CASE STUDY ON SLENDER MULTI-STOREY RC BUILDING WITH BRICK INFILL

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Abstract

Earthquakes are natural hazards under which disasters are mainly caused by damage or collapse of buildings and other man-made structures. It should be noted that 70 to 80 % of buildings of urban areas in India fall under the classification of soft storey according to IS 1893 (2002) Part-I. In analysis and design of the high rise building generally do not consider the effect of the brick masonry infill and design it by considering bare frame. Here to observe the effect of brick masonry infill and without infill in analysis of plane frame.

The main focus of the work is to carry out analysis of existing slender RC brick infilled building located at Bangalore, using ETABS 9.7.1. The analysis is carried out on RC bare frame with beam and column having dimension 150x450mm, RC frame with brick infill with openings for doors and windows, for different zones like 2,3,4, and 5. And also the analysis is done on same RC frame with brick infill with openings for revised beam and column dimension 230x450mm with different zones 2,3,4, and 5.

In second part of work is carried out the pushover analysis on a RC frame building and comparing the results with RC bare frame and RC frame with brick infill with opening

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1. INTRODUCTION

In many countries situated in seismic regions, reinforced concrete frames are infilled fully or partially by brick masonry panels with or without openings. Although the infill panels significantly enhance both the stiffness and strength of the frame, their contribution is often not taken into account because of the lack of knowledge of the composite behaviour of the frame and the infill

The impact of the infills on the seismic behavior of buildings may be positive or negative, depending on a large number of influential parameters. Generally, the performance of the structure can be significantly improved by the increase of strength and dissipation capacity due to the masonry infills, even if in presence of an increasing in earthquake inertia forces. However, for a proper design of masonry infilled reinforced concrete frames it is necessary to completely understand their behavior under repeated horizontal loading. Neglecting the significant interaction between the filler walls and building frames is the main reason why structural systems incorporating integrated infills panels react to strong earthquakes in a manner quite different from the expected one.

A review of analysis and design provisions related tomasonry infilled RC frames in seismic design codes of different countries shows that only a few codes have considered the effect of infill in analysis and design of masonry infilled RC frames. On the other hand, the stiffness and strength of the infilled frames with opening are not taken care of by most of the codes. Hence, the behavior of infilled frames with openings needs to be studied extensively in order to develop a rational approach or guidelines for design. The masonry infill is very stiff and has considerable strength, meaning that the load capacity of masonry infilled frames increases substantially.

In the case of horizontal loading due to wind or seismic action, it is usual to assume that an equivalent compression strut can replace the action of the masonry panels.

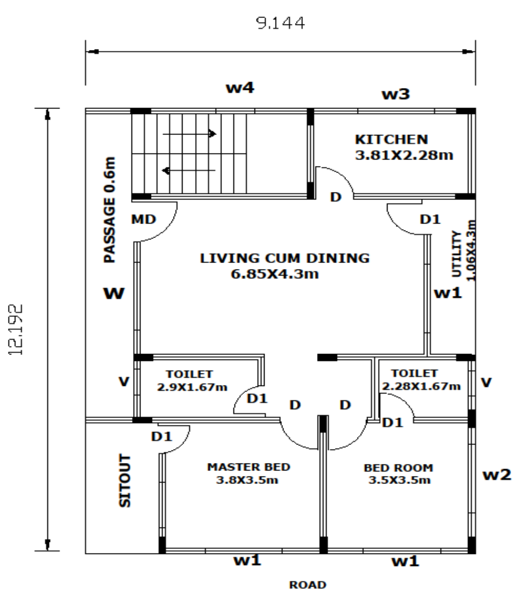
2. SECTIONS OF STRUCTURAL ELEMENTS OF EXISTING BUILDING

Type of Structure: Ordinary moment resisting RC frame
Ground floor: Soft storey
First and Second floor; RC Frame with brick infill with openings
Grade of Concrete: M 20
Grade of Reinforcing Steel: Fe 415
Number of Stories: G + 2 storeys

Building height: 9 m

2.1 Front Elevation of Existing Building

2.2 Plan of Existing Building



FIRST FLOOR PLAN

UNITS - Meter

2.3 Column Size

Rectangular columns at the plinth, ground floor and first floor level: 150mmx450mm

2.3.1 Width of Existing Building Column 150mm

2.3.2 Depth of Existing Building Column 450mm

2.4 Beam Size

Rectangular beam at the ground floor and first floor level: 150mmx450mm

2.4.1 Width of Existing Beam 150mm

2.4.2 Plinth Level Beam Size

Rectangular beam at the plinth level: 150mmx450mm.

