IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 14, Issue 4 Ver. III (Jul. – Aug. 2017), PP 84-91
www.iosrjournals.org

Capacity Analysis of Rcc Frame Structure with and Without Infill Walls

[1]N.Rahul verma*, [2]B.Suresh, [3]V.Navodaya
[1]*M.tech student Spoorthy Engineering College Hyderabad Telangana*
[2]*Chief Structural Consultant at Cistsocon (Structural Consultancy)*
[3]*Assistant Professor Head of Department at Spoorthy Engineering College, Hyderabad, Telangana*
Corresponding Author: N.RAHUL VERMA

Abstract: *Often in a framed structure, the frames are infilled with stiff construction such as brick or concrete block masonry, primarily to create an enclosure and to provide safety to the users. Such masonry walls are known as Infill walls. The typical multi-storey reinforced concrete framed constructions in India comprise with brick masonry infills. Unreinforced masonry infill wall panels may not contribute towards resisting gravity loads, but contribute significantly, in terms of enhanced stiffness and strength under earthquake (or wind) induced lateral loading. However, in practice, the infill stiffness is commonly ignored in frame analysis, resulting in an under-estimation of stiffness and natural frequency. Also, the infill walls have energy dissipation characteristics that contribute to improved seismic resistance. It is important to study the conclusions of the common practice of ignoring the infill stiffness with regard to performance under seismic loading. One typical existing building located in moderate seismic zone of India (as per IS: 1893-2002[1]) are identified. Features like vertical geometric irregularity and vertical irregularity (soft storey) are found in the building and is compared with same structure without any irregularities and made symmetric. Infills walls were modelled using the equivalent strut approach. Static analysis (for gravity and lateral loads), response spectrum analysis and non-linear pushover analysis (assigning the hinge properties to beams and column sections) were performed. Seismic performance was compared in the pushover analysis for the two cases. The results are described in detail in this paper.*

Keywords: *Infill walls, Fema356, Pushover analysis, User-defined Plastic hinges, Inelastic Analysis.*

Date of Submission: 13-07-2017 Date of acceptance: 24-07-2017

I. Introduction

Now a days in India a large number of buildings in India are constructed with masonry infill panel for functional and architectural reasons. Masonry infill walls are normally considered as non-structural elements and their stiffness contributions are generally ignored in practice i.e. while the structure is designed for loads. However, infill walls tend to interact with the frame when the structure is subjected to lateral loads, and also exhibit energy-dissipation characteristics under seismic loading. Masonry walls contribute to the stiffness of the infill under the action of lateral load. The term 'infilled frame' is used to denote a composite structure formed by the combination of a moment resisting plane frame and infill walls. The infill may be integral or non-integral depending on the connectivity of the infill to the frame. In the case of buildings under consideration, integral connection is assumed. The composite behaviour of an infilled frame imparts lateral stiffness and strength to the building. Here in the below figure it shows the behaviour of the Infill wall under the action of Lateral loads (Reference from FEMA 356).

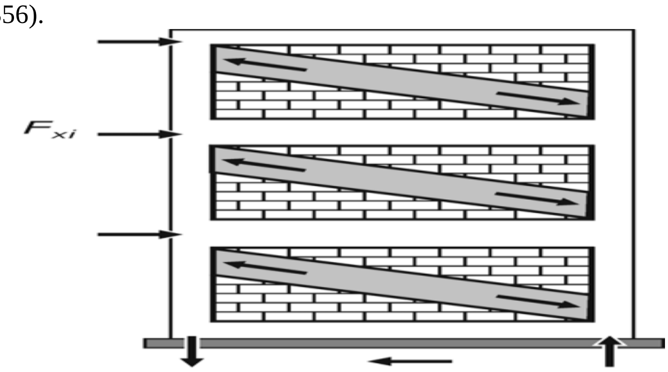

Fig .1 Compression strut analogy- Eccentric Strut (FEMA 356)

