Seismic Assessment of Multi Storey RCC Frame Structures by Nonlinear Static Analysis

Rajesh Mangalwedhe[1] Dr. S.A. Bhalchandra[2]
[1]M.E. Student [2]Associate Professor
[1,2]Department of Civil Engineering
[1,2]Government College of Engineering, Aurangabad, India

Abstract— In this paper, the effect of masonry infill on the seismic response of a five-storey reinforced concrete frame has been studied. Seismic analysis has been performed using Equivalent lateral force Method and pushover analysis for different reinforced concrete (RC) frame building models that include bare frame, brick infilled frame and concrete infilled frame. The results of bare frame, in-filled frame are discussed and conclusions are made for capacity curve, capacity spectrum curve, hinge formation, base shear and Displacement at various points. In modeling the infill panels the Equivalent diagonal Strut method is used and the software ETABS 2015 is used for the analysis of all the frame models.

Key words: RC Frame, Masonry Infill, Equivalent Diagonal Strut, Pushover Analysis

I. INTRODUCTION

The structural engineering community has developed a new generation of design and seismic procedures that incorporate performance based structures and are away from simplified linear elastic methods and towards a nonlinear technique. For this The pushover analysis is a method to observe the successive damage states of the building. The method is relatively simple and provides information on strength, deformation and ductility of the structure and distribution of demands which help in identifying the critical members likely to reach limit states during the earthquake and hence proper attention can be given while designing and detailing. This method assumes a set of incremental lateral load over the height of the structure. Local nonlinear effects are modelled and the structure is pushed until a collapse mechanism is developed. With the increase in magnitude of loads, weak links and failure modes of building are found. At each step, the base shear and roof displacement can be plotted to generate the pushover curve.

II. METHODOLOGY

A. General

In this present work G+5 soft storied Reinforced concrete frame building with and without infill situated in Zone V with subsoil type medium 1 were analysed in ETAB 2015 software. For this present work for each storey three different models are carried out that is bare frame, Brick infill and concrete infill models. The results are carried out by Equivalent static force method and pushover analysis.

