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Analysis of Multistory Steel Structure with Different Infills

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Abstract – In last three decades earthquake resistant design of structure has gained a lot of importance. As Earthquake occurrence became more frequent, researchers developed new methods of Earthquake analysis to access the behaviour of structure under horizontal loading. One of which is performance based seismic design. It provides methodology for accessing the performance occupancy, life safety or Collapse prevention level. A non-linear static pushover analysis can be used to analyse the inelastic response of structure to lateral load or displacement. Pushover analysis demonstrates progressive failure in the structure and predicts potential weak areas.

In present study a three model of G+9 story steel framed building is consider for seismic design and performance evaluation. The model analysed and designed using the software package ETABS by response spectrum method for earthquake zone V according to IS 1893-2016. The performance is accessed by Capacity Spectrum Method using non-linear pushover analysis. The result of these models are analysed and compared in terms of base shear, story displacement, model time period, model frequencies, pushover curve, spectrum curve, performance point of the structure. If overall performance of the structure have been between Life safety-Collapse prevent, building is safe. Capacity based design procedure helps the engineers to have an insight into the behavior of the structure subjected to design ground motions and allows the buildings to be designed for specific performance levels.

Key Words: Infills, Displacement, Base shear, Pushover analysis, Performance point.

1.INTRODUCTION

Structure in concrete has become very common in civil engineering in the last five decades. Concrete has established to be a universal building material because of its high compressive strength and its ability to offset its use by incorporation of steel reinforcement. Masonry infills are used to fill the gap between the columns. The frame with infills have additional strength and rigidity as compared to bare frame. So provide steel frame with different infills.

Steel is most useful material for building construction and its strength is ten times that of concrete. It can withstand extreme forces in buildings. The relevant Indian Code of practice, IS 800:2007, applicable to the structural use of hot –rolled steel.

Infill wall has a common function to bear its own weight. Beams can carry the weight of the infills. The interaction of the infills with the surrounding frame has a major influence on the structural response of the complete composite structure. Infills are normally considered as a non-structural element and their effects are generally ignored in practice.

1.1 Methods of Analysis

To provide engineers with a capability to design buildings that have predictable and reliable performance in earthquakes. Performance based design procedure are demand and capacity. Demand is the representation of earthquake ground motion. Capacity is a representation of the structure's ability to resist the seismic forces. The two main methods to find the performance of the structure is the capacity spectrum method and displacement coefficient method. In the capacity spectrum method, both the capacity and demand spectrum in ADRS (acceleration displacement response spectra) format are plotted onto a single graph. The point where the capacity curve meets the demand curve is the performance point which gives the overall performance of the building for the ground motion considered. In the displacement coefficient method, an equation with a set of coefficients is used to calculate the target displacement for the corresponding pushover curve. This target displacement is considered as the performance point. Depending on where the performance point lies in the capacity spectrum curve building's performance level is decided. They are Immediate Occupancy level, Life Safety level and Collapse Prevention level. Thus, an engineer gets an insight into the performance of the building for a particular ground motion and can decide on which safety level the structure is designed for the buildings.

2. OBJECTIVE

1. To assess the beam and column section which is suitable for the building by the ETABS software.
2. To analyze the behavior of Bare frame, Bare frame with brick infill, Bare frame with precast panels under seismic loading.

3. Performance of the structure is carried out by Pushover Analysis .

3. METHODOLOGY

In this study, the steel frame with different infills were analyzed using ETABS software. A plan of commercial structure of size (16x16)m is chosen for G+9 building with all columns of height 4m and beams of 4m length. As per the objective of the study a particular frame is taken from the prototype and scaled down and tested on the behavior of Steel bare frame, Steel bare frame with brick masonry infill & Steel bare frame with Ferro-cement infill panels under seismic loading. Pushover analysis is performed to understand the non linear behavior of0the structure.

3.1 Seismic analysis methods

After detailing the dimension of the structural model, analysis performed to determine seismically induced forces in the structures.

