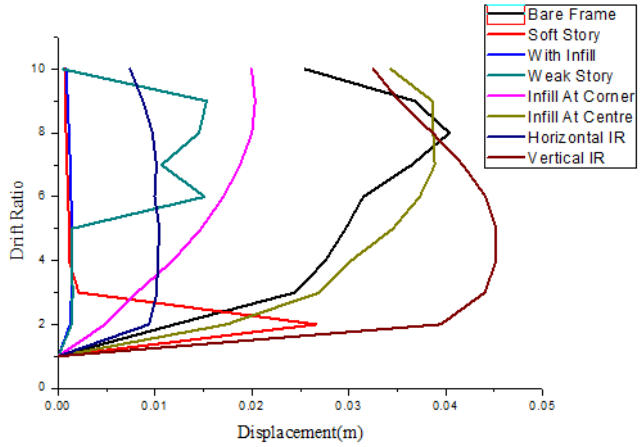

Figure 3: Inter Story Drift of 9 Story with different irregular arrangements for Kobe Ground motion data.

As Kobe ground motion data is applied on different types of infill frames. It is observed that the vertical irregular arrangement has reached max inter story drift of 0.0425 mm and structure with infill wall reached minimum displacement of 0.0087 mm. In weak story structure shows that it is slightly constant i.e. the displacement increases as the story of the building increases up to 0.025 mm. For infill at center initial increasing displacement is up 0.014 mm. Horizontal irregular arrangement, soft story and infill at corner shows relatively similar behavior but less than that of infill at center.

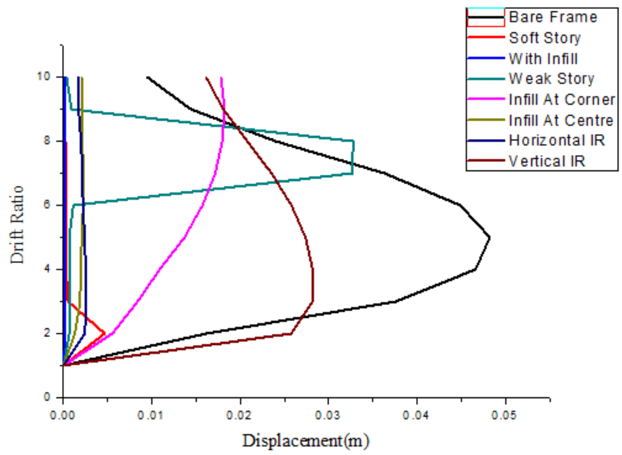

Figure 4: Inter Story Drift of 9 Story with different irregular arrangements for Northridge Ground motion data.

As Northridge ground motion data is applied on different types of infill frames. It is observed that the bare frame has reached max inter story drift of 0.048 mm and structure with infill wall reached minimum displacement of 0.0017 mm. In weak story structure shows that it is slightly constant i.e. the displacement increases as the story of the building increases up to 0.031 mm. For infill at corner initial increasing displacement is more up to ground floor the story then it increases gradually up to 0.02 mm. Horizontal irregular arrangement, infill at center and infill at corner shows relatively similar behavior but less than that of infill at corner.

5.3 Displacement profile of 15 Story structure

This graph shows displacement profiles of 9Story structure with different irregular arrangements (bare frame, soft story, weak story, and infill at center, infill at corner, horizontal irregular arrangement and vertical irregular arrangement)

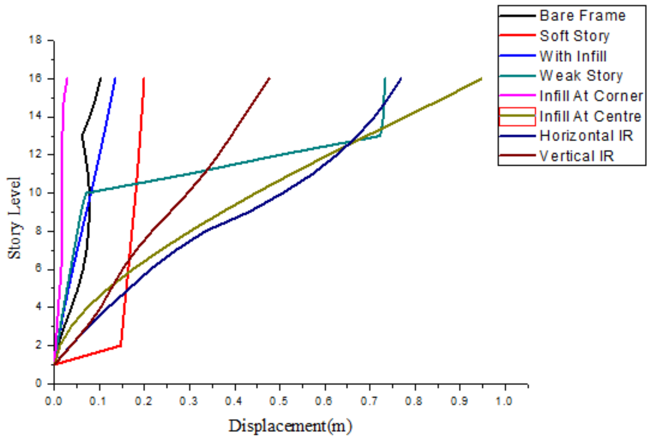

Figure 5: Displacement profiles of 15 Story with different irregular arrangements for Kobe Ground motion data.