2.4.3 Slab Thickness:

RC Building frame slab thickness is 150mm.

2.4.4 Masonry Wall Thickness:

RC Building frame Brick wall thickness is 150mm.

2.4.5 Support Condition:

The support is fixed at the ends.

2.4.6 Sizes of Doors, Window, and Ventilater:

W = 1.83 X 2m
W1 = 1.83 X 1.403m
W2 = 1.22 X 1.403m
W3 = 1.83 X 1.915m
W4 = 0.915 X 1.403m
V = 0. 3X 0.9m
MD = 1.098 X 2.135 m
D = 0.915 X 2.135 m
D1 = 0.8 X 2.135 m

Where W = window D = Door, MD = Main Door, V = ventilator

2.5 Loading Condition

Dead load:
Self weight of the column= 0.15x0.45x25 = 1.687 kN/m
Self weight of the Beam = 0.15x0.45x25 = 1.687 kN/m
Self weight of the Slab = 0.15x1x25 = 3.75 kN/m^2

Live load
Live load = 3kN/m^2

Earthquake load
The design value of base shear V_B
$V_B = A_h W$ as per (IS: 1893 Cl.7.5.3)

Calculate the design horizontal Seismic coefficient A_h

- The design horizontal coefficient A_h is given by $A_h = (Z/2). (I/R). (S_a/g)$
- Zone Factor (Z) for the applicable seismic zone (IS: 1893 Cl.6.4.2),
- Importance factor(I) for the use importance of the building (IS: 1893 Table 2),
- Response reduction factor(R) for the lateral load resisting system adopted.

(IS: 1893 Table 7), And take S_a/g for the computed time period value T_a and with 5% damping Coefficient using the response spectra curves IS: 1893 Fig 2 for the soil type observed. Thus value of A_h will be determined for T_a

2.6 Natural Time Period

- Fundamental natural period of vibration (T_a), in seconds, of a moment-resisting frame building without brick infill panels may be estimated by the empirical expression:

  $T_a = 0.075\ h^{0.75}$ for RC frame building
  Where h=9 m,
  $T_a = 0.075\ h^{0.75} = 0.389$sec

- The approximate fundamental natural period of vibration (T_a), in seconds, of all other buildings, including moment-resisting frame buildings with brick infill panels, may be estimated by the empirical expression:

$T_a = 0.09h/\sqrt{d} = 0.09 \times 9/\sqrt{11.75} = 0.23$sec X-Direction d = 11.75m

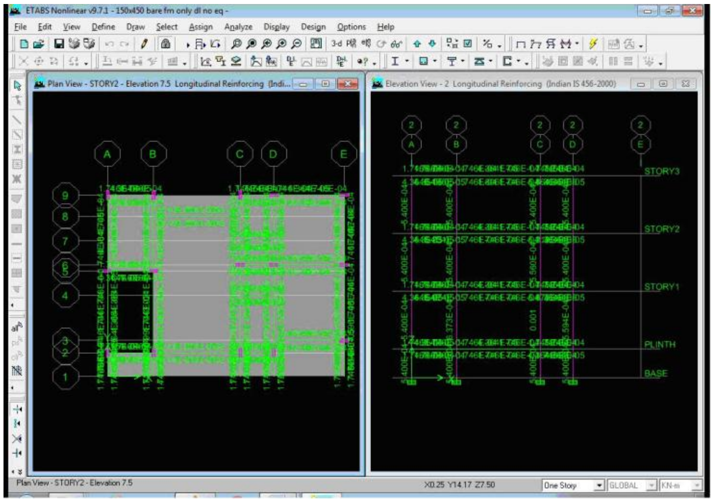
$T_a = 0.09h/\sqrt{d} = 0.09 \times 9/\sqrt{9.11} = 0.26$sec Y-Direction d = 9.11m

Where
h= height of building in m.
d= base dimension of the building at the plinth level in m, along considered direction of lateral force.