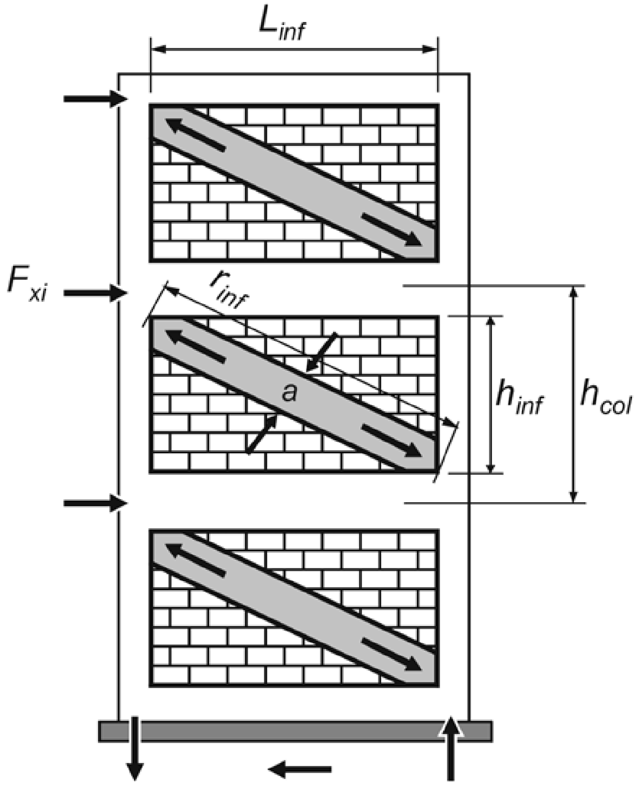

Fig 2. Compression strut analogy- Eccentric Strut (FEMA 356)

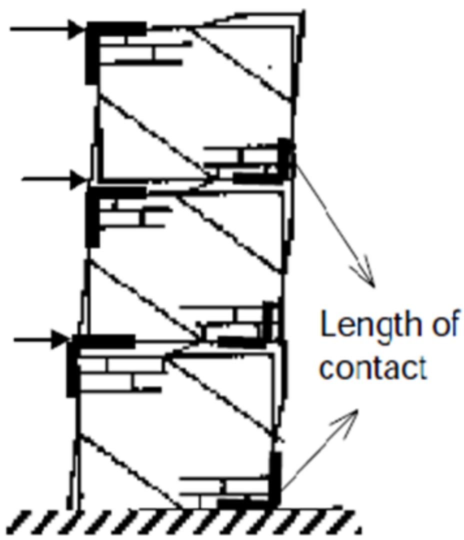

Fig 3 Deformation of the frame under Strut action

Building Description

One typical building is considered from low seismic zone (Zone II) of India. Building has a features like Vertical Geometric irregularities whereas for comparison the same building is modelled without any irregularities and is fairly symmetric. Building is a Ground + 4 storey building (15m high) for comparison another symmetric building is also of same height. Both the buildings are made of Reinforced Concrete (RC) Ordinary Moment Resisting Frames (OMRF).

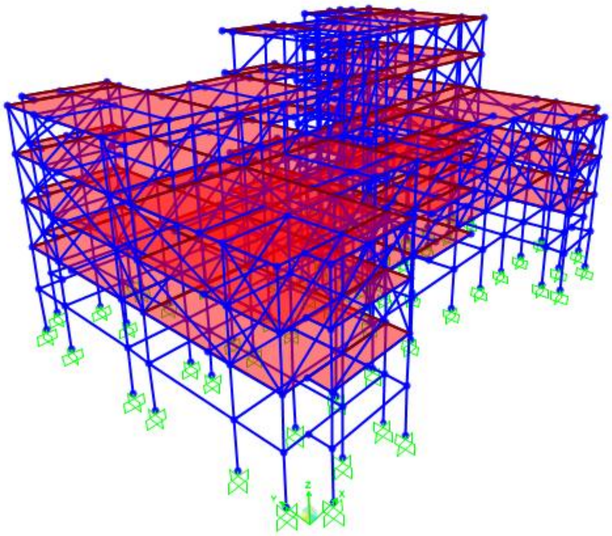

Fig 4 Building with Strut modelled.