As Kobe ground motion data is applied on different types of infill frames. It is observed that the infill at center arrangement has reached max displacement of 0.947 mm and structure with infill at corner reached minimum displacement of 0.0134 mm. In weak story shows that it is slightly constant i.e. the displacement increases as the story of the building increases up to 0.733 mm. For bare frame initial increasing displacement is up to 0.101 mm. Horizontal irregular arrangements, infill at center and infill at corner shows relatively similar behavior but less than that of bare frame.

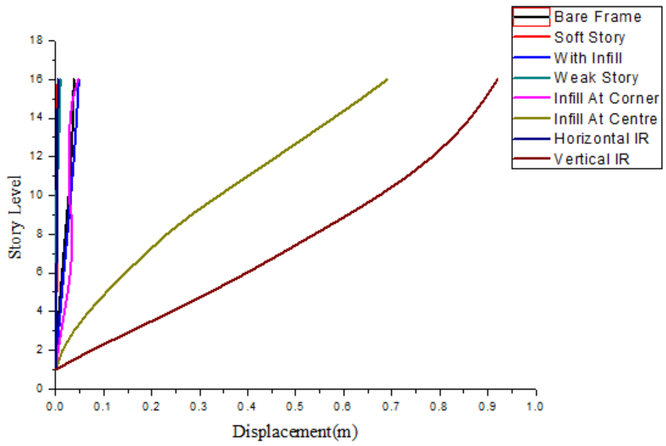

Figure 6: Displacement profiles of 15Story with different irregular arrangements for Northridge Ground motion data.

As Northridge ground motion data is applied on different types of infill frames. It is observed that the vertical irregular arrangement has reached max displacement of 0.9199 mm and structure with weak story reached minimum displacement of 0.009 mm. In infill at center arrangement shows that it is slightly constant i.e. the displacement increases as the story of the building increases up to 0.690 mm. For bare frame initial increasing displacement is up to 0.0380 mm. Horizontal irregular arrangements, infill at center and soft story shows relatively similar behavior but less than that of bare frame.

5.4 Inter story drift of 15 Story structure

Following graph shows inter story drift of 9Story structure with different irregular arrangements (bare frame, soft story, weak story, and infill at center, infill at corner, horizontal irregular arrangement and vertical irregular arrangement)

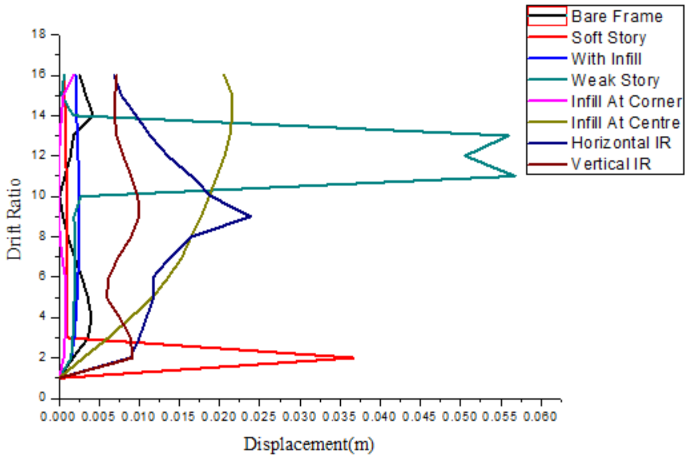

Figure 7: Inter Story Drift of 15 Story with different irregular arrangements for Kobe Ground motion data.

As Kobe ground motion data is applied on different types of infill frames. It is observed that the weak story has reached max inter story drift of 0.060 mm and structure with infill wall reached minimum displacement of 0.0001 mm. In soft story shows that it is slightly constant i.e. the displacement increases as the story of the building increases up to 0.035 mm. For Horizontal irregular arrangement increasing displacement up to 0.025 mm. bare frame arrangement, infill at center and soft story shows relatively similar behavior but less than that of horizontal irregular arrangement.