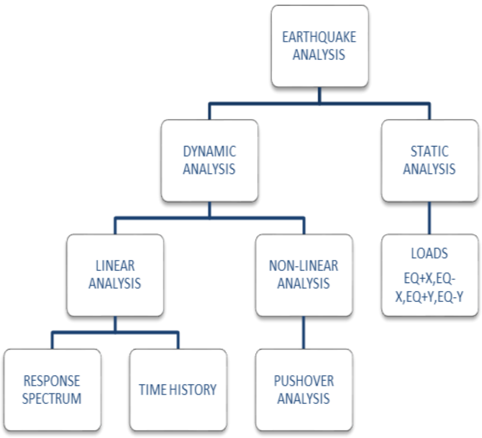
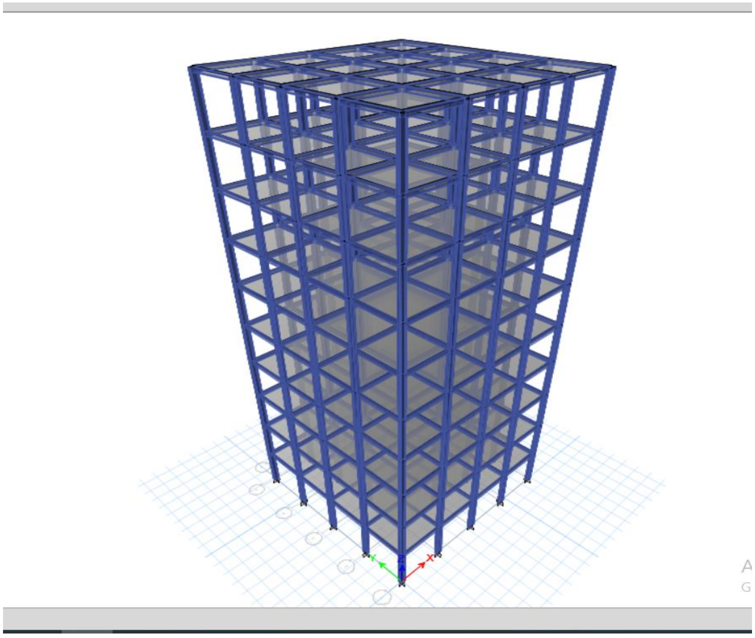


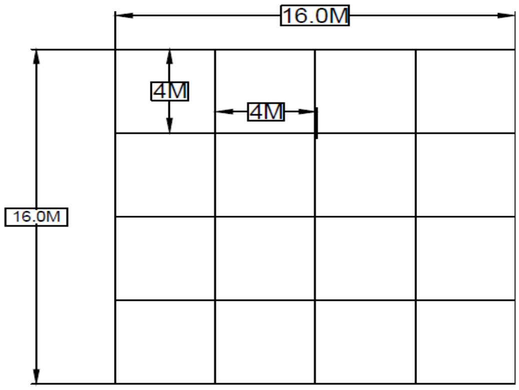
Fig-1 Seismic analysis method

4. STRUCTURAL MODELLING AND ANALYSIS

For the analysis, three models of building of G+9 story are made. In this study, bare frame, frame with brick infills, frame with pre cast panels are taken for analysis. Total height of the building is 40m. Story height is 4m in this study. All columns are fixed from the base. The models are analyzed as per Indian Standard Code and non-linear analysis by FEMA 440 EL and ASCE 41-13 NSP.



3D View of the model



PLAN OF 4MX4M FRAME

4. MATERIAL PROPERTIES

Table -1: Building parameter

Particular	Details
Slab (thickness)	150 mm
Beams	ISWB 300 Steel Section
Column	ISMC 400 Steel Section 12mm flats with top and bottom.
Brick Infill (thickness)	230 mm
Pre cast Panels (thickness)	50 mm
Dead Load	Automatically calculated by the program
Live Load	4 kN/m^2 for all the floors

Earthquake Load	As per IS 1893 (Part – 1): 2016
Type of Soil.	Type II, Medium
Importance Factor	1
Response Reduction Factor	5