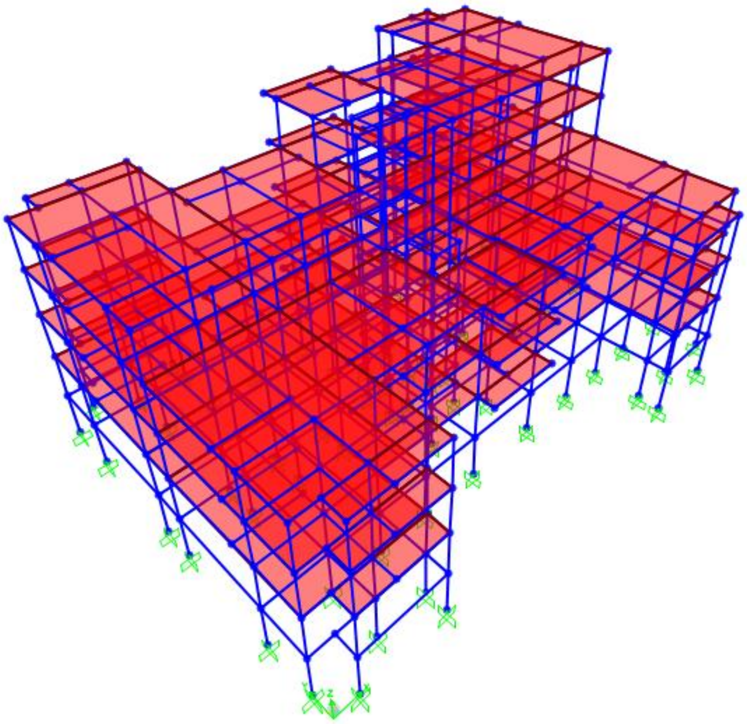

Fig 5 Building without strut modelled

In both the buildings, the columns are supported on isolated footings with plinth beams. The concrete slab is 150 mm thick at each floor level. The brick wall thicknesses are 230 mm for external walls and 115 mm for internal walls. Imposed load is taken as 2 kN/m^2 for all floors. The grade of concrete and steel used in both the buildings are M25 and Fe500 respectively.

Structural Modelling

The two buildings are modelled and analysed for static, response spectrum and pushover analyses, using the finite element package SAP2000. The analytical models of the buildings include all components that influence the mass, strength and stiffness. The non-structural elements and components that do not significantly influence the building behaviour were not modelled. The floor slabs are assumed to act as diaphragms, which ensure integral action of all the vertical lateral load-resisting elements. Beams and columns were modelled as frame elements with the centrelines joined at nodes. Rigid offsets were provided from the nodes to the faces of

the columns or beams. The stiffness for columns and beams were taken as $0.7EIg$, accounting for the cracking in the members and the contribution of flanges in the beams. The weight of the slab was distributed to the surrounding beams as per IS 456: 2000 [4], Clause 24.5. The mass of the slab was lumped at the centre of mass location at each floor level. Staircases and water tanks were not modelled for their stiffness but their masses were considered in the static and dynamic analyses. The design spectrum for medium soil as specified in IS 1893:2002 was used for the analyses. The effect of soil-structure interaction was ignored in the analyses. The columns were assumed to be hinged at the level of the bottom of the base slabs of respective isolated footings. The first ten modes were considered for the dynamic analysis (response spectrum method), which gives more than 99% mass participation in both the horizontal directions. The SRSS method of modal
Combination was used for analysis.