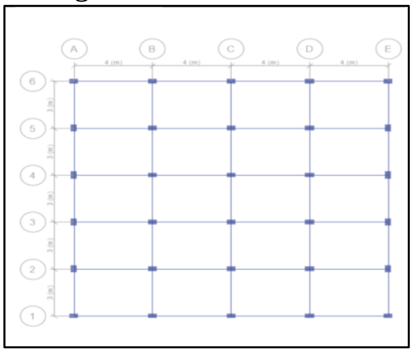


Fig. 1: General plan view

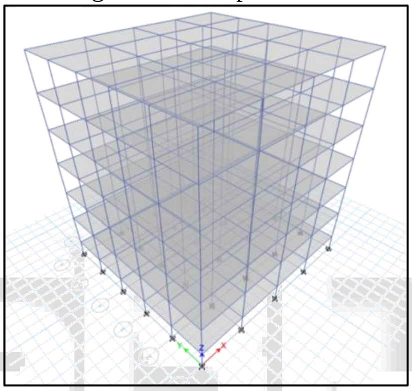


Fig. 2: General 3D view

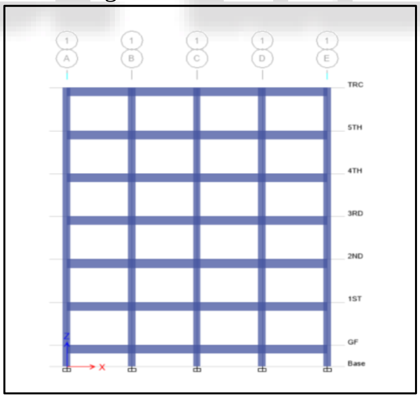


Fig. 3: General Elevation view

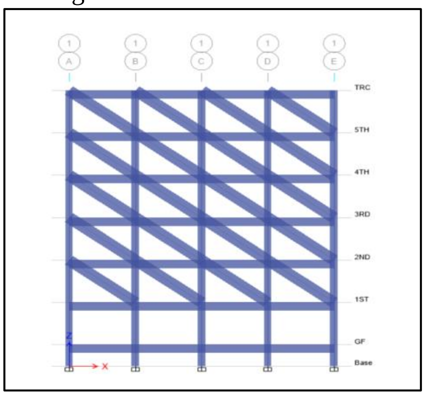


Fig. 4: General Elevation view of infill

Floor height	3m
Infill wall	230 mm
Imposed load on floor	3 KN/m^3
Floor finish	1 KN/m^3
Size of columns	300 mm x 450 mm
Size of beams	300 mm x 600 mm
Depth of slab	150 mm
Grade of Concrete	M 20
Grade of Steel	Fe 415
Specific weight of RCC	25 KN/m^3
Specific weight of infill	20 KN/m^3
Type of Soil	Hard soil
Zone	V

Table 1: Description of building

B. *Equivalent Diagonal Strut Method*

The most accepted method for the analysis of in-filled frame structure is Equivalent Diagonal Strut Method in which entire infill is replaced by a single equivalent strut. In this method beams and column are designed as frame members which are having six DOF at every node and brick infill is replaced by a pin jointed diagonal strut. The thickness of a pin jointed diagonal strut is considered to be same as infill and its length is equal to the length of the diagonal between the two compression corners. Width of a strut is calculated by using Smith's formula.

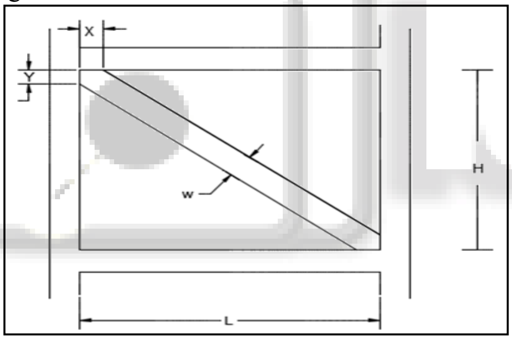


Fig. 5: Equivalent Diagonal Strut Model

$$W = \frac{1}{2}\sqrt{X^2 + Y^2} \quad (1)$$

Here, Parameter X and Y are computed as

$$X = \frac{\pi}{2}\sqrt[4]{\frac{4E_f I c H}{E_m t \sin 2\theta}} \quad (2)$$

$$Y = \pi\sqrt[4]{\frac{4E_f I_b L}{E_m t \sin 2\theta}} \quad (3)$$

Where,

w= width of equivalent strut

E_m, E_f= Elastic modules of the masonry & frame materials respectively

H= height of the infill wall

L= length of the infill wall

I_c= moment of inertia of column

I_b= moment of inertia of beam

θ= slope of infill diagonal to the horizontal

III. RESULTS AND DISCUSSION

The seismic analysis of all the frame models that includes bare frame, brick in-filled frame and concrete In-filled frame has been done by using software ETABS and the results are shown below. The parameters which are to be studied are Capacity curve, capacity spectrum curve, hinge formations, base shear and displacement at various points.

Model	Design base shear	Roof displacement
Bare frame	115.46	15.24
Brick infill	184.49	8.06
Concrete infill	184.49	7.80

Table 2: Equivalent static lateral force method calculation

A. *Pushover Analysis Results*

The objective of this study is to see the variations of base shear vs. roof displacement graph, pattern of hinge formation, base shear and roof displacement at first yield point, performance point and at the ultimate point respectively.