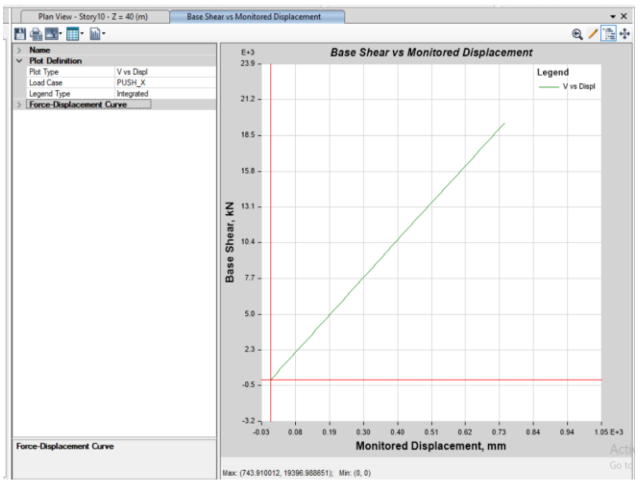
6. PROCEDURE OF PUSHOVER ANALYSIS

- Define all material and section properties, load patterns, load cases, load combinations, mass source, and functions.
- Model the structure and assign supports and assign all the values of the above mentioned properties.
- Then steel design should carried out. Once the steel design is done, unlock the model. Define gravity and pushover load cases in both directions to the model.
- Assign the pushover hinges to selected frame objects. Hinges may be defined manually or by using one of the several default specifications which are available.
- Then run analysis of static pushover analysis.
- Check the result obtained from the analysis and compare the result of three models. Review the results and display the static-pushover curve and displacement and the sequence of hinge formation.

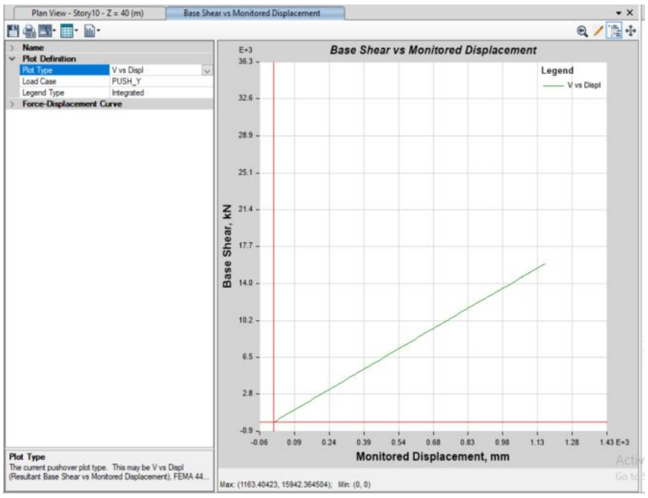
7. ANALYSIS AND RESULTS

7.1 Pushover Curves

Figure shown below are the Pushover Curve of different building, the data about displacement and base shear have obtained.

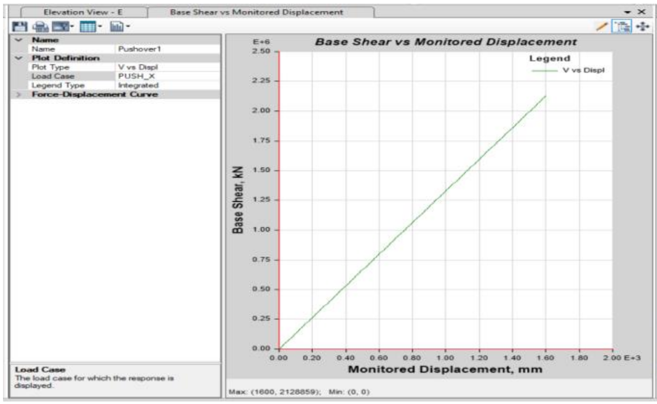


a) Pushover Curve of Bare Frame in X-direction.

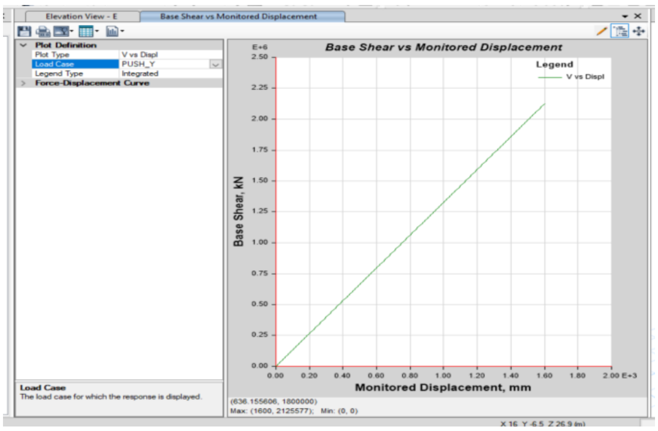


b) Pushover Curve of Bare Frame in Y-direction.