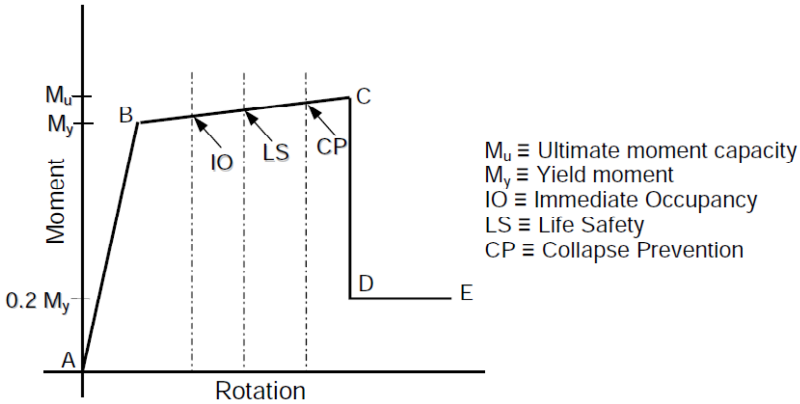

Fig 6 Moment Rotation relationship for Plastic hinges

For pushover analysis, beams and columns were modelled with concentrated plastic hinges for flexure and shear at the column and beam faces, respectively. Beams have both moment (M3) and shear (V2) hinges, whereas columns have axial load and biaxial moment (PMM) hinges and shear hinges in two directions (V2 and V3). The normalised moment-rotation relations for the hinges were obtained from IS 456:2000.

Modelling of masonry infill

In the case of an infill wall located in a lateral load resisting frame the stiffness and strength contribution of the infill are considered by modelling the infill as an equivalent compression strut Because of its simplicity, several investigators have recommended the equivalent strut concept. In the Present analysis, a trussed frame model is considered. This type of model does not neglect the bending moment in beams and columns. Rigid joints connect the beams and columns, but pin joints at the beam-to column junctions connect the equivalent struts. Infill parameters (effective width, elastic modulus and strength) are calculated using the method recommended by FEMA 356.

Stiffness of Infill wall

The elastic in-plane stiffness of a solid unreinforced masonry infill panel prior to cracking shall be represented with an equivalent diagonal compression strut of width, *a*, given by Equation (7-14) in FEMA 356. The Equivalent strut shall have the same thickness and modulus of elasticity as the infill panel it represents.

$a = 0.175\ (\lambda_1 h_{col})^{-0.4}\ r_{inf}$ ---------------------- (Eq.1)

Where a = width of Equivalent strut.

$$\lambda_1 = \left[\frac{E_{me} t_{inf} \sin 2\theta}{4 E_{fe} I_{col} h_{inf}}\right]^{\frac{1}{4}}$$ -- (Eq.2)

E_{me}= Expected modulus of elasticity of infill material , Mpa.
E_{fe}= Expected modulus of elasticity of frame material, Mpa
H_{col}= Column height between the centre lines of beams, in mm

I_{col}= Moment of Inertia of column, mm^4
I_{inf} = Length of infill panel, mm
R_{inf} = Diagonal length of Infill panel, mm
T_{inf} = Thickness of Infill panel and Equivalent strut, mm
Θ = angle whose tangent is the infill height-to-length aspect ratio, radians
λ= coefficient used to determine equivalent width of infill strut.

II. Analysis Results And Discussion

Both the buildings (with and without strut model) were analysed using equivalent static method (linear static method) and response spectrum method (linear dynamic method) according to IS 1893:2002[1]. Pushover analysis (non-linear static method) was also carried out. The pushover analysis provides an insight into the structural aspects, which control the performance during earthquakes. It also provides data on the strength and ductility of a building. The analyses were done by using the finite element analysis software, SAP2000.