3. ANALYSIS:

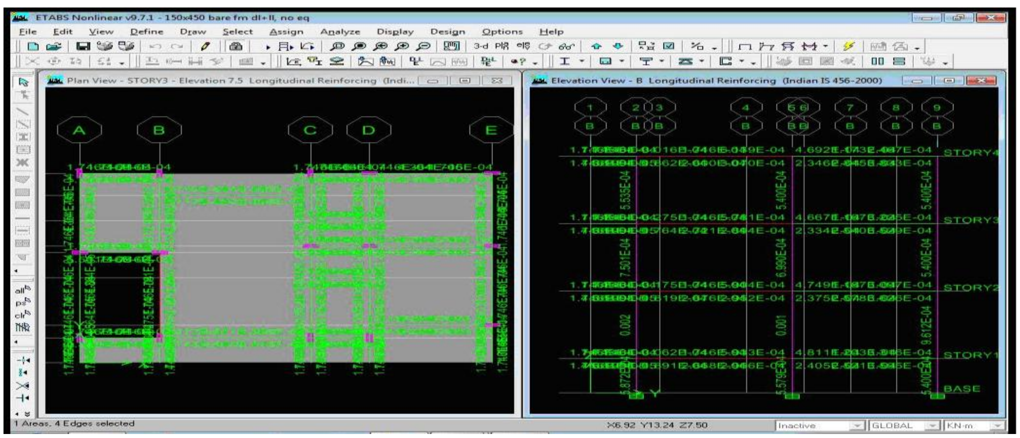
3.1 Case 1: Bare frame

CASE1: BARE FRAME		RESULTS	
Loads considered	DL	None of the Beams failed	None of the columns failed
Beam cross section(mmXmm)	150x450mm		
Column cross section(mmXmm)	150x450mm		
Slab thickness(mm)	150		



3.2 Case2: Bare Frame

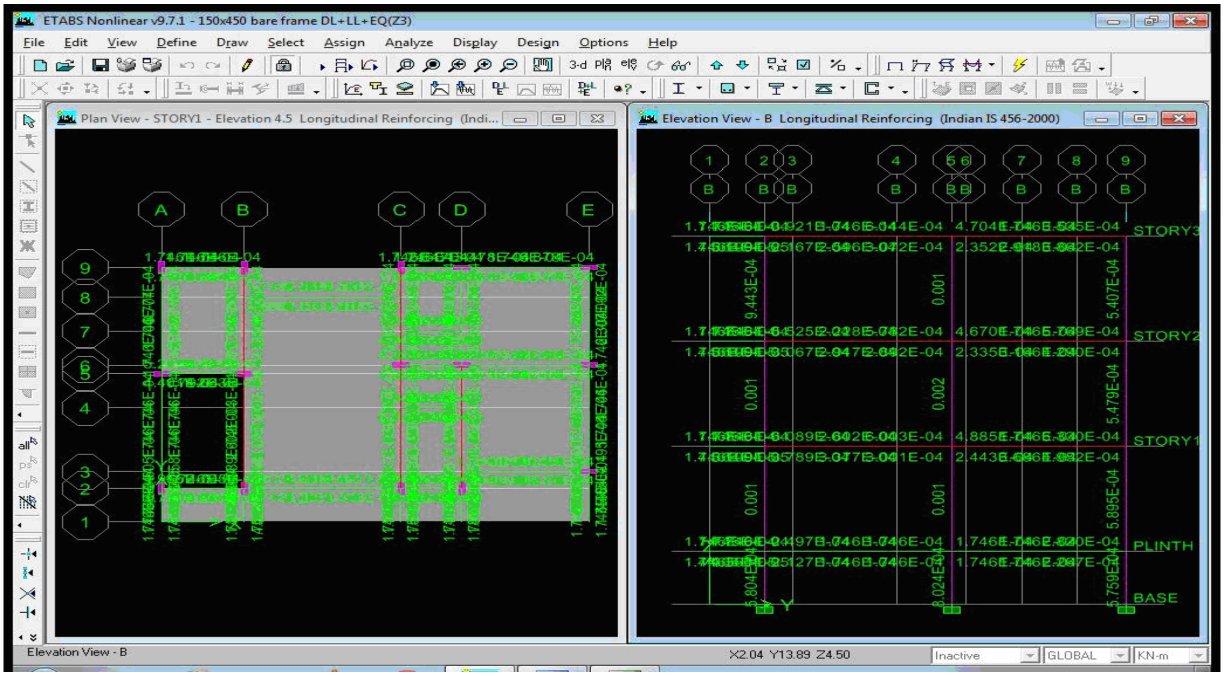
CASE2: BARE FRAME		RESULTS	
Loads considered	DL + LL	Beam no 18 failed at Storey3, storey2 Storey1 and at plinth level	None of the columns failed
Beam cross section(mmXmm)	150x450mm		
Column cross section(mmXmm)	150x450mm		
Slab thickness(mm)	150		