Maximum Base Shear for both Push-X – 19396.988KN for displacement 743.91 mm and Push-Y- 15942.36 KN for displacement of 1163.4 mm.

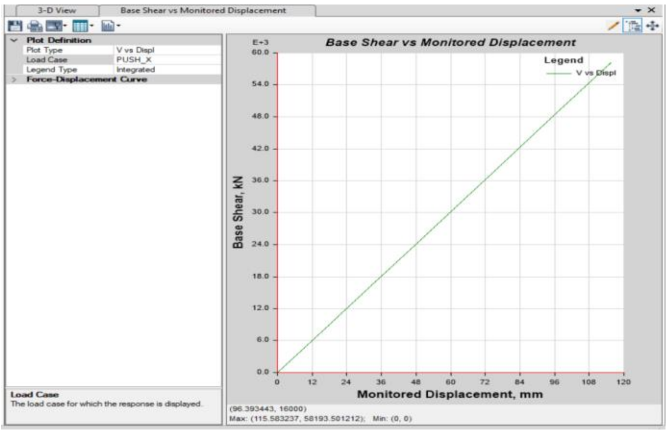


c) Pushover Curve of Brick infill in X-direction

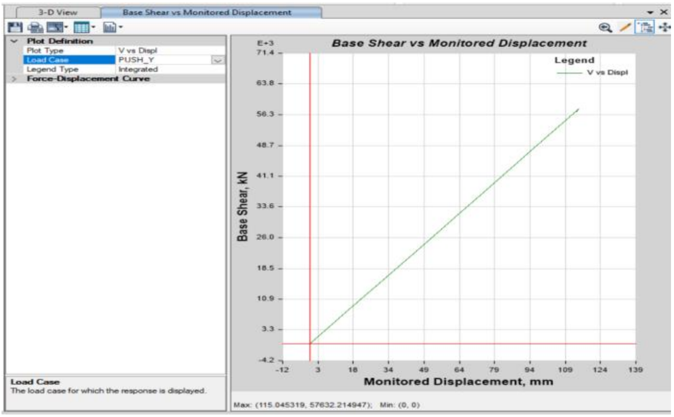


d) Pushover Curve of Brick infill in Y-direction

Maximum base shear for both Push-X – 2128859 KN for displacement 1600 mm and Push-Y-2128859kN for displacement of 1600 mm.



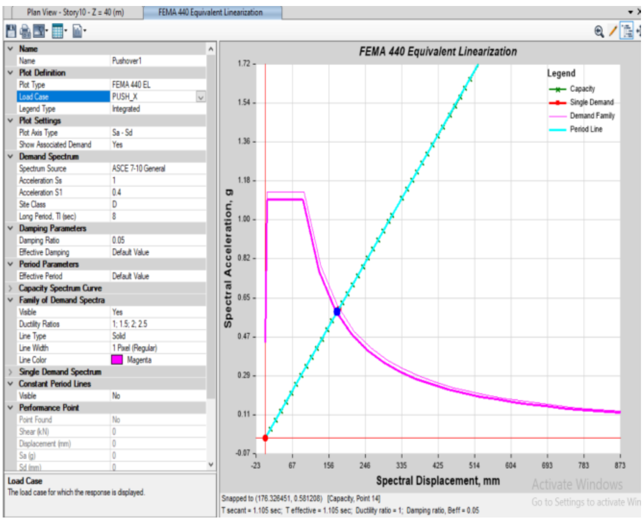
e) Pushover Curve of pre cast panel in X-direction