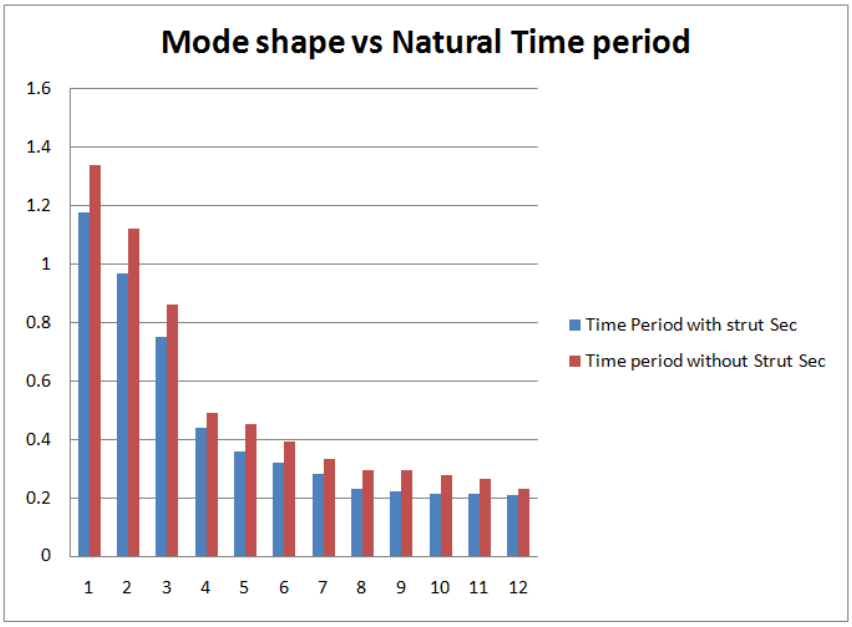

Fig 7 Mode shapes versus Natural Time period curve for Building.

The periods of vibration of the buildings were determined from Eigen value analyses using SAP 2000. When infill stiffness is considered, the fundamental period of the structure reduces and the structure attracts more base shear. Figure 7 shows the fundamental period of two buildings analysed with and without considering infill stiffness. As Building has open ground storey, the difference in the fundamental period is relatively less.

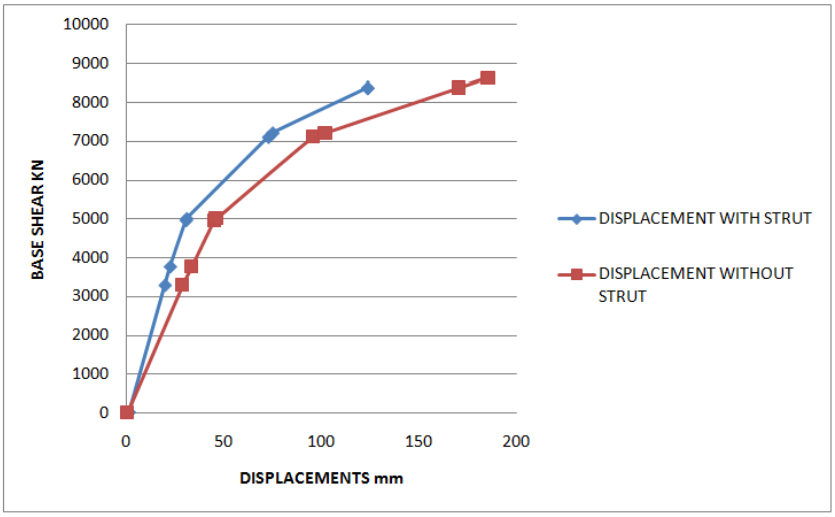

Fig 8 Base shear versus Roof displacement curve for Building in X direction.

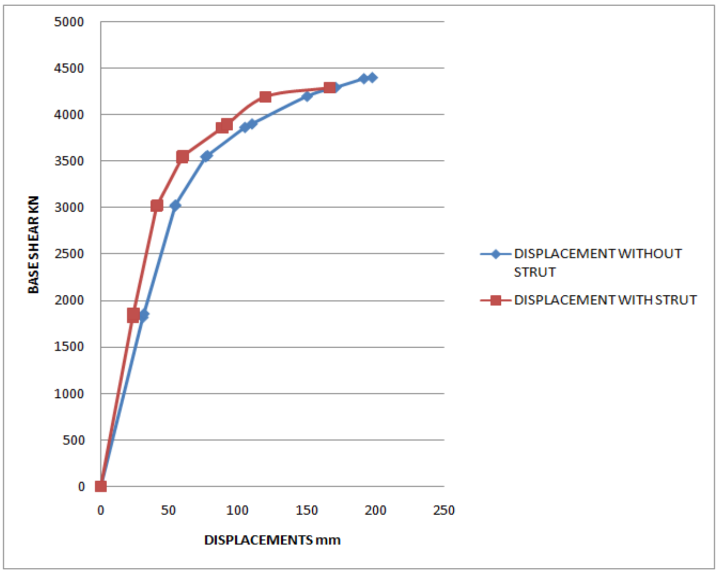

Fig 9 Base shear versus Roof displacement curve for Building in Y direction.

