Analysis of Steel Structure with Different infills Subjected to Lateral Loading

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Abstract : In the present study, an attempt is made to study the difference in structural behaviour of 3-dimensional (3D) 4 by 4 bays of 10 storey moment resisting steel frames when provided with different types of infill materials in the event of an earthquake. The detailed investigations are carried out as per IS 1893 (Part–1):2016, considering primary loads and their combinations with load factor. The models analysed consist of one moment resisting steel frame (Bare frame), but also provided with masonry infills & ferro-cement panels. The above-mentioned models are analysed and designed for the static analysis case to obtain the beam and column sections for building with multiple iterations. Finally ISMC 200 double-channel section for beams and ISNB350-3 with top and bottom plate of 320mm width and 25mm thick for columns and two different models are made using two different column sections.Models are analysed using pushover analysis by SAP 2000 v22. The results of all models are compared in terms of base shear, storey displacement, modal time period, modal frequencies, Pushover curve, spectrum curve, performance point of the structure. If the overall performance of the buildings were found between O–CP (Operational to Collapse Prevent) stages..

IndexTerms **–Bare frame,Pushover analysis,Ferrocement panel,Infill panel**

I. INTRODUCTION

Now a days large number of reinforced concrete and steel buildings are constructed with masonry infills. Masonry infills are usually used to fill the void between the vertical and horizontal resisting components of the building frames with the assumption that these infills won't participate in resisting any reasonably load either axial or lateral; thus its significance within the analysis of frame is mostly neglected. An infill wall enhances significantly the strength and rigidity of the structure. It has been recognised that frames with infills have additional strength and rigidity as compared to the bared frames and their ignorance has become the reason behind the failure of the many of the multi-storeyed buildings. Infill walls are considered to be non-load bearing, but they resist wind loads applied to the facade and also support their own weight and that of the cladding.

1.1 SEISMIC ANALYSIS METHODS

The structural model is analysed to determine seismically induced forces in the structures. The analysis can be performed based on external action, the behaviour of structure or structural material, and the type of structural model selected. Linear static analysis or equivalent static analysis is used for normal structures with restricted height. Linear dynamic analysis can be performed in two ways, response spectrum method or by elastic time history method. Non-linear static analysis is an improvement over linear static or dynamic analysis in the sense that it allows inelastic behaviour of the structure. A non-linear dynamic analysis or inelastic time-history analysis is the only method to describe the actual behaviour of a structure during an earthquake.

II. OBJECTIVES

1. To assess the suitability of the beams and columns sections for the building in the SAP2000.
2. To analyse the behaviour of steel frame with masonry infill versus ordinal ferro-cement panels under seismic loading.
3. Finite Element Analysis on Steel Frames using modal analysis by Equivalent Static Method, Response Spectrum with different infill materials.
4. Pushover analysis is carried out to evaluate the performance of the building according to ATC 40, FEMA 356.

III. STRUCTURAL MODELING AND ANALYSIS

For the analysis work, six models of building (G+9) floors are made to the commercial building. In this study, bare frame, framed with both masonry infills and Ferro-cement panels and also two different column sections has taken for pushover analysis. Typically, no. of bays and bay width in both X and Y directions are 4 and 4m respectively. Total height of the building is 40 m. Story height is 4 m were considered in this study. All columns are fixed from base for foundations. The models are analyzed as per Indian Standard Code and ATC – 40 and FEMA356.In this study, a single model of bare frame building and 2 different material infills of masonry infills and Ferro-cement panels having a different column sections.

IV. MATERIAL PROPERTIES

The material used in the structure is steel and concrete for beam and column members and slab respectively. Fe345 grade of steel and M20 grade of concrete are used for all the models used in this study. Parameters considered for this study is given below.