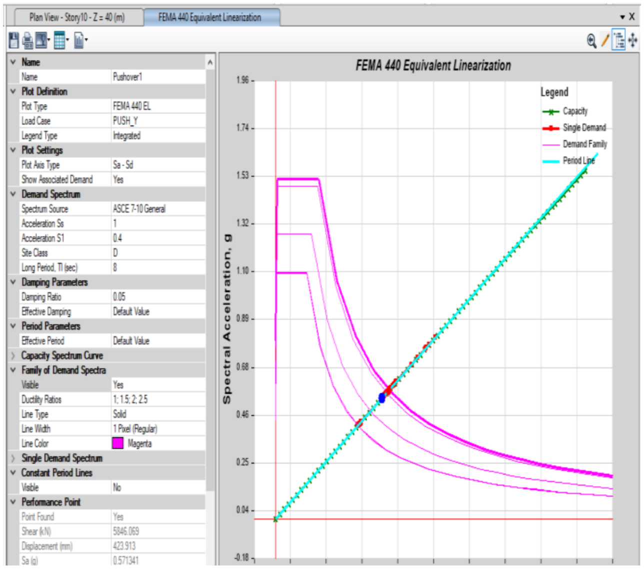
f) Pushover Curve of pre cast panel in Y-direction

Maximum Base shear for both Push-X – 58193.5 KN for displacement 115.58 mm and Push-Y- 57632.2 KN for displacement of 115.04 mm.

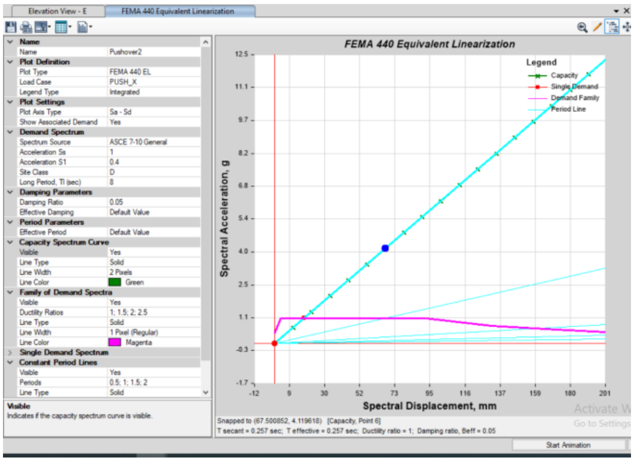
7.2 Response curve



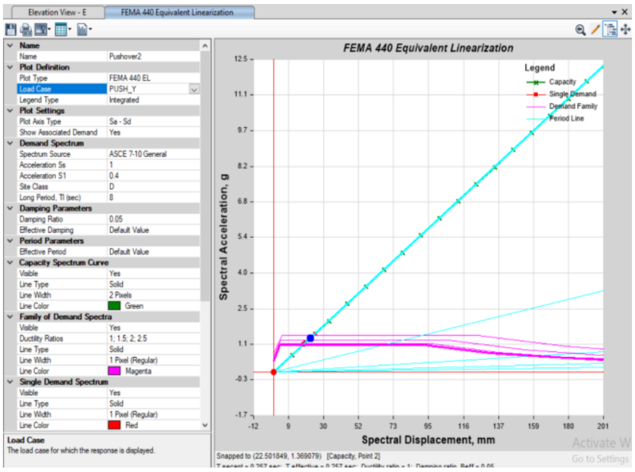
a) Performance Point by FEMA 440 EL in X-direction (Bare frame)



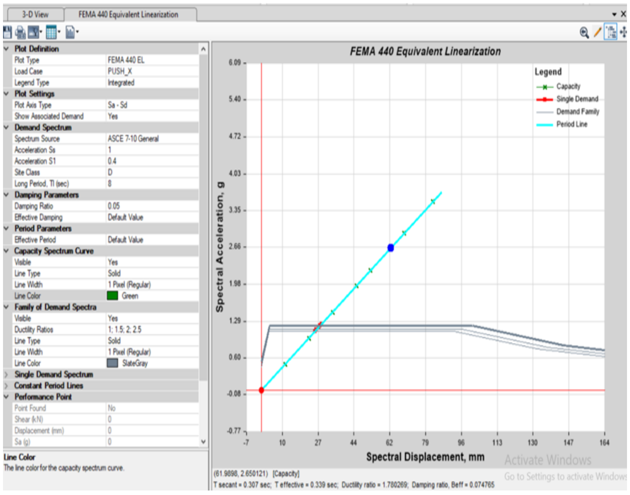
b) Performance Point by FEMA 440 EL in Y-direction(Bare frame)