1) *Capacity Curve*

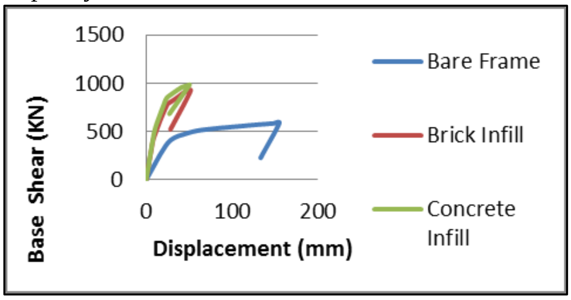


Fig. 6: Base shear Vs. Roof displacement

2) *Capacity Spectrum Curve*

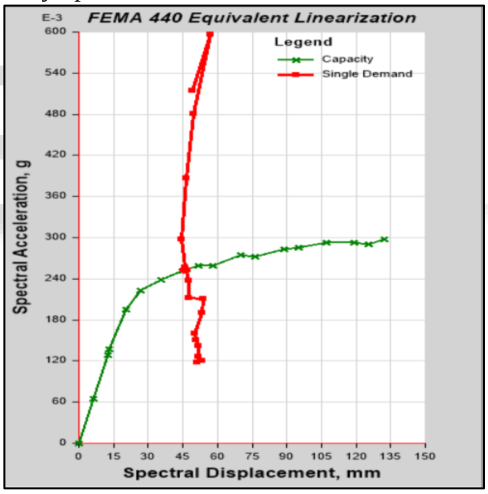


Fig. 7: Capacity spectrum for bare frame

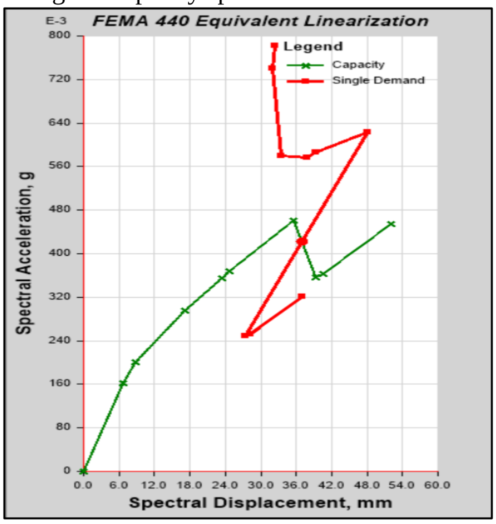


Fig. 8: Capacity spectrum for brick infill frame

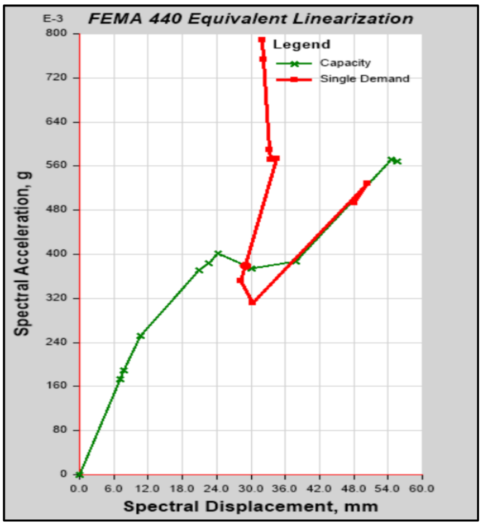
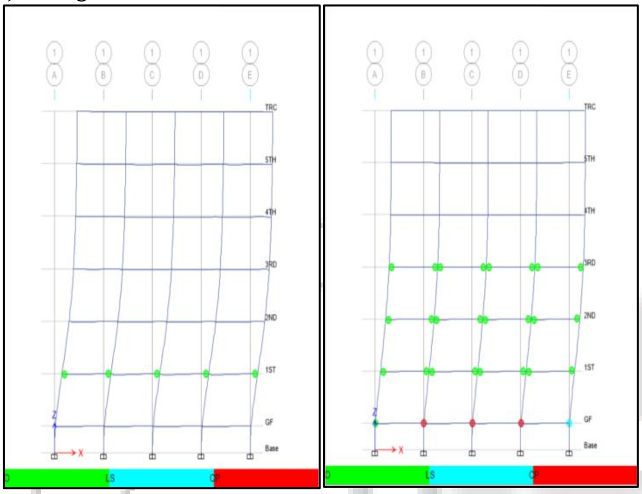