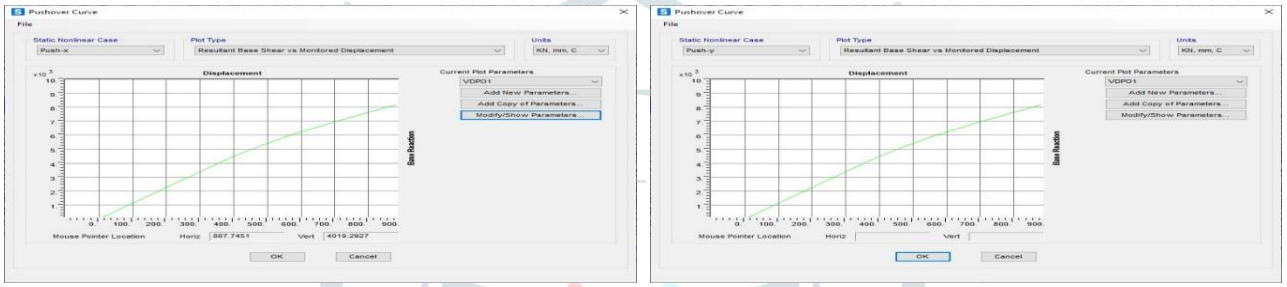
Table 1 – Building parameter considered in this study.

Particular	Details	Particular	Details
Slab (thickness)	150 mm	Beams	ISMC 200 D Steel Section
Column	ISNB350-3 Steel Section	Masonry Infill (thickness)	230 mm
	ISHB 350-2 with top and bottom plate of 320 mm width and 25 thick Steel Section	Ferro cement Panels (thickness)	50 mm
Live Load	4 kN/m^2 for all the floors	Dead Load	IS codes
Earthquake Load	As per IS 1893 (Part – 1): 2016	Importance Factor	1
Type of Soil.	Type II, Medium	Response Reduction Factor	5

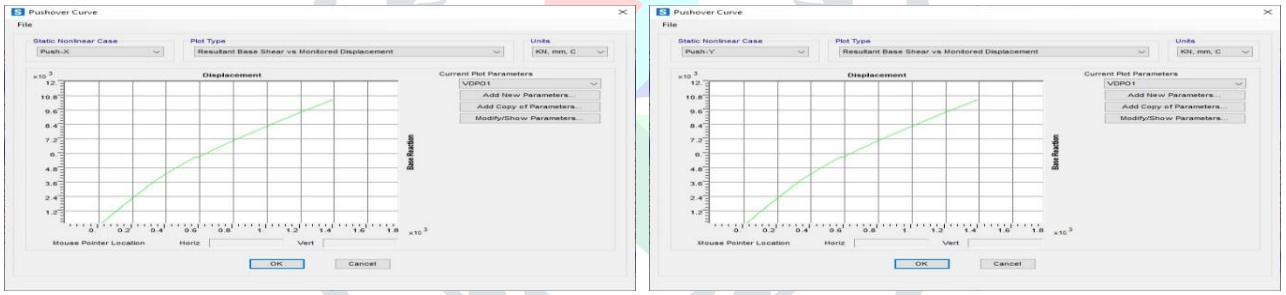
V. ANALYSIS AND RESULTS

5.1 Pushover Curves

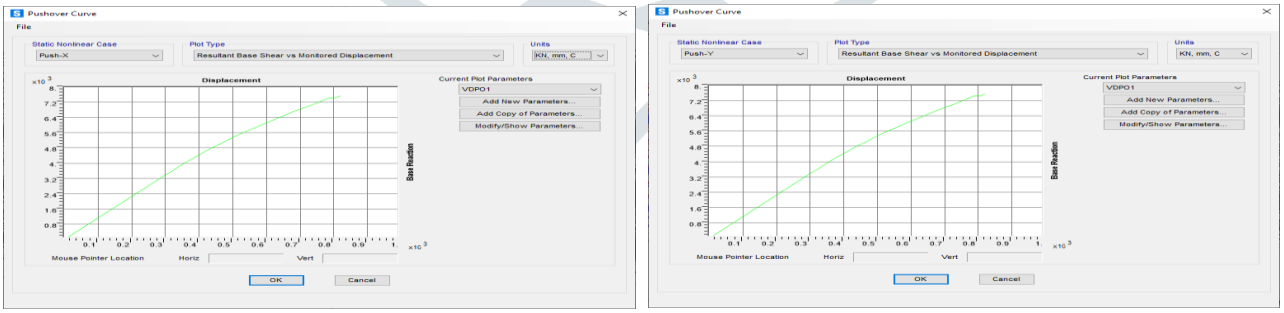
In below figures from the pushover curves of all buildings the data about displacement and base shear have obtained.