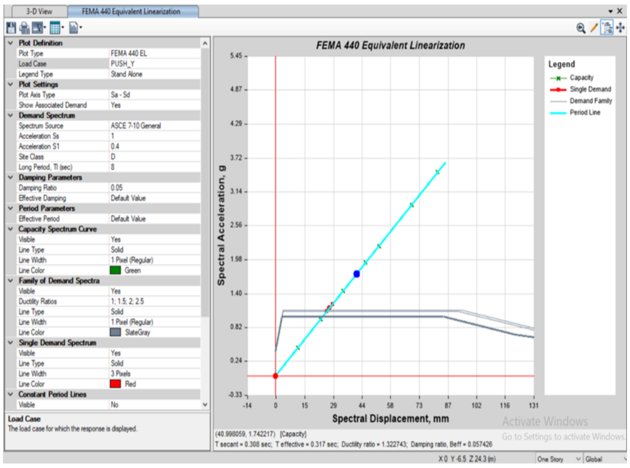
c) Performance Point by FEMA 440 EL in X-direction (Brick infill frame)



d) Performance Point by FEMA 440 EL in Y-direction (Brick infill frame)



e) Performance Point by FEMA 440 EL in X-direction (Pre cast)



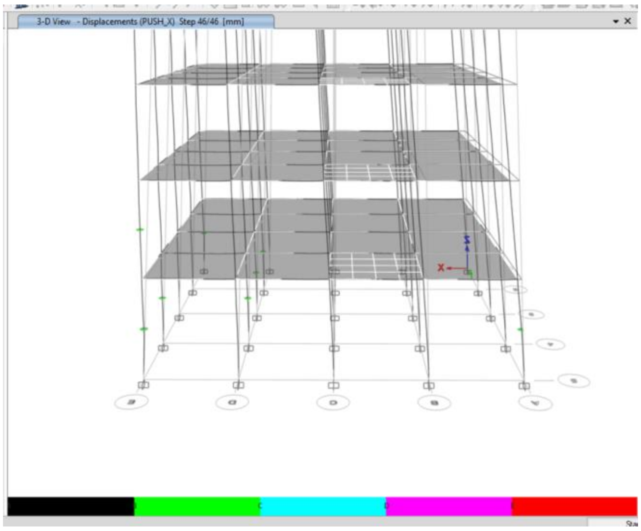
f) Performance Point by FEMA 440 EL in y-direction (Pre cast)

Structure Type	Performance Point (kN)		Displacement (mm)	
	Along X-direction	Along Y-direction	Along X-direction	Along Y-direction
Bare Framed Building	5799.845	4222.45	221.137	306.174
Framed Building with Masonry Infills	25995.74	26006	19.537	19.58
Framed Building with Pre-cast Panels	19761.77	21275.39	44.81	42.469

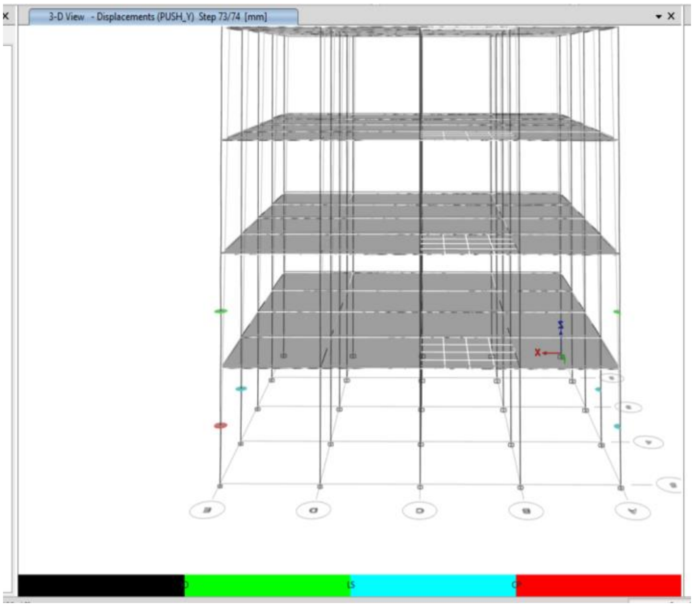
Table 2 – Performance Point for all modelled buildings