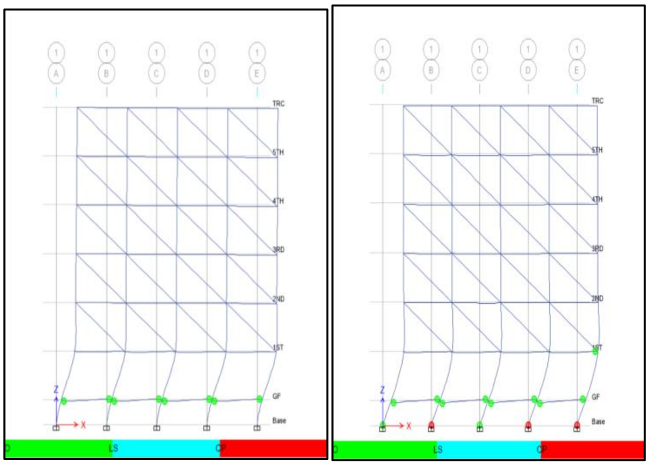
Fig. 9: Capacity spectrum for concrete infill frame

3) *Hinge Formation Pattern*



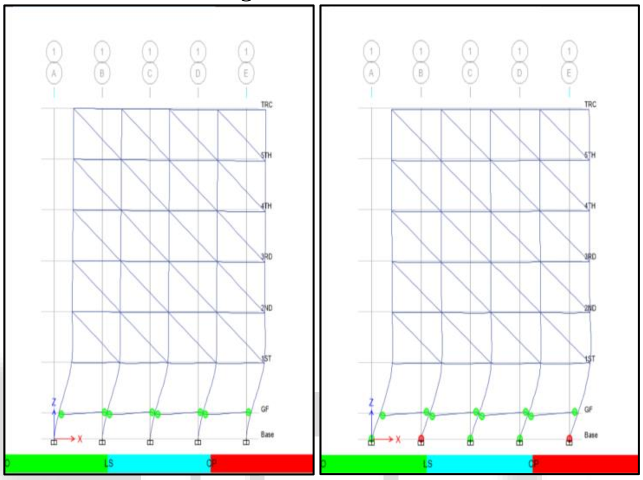
Yield point Ultimate point

Fig. 10: Bare frame



Yield point Ultimate point

Fig. 11: Brick infill



Yield point Ultimate point

Fig. 12: Concrete infill

The number of hinges shown in fig 10, fig11, fig 11. In each member showing the hinges in beams the immediate occupancy, Life Safety and Collapse Prevention and some hinges are shown in column to define the force deflection behaviour of the hinge. Frame is estimating the the plstic hinge formation at the yielding and significant difference in the hinging patterns at the ultimate state.

B. Comparison of Nonlinear analysis with linear analysis

Model	Linear Analysis	Nonlinear analysis		
	Design base shear (KN)	At first yield point (KN)	At performance point (KN)	At yield point(KN)
Bare frame	115.46	411.57	500.21	587.74
Brick infill	184.49	588.48	859.63	923.20
Concrete infill	184.49	696.93	898.05	983.85

Table 3: Comparison of base shear at various points

Model	Linear Analysis		Nonlinear analysis		
	Roof displacement (mm)	Max Allowable displacement (0.4% h) (mm)	At first yield point (mm)	At performance point (mm)	At yield point (mm)
Bare frame	15.24	78	25.7	55.3	154.86
Brick infill	8.06	78	13.2	37.2	51.72
Concrete infill	7.80	78	11.3	31.3	50.48

Table 4: Comparison of Roof displacement at various points

IV. CONCLUSION

Based on the above study following conclusions are drawn:

– Pushover analysis is powerful and very useful tool for structural engineers to design new structure that will adequately perform in future expected earthquake.

- The consideration of infill as equivalent diagonal strut in the analysis is helpful, in reducing the displacement of the structure.
- Displacement of the bare frame structure is more than concrete infill and brick infill.
- The lateral load resisting capacity of the concrete infill is more than brick infill although bare infill has lesser load resisting capacity than concrete infill and brick infill.
- The base shear carrying capacity at performance point is almost 4.5 times as compared to design base shear.

ACKNOWLEDGMENT

I have great pleasure to thanks my guide Dr. S.A. Bhalchandra for her guidance, constant inspiration, comprehensive critical remarks and continuous encouragement with valuable suggestions in completion of the work. Here I get an opportunity to express my sincere gratitude to Head of Department Dr. P. B. Murnal to provide me all necessary facilities to carry out my research program.

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