(a) Pushover Curve of Bare Framed Building with ISNB350–3 as a Column in both X and Y direction.



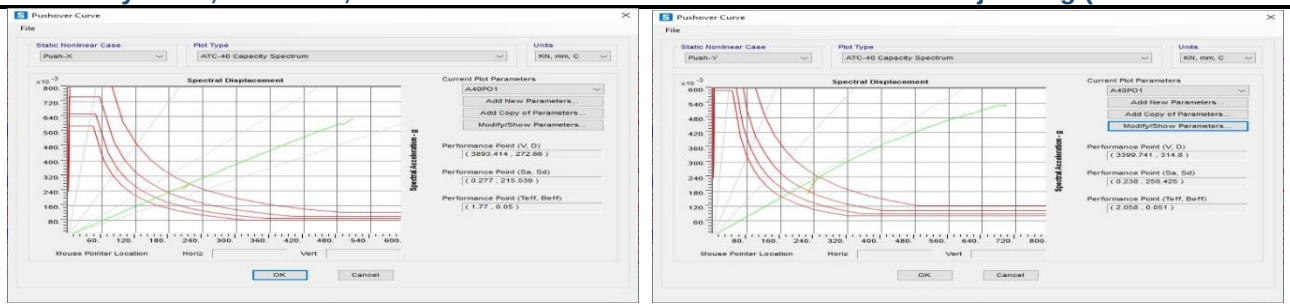
(b) Pushover Curve of Framed Building with Masonry Infills and ISNB350–3 as a Column.



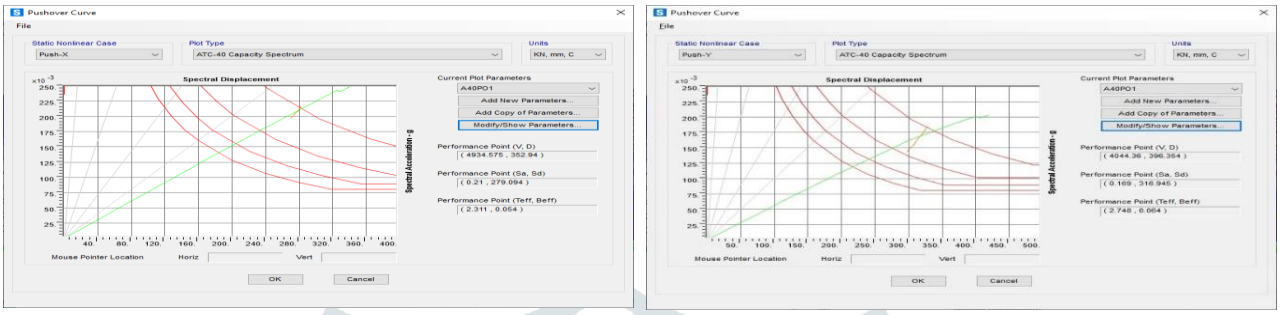
(c) Pushover Curve of Framed Building with Ferro-cement Panels and ISNB350–3 as a Column.

5.2 Spectrum Curves

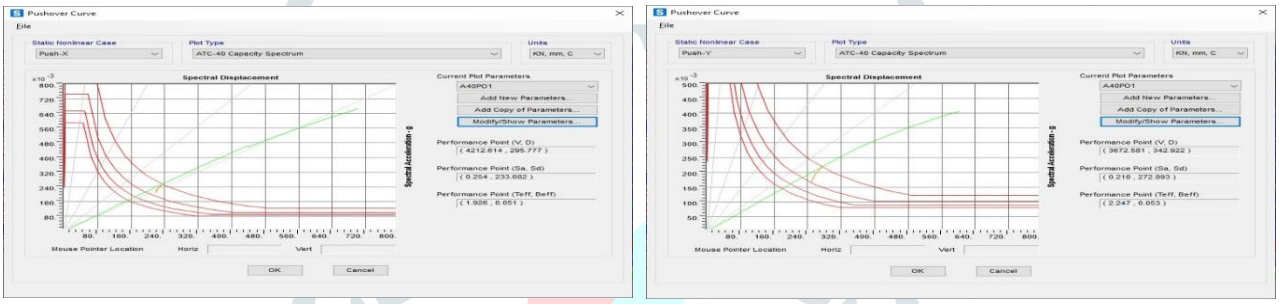
In this study, capacity spectrum method is followed. Capacity spectrum curve is useful for calculate the overall demand and capacity of the structure. It is useful to obtain the performance point of the structure. Spectrum curve of all buildings are shown in below figures.