Hinge Result

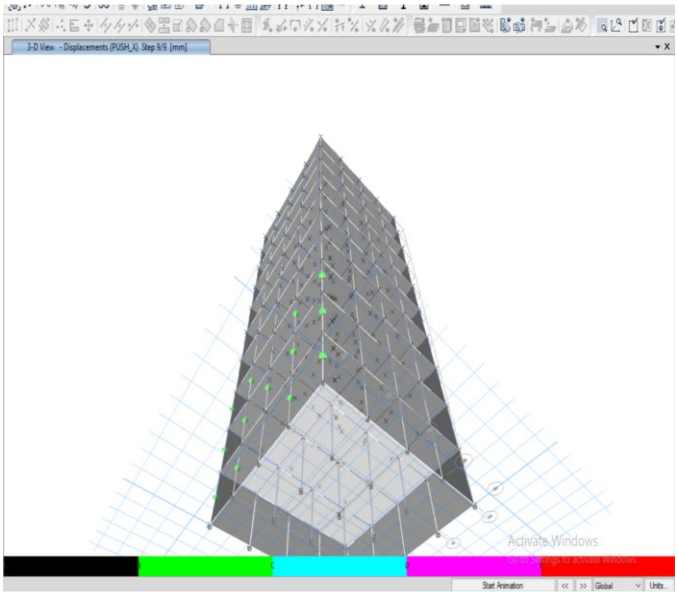
In the following figures shown that the location of hinges formed for different performance levels in their final steps of analysis for Push – X and Push – Y direction. If hinges are in O–CP (Operational to Collapse Prevent) stage, we can say that overall structure is safe. The various stages of location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



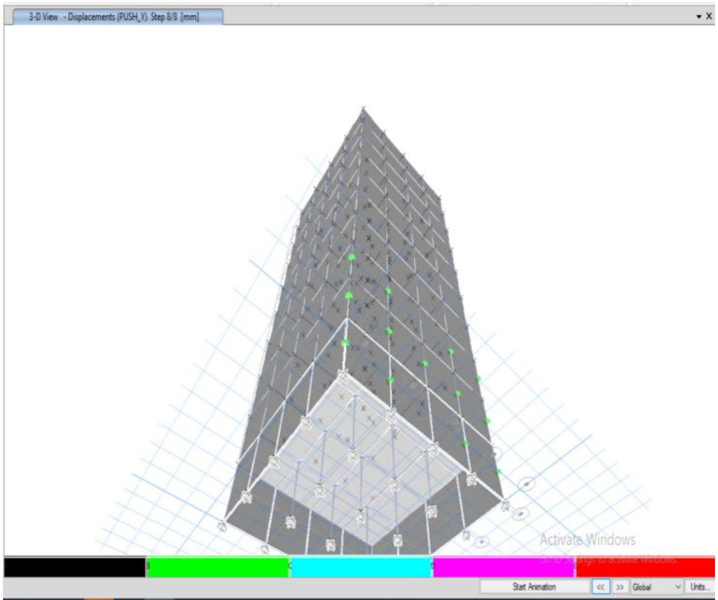
a) Hinge status at performance point X-Direction (Bare Frame)



b) Hinge status at performance point Y-Direction (Bare Frame)



c) Hinge status at performance point X-Direction (pre-cast panel)



d) Hinge status at performance point Y-Direction (pre-cast panel)

8. CONCLUSIONS

1. Models analyzed and designed for seismic zone V, it satisfies all the requirements according to IS 1893–2002 and IS 800–2007.
2. Story displacement for Earthquake along X and Y are more in bare frame i.e., 44.1 mm and 55.679 mm respectively as compared with Brick infills and Pre-cast infills.
3. Pushover analysis results shows that hinges formed in members at performance point are under "immediate occupancy level".
4. Capacity based design procedure helps the engineers to have an insight into the behavior of the structure subjected to design ground motions and allows the buildings to be designed for specific performance levels.

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