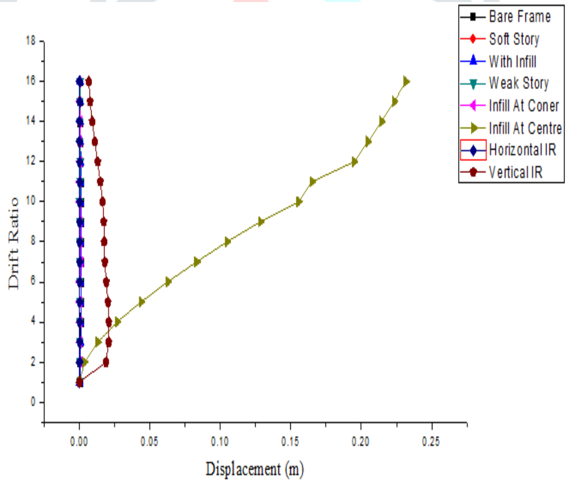

Figure 8: Inter Story Drift of 15 Story with different irregular arrangements for Northridge Ground motion data.

As Northridge ground motion data is applied on different types of infill frames. It is observed that the infill at center has reached max inter story drift of 0.029 mm and structure with infill wall reached minimum displacement of 0.0005 mm. In vertical irregular arrangement shows that it is slightly constant i.e. the displacement increases as the story of the building increases up to 0.006 mm. For Horizontal irregular arrangement increasing displacement up to 0.001 mm. bare frame arrangement, infill at center and soft story shows relatively similar behavior but less than that of horizontal irregular arrangement.

5.5 Nonlinear time history analysis (NTHA)

Results obtained from NLTHA. Based on these results, seismic analysis of nine storey steel MRF with and without infill wall is discussed. Dynamic analyses of for 9, 15, 21-story, frames were carried out for selected ground motions. For NLTHA of each design under specific record, the acceleration time history of each earthquake is scaled through scale factor to have the same design spectral acceleration at the fundamental period gives calculation of typical scale factor. To investigate the performance of

MRF in high to medium seismicity, Nonlinear Time History Analysis is performed under the ground motion records of 1984 Northridge and 1995 Kobe earthquakes.

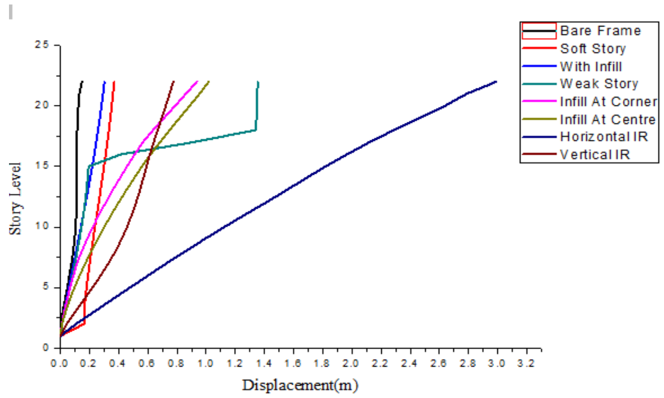

Fig. 9: Displacement profile of 21Story with different irregular arrangements for Kobe Ground motion data.

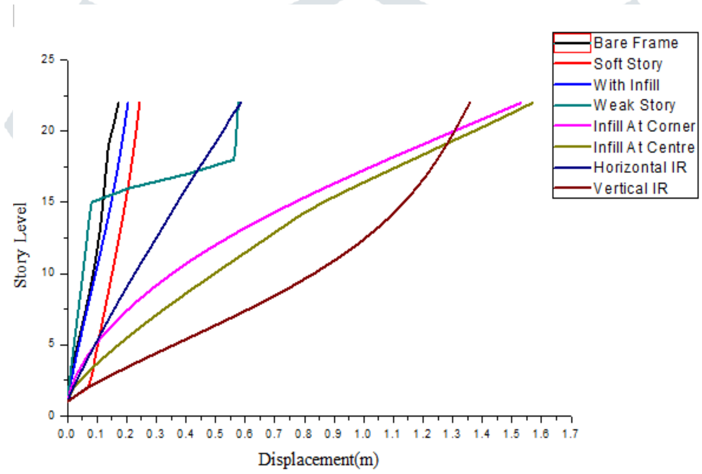

Fig. 10: Displacement profiles of 21Story with different irregular arrangements for Northridge Ground motion data.

Kobe ground motion data is applied on different types of infill frames. It is observed that the horizontal irregular arrangement has reached max displacement of 3.2 mm and structure bare frame wall reached minimum displacement of 0.0050 mm. In weak story shows that it is slightly constant i.e. the displacement increases as the story of the building increases up to 1.11 mm. For infill at center initial increasing displacement are up to 0.77 mm. Horizontal irregular arrangements, soft story and infill at corner shows relatively similar behavior but less than that of weak story.