(a) Spectrum Curve of Bare Framed Building with ISNB350–3 as a Column in both X and Y direction.



(b) Spectrum Curve of Framed Building with Masonry Infills and ISNB350–3 as a Column.



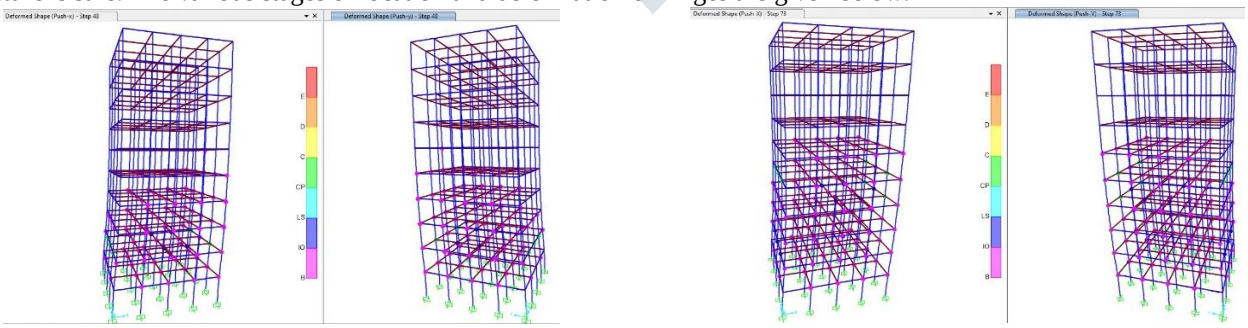
(c) Spectrum Curve of Framed Building with Ferro-cement Panels and ISNB350–3 as a Column.

Table 2 – Performance Point for all modelled buildings.

Structure Type	Performance Point (kN)		Displacement (mm)	
	Along X-direction	Along Y-direction	Along X-direction	Along Y-direction
Bare Framed Building with	3410.998	3410.998	301.793	301.793
Framed Building with Masonry Infills	4025.590	4025.590	368.781	368.781
Framed Building with Ferro-cement Panels	3693.655	3693.655	328.464	328.464

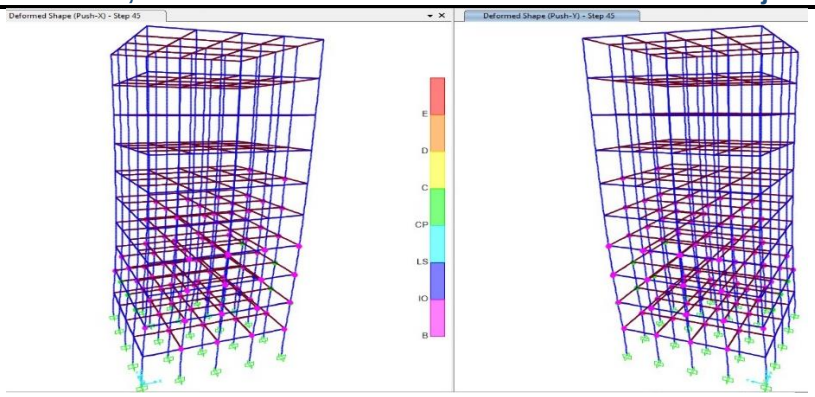
5.3 Hinges Result

In the following figures shown that the location of hinges formed for different performance levels in their final steps of analysis for Push – X and Push – Y direction. If hinges are in O–CP (Operational to Collapse Prevent) stage, we can say that overall structure is safe. The various stages of location and deformation of hinges are given below.



(a) Hinges Status at maximum base shear of Bare Framed Building with ISNB350–3 as a Column in both X and Y direction.

(b) Hinges Status at maximum base shear of Framed Building with Masonry Infills and ISNB350–3 as a Column.



(c) Hinges Status at maximum base shear of Framed Building with Ferro-cement Panels and ISNB350–3 as a Column.