Figure 8 and 9 shows the base shear versus roof displacement curve for Building with and without strut in both the directions as obtained from pushover analyses. The curve shows that consideration of infill stiffness gives more base shear capacity along *X* and *Y* directions, respectively. It also increases the ductility by an amount of 47% and 88% along *X* and *Y* directions, respectively.

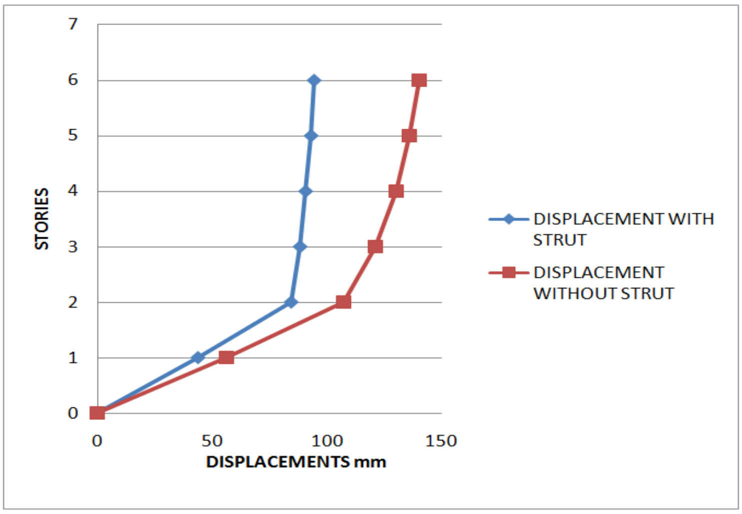

Fig 10 Displacement profile of Building at the formation of mechanism in X direction

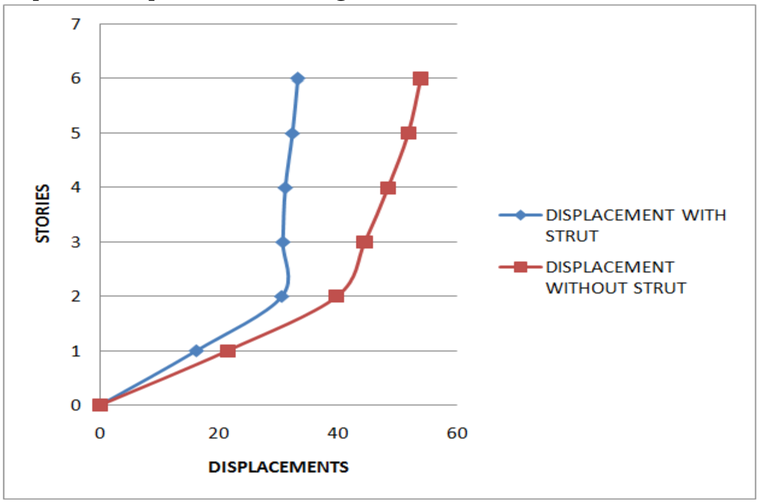

Fig 11 Displacement profile of Building at the formation of mechanism in Y direction

Figure 10 and 11 shows displacement profile for Building at the formation of mechanism. The building is significantly less stiff in *X*-direction, compared to the *Y*-direction, and the maximum displacement in the *Y* direction works out to 89.7mm. It is only 0.6% of the total height of the building and it satisfies the requirement of inelastic drift limitation of 1.2% of total height. And in X direction it is 123mm and it is only 0.8% of the total height of the building with strut.

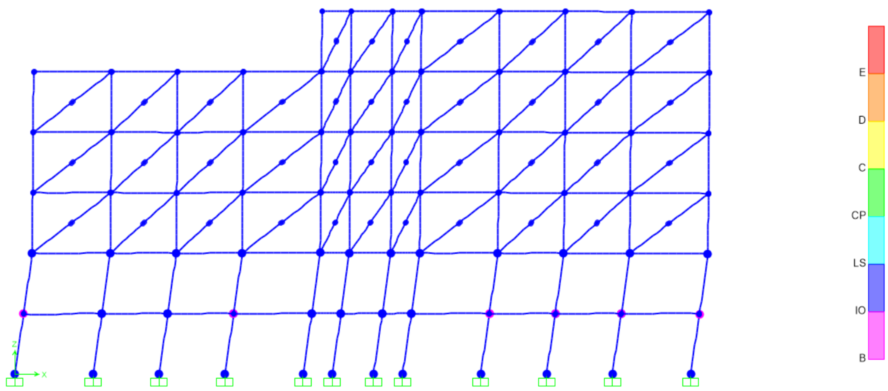

Fig 11 Load Resisting Mechanism for a typical frame of Building with Infill panels