After that the Northridge ground motion data is applied on different types of infill frames. It is observed that the infill at center arrangement has reached max displacement of 1.56 mm and structure bare frame wall reached minimum displacement of 0.035 mm. In infill at corner arrangement shows that it is slightly constant i.e. the displacement increases as the story of the building increases up to 1.50 mm. For vertical irregular arrangement initial increasing displacement are up to 1.3 mm. Horizontal irregular arrangements, soft story and weak story shows relatively similar behavior but less than that of vertical irregular arrangement.

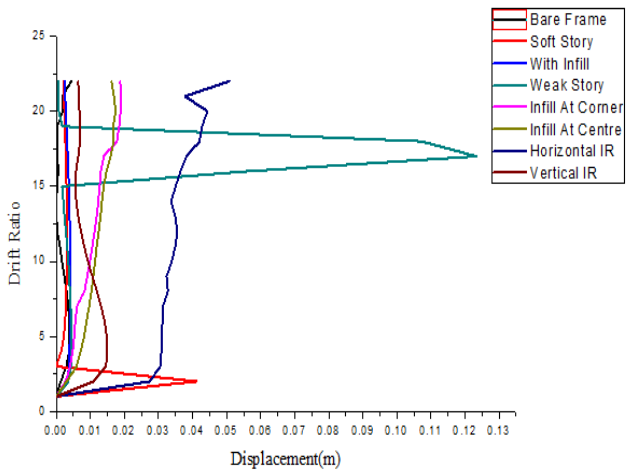

Fig. 11: Inter Story drift of 21Story with different irregular arrangements for Kobe Ground motion data.

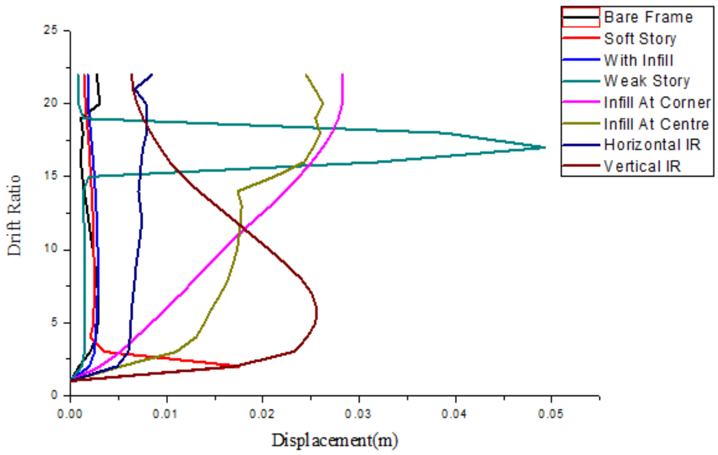

Fig. 12: Inter Story drift of 21Story with different irregular arrangements for Northridge Ground motion data.

As Kobe ground motion data is applied on different types of infill frames. It is observed that the weak story has reached max inter story drift 0.123 mm and structure with infill wall reached minimum displacement of 0.00252 mm. In horizontal irregular arrangement shows that it is slightly constant i.e. the displacement increases as the story of the building increases up to 0.05 mm. For infill at center initial increasing displacement is less up to 0.02. infill at corner arrangement, Vertical irregular and bare frame shows relatively similar behavior but less than that of infill at center.

As Northridge ground motion data is applied on different types of infill frames. It is observed that the weak story has reached max inter story drift 0.0493 mm and structure with infill wall reached minimum displacement of 0.00179 mm. infill at corner arrangement shows that it is slightly constant i.e. the displacement increases as the story of the building increases up to 0.029 mm. For infill at center initial increasing displacement is less up to 0.022. Horizontal irregular arrangement, Vertical irregular and bare frame shows relatively similar behavior but less than that of infill at center

VI. Conclusion

The concluding remarks on the seismic performance of these designs are summarized as follows: -

1. From the different applied ground motion data, it is found that greater the opening in the building it causes in reduction of lateral stiffness of the infilled frame as the effect of ground motion is initially absorbed by infill.
2. 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. If the effect of infill wall is considered, then the deflection has reduced drastically. And, deflection is more at last story because earthquake force acting on it more effectively.
3. The increase in the opening percentage leads to a decrease on the lateral stiffness of in filled frame.
4. Deflection in case of center opening is large compare to corner opening.

References

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