VI. CONCLUSION

1. The performance points are determined for all six building models.
2. Results obtained from the bare framed building with masonry infills and ISHB350–2 with Top and Bottom Plate of 320mm width and 25mm thick as a column gives the minimum displacement of 368.781mm at performance point of 3893.414 kN along X-direction.
3. The results obtained from framed building with masonry infills and ISHB350–2 with Top and Bottom Plate of 320mm width and 25mm thick as a column gives the maximum displacement of 328.464mm at performance level.

REFERENCES

[1] ATC 40, "Seismic evaluation and retrofit of concrete buildings", Applied Technology Council, Vol. 1, 1996.
[2] Earthquake Resistant Design of Structure by Pankaj Agarwal & M. Shrikhande.
[3] Earthquake Resistant Design of Structure by Shashikant K. Duggal.
[4] FEMA 356, Pre-standard and comment for the seismic rehabilitation of buildings, November, 2000.
[5] I.S 875, Code of Practice for Design Loads (Other Than Earthquake) for Buildings and Structures – Part 1: Dead loads – Unit weights of building materials and stored materials (Second Revision), Bureau of Indian Standards, New Delhi, 1987.
[6] I.S 1161, Steel Tubes For Structural Purposes — Specification (Fifth Revision), Bureau of Indian Standards, New Delhi, 2014.
[7] I.S 1893, Criteria for earthquake resistant design of structures – Part 1: General provisions and buildings (Fifth Revision), Bureau of Indian Standards, New Delhi, 2002.
[8] Arafa Elhelloty, "Effect of Lateral Loads Resisting Systems on Response of Buildings Subjected to Dynamic Loads", International Journal of Engineering Inventions, Volume 6, Issue 10, October 2017, 62 – 76.
[9] Dr. S.S. Sankhla, Deepak Bhati, "A Comparative Study on the Effect of Infill Walls on RCC Frame Structures", IOSR Journal of Mechanical and Civil Engineering, Volume 13, Issue 6, November 2016, 01 – 08.
[10] Basavaraj M. Malagimani, Swapnil B. Cholekar, Hemant L. Sonawadekar, "Comparative Study of RC Structures with Different Types of Infill Walls with Effect of SSI by Pushover Analysis", International Research Journal of Engineering and Technology, Volume 04, Issue 06, June 2017, 2545 – 2550.
[11] Mayank Chouhan and Dr. Savita Maru, "Pushover Analysis of Steel Frame Structures with Different Types of Bracing System", International Journal of Science Technology & Engineering, Volume 4, Issue 2, August 2017, 37 – 44.
[12] Dr. S.S. Sankhla, Deepak Bhati, "A Comparative Study on the Effect of Infill Walls on RCC Frame Structures", IOSR Journal of Mechanical and Civil Engineering, Volume 13, Issue 6, November 2016, 01 – 08.
[13] Baran, M., & Sevil, T. (2010). Analytical and experimental studies on infilled RC frames. International Journal of Physical Sciences, 5(13), 1981-1998.
[14] Moghaddam, H. A. (2004). Lateral load behavior of masonry infilled steel frames with repair and retrofit. Journal of structural engineering, 130(1), 56-63.
[15] Liu, Y., & Manesh, P. (2013). Concrete masonry infilled steel frames subjected to combined in-plane lateral and axial loading–An experimental study. Engineering Structures, 52, 331-339.
[16] Vogiatzis, T., & Avdelas, A. (2016). Finite element modeling and numerical investigation of the structural behaviour of partially restrained steel frames with reinforced concrete infill walls. In Proceedings of 7th International Conference From Scientific Computing to Computational Engineering, Athens, Greece (Vol. 1, pp. 189-196).
[17] Sankhla, S. S., & Bhati, D. (2016). A Comparative Study on the Effect of Infill Walls on RCC Frame Structures. Journal of Mechanical and Civil Engineering, 13(6), 1-8.
[18] Yeshodhara T S, Pradeep A R, Dr. N Jayaramappa" Analysis of Multistoried Infilled Steel Structure Subjected to Lateral Loading" International Research Journal of Engineering and Technology (IRJET) Volume-8, Issue-4, April 2021 1679-1687