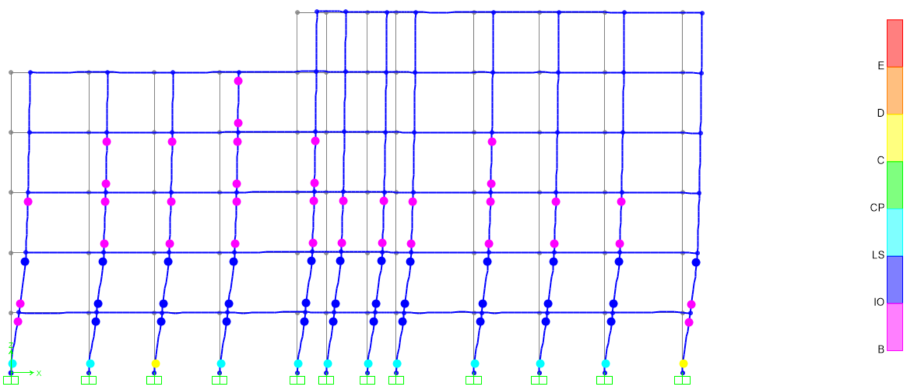

Fig 12 Load Resisting Mechanism for a typical frame of Building for Bare frame.

Above figure 11 and 12 depicts the failure mechanism at a typical frame of Building. It shows that the hinge formation is concentrated in the plinth and ground levels when the infill stiffness is considered. Whereas when the infill stiffness is neglected it shows better performance as the hinges are spread over the elevation of the frame. It is also seen that bending moment in the ground floor columns are enhanced by almost 100 percent when the soft storey effect is considered, indicating that the existing buildings are vulnerable.

III. Conclusions

The influence of masonry infill on the response of multi-storeyed building under seismic loading is Illustrated through typical examples. The presence of masonry infill panels modifies the structural force distribution significantly. The total storey shear force increases considerably as the stiffness of the building increases in the presence of masonry infill. Also, the bending moments in the ground floor columns increase, and the mode of failure is by soft storey mechanism (formation of hinges in ground floor columns). The lateral load resisting mechanism of the masonry infilled frame essentially different from the bare frame. The bare frame acts primarily as a moment resisting frame with the formation of plastic hinges at the joints under lateral loads. In contrast, the infill frame behaves like a braced frame resisted by a truss mechanism formed by the compression in the masonry infill panel and tension in the column. The plastic hinges are confined with the joint in contact with the infill panel. It is seen that the existing buildings with open ground storey are deficient and in need of retrofit.

References

[1] IS 1893: Part 1 (2002); "Criteria for earthquake resistant design of structures", Bureau of Indian Standards, New Delhi.
[2] ATC 40, Volume 1 (1996) "Seismic evaluation and retrofit of concrete buildings", Applied Technology
[3] Council, Seismic Safety Commission, State of California.

[4] IS 456:2000; "Plane and Reinforced Concrete-Code of Practice", Bureau of Indian Standards, New Delhi.
[5] FEMA 356, "Federal Agency Management Agency", Pre standard and commentary for the Seismic rehabilitation of Buildings.
[6] NPTEL Chapter 7 "Non Linear seismic response of structures".
[7] Design of Reinforced Concrete Structures by Pillai and Menon
[8] Ashraf Habibullah, S.E., and Stephen Pyle, S.E," Practical Three Dimensional Nonlinear Static Pushover Analysis", Structure Magazine 1988.
[9] Pankaj Agarwal & Manish Shrikhande, "Earthquake resistant Design of structure", PHI publication.

B. Suresh. "Capacity Analysis of RCC Frame Structure with and Without Infill Walls." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) 14.4 (2017): 84-91.