3.3 Case3: Bare Frame

3.3.1 Bare Frame (Zone-3)

BARE FRAME (ZONE-3)		RESULTS	
Loads considered	**DL + LL + EQ**	**BEAMS**	**COLUMNS**
Zone factor(Z)	0.16	B17, B18 failed at Storey 3 B17, B21 ,B24 & B18 failed at Storey 2 B20, B17,B18 ,B20, B21 andB24 failed at Storey 1	None of the columns failed
Importance factor(I)	1		
Response reduction factor (R)	3		
Soil type	II		
Time period(T)	0.389 sec		
Beam cross section(mmxmm)	150 X 450mm		
Column cross section(mmXmm)	150 X 450mm		
Slab thickness(mm)	150mm		



3.3.2 Bare Frame (Zone-5)

BARE FRAME (ZONE-5)		**RESULTS**	
Loads considered	**DL + LL + EQ**	**BEAMS**	**COLUMNS**
Zone factor(Z)	0.36	B17 ,B18 , B20 , B21 & B24 beams failed at Storey 3. B3, B5, B11, B17,B18, B20, B21 & B24 beams failed at Storey 2. B3, B5, B11, B17,B18, B20, B21& B24 beams failed at Storey 1. B5 beam failed at Plinth level.	C2 ,C3 , C7 ,C6 C5 & C4 columns failed at Storey 2. C4 , C5, C6 ,C7 & C15 columns failed at Storey 1.
Importance factor(I)	1		
Response reduction factor (R)	3		
Soil type	II		
Time period(T)	0.389 sec		
Beam cross section(mmxmm)	150 X 450mm		
Column cross section(mmXmm)	150 X 450mm		
Slab thickness(mm)	150mm		

3.4 Case4: RC Frame with Brick Infill with Openings

CASE4: RC FRAME WITH BRICK INFILL WITH OPENINGS		RESULTS	
Loads considered	DL&LL	BEAMS	COLUMNS
Beam cross section(mmXmm)	150X450	None of the beams have failed.	None of the columns have failed..
Column cross section(mmXmm)	150X450		
Slab thickness(mm)	150		

3.4.1 RC Frame with Brick Infill with Openings – DL+LL+EQ (Zone 2)

RC FRAME WITH BRICK INFILL WITH OPENINGS(ZONE–2)		RESULTS	
Loads considered	DL + LL + EQ	BEAMS	COLUMNS
Zone factor(Z)	0.10	None of the beams have failed.	None of the columns have failed.
Importance factor(I)	1		
Response reduction factor (R)	3		
Soil type	II		
Time period(T)	0.389 sec		
Beam cross section(mmxmm)	150 X 450mm		
Column cross section(mmXmm)	150 X 450mm		
Slab thickness(mm)	150mm		

3.4.2 RC Frame With Brick Infill With Openings – DL+LL+EQ (Zone 3)

RC FRAME WITH BRICK INFILL WITH OPENINGS(ZONE–3)		RESULTS	
Loads considered	DL + LL + EQ	BEAMS	COLUMNS

Zone factor(Z)	0.16	None of the beams have failed.	None of the columns have failed.
Importance factor(I)	1		
Response reduction factor (R)	3		
Soil type	II		
Time period(T)	0.389 sec		
Beam cross section(mmxmm)	150 X 450mm		
Column cross section(mmXmm)	150 X 450mm		
Slab thickness(mm)	150mm		

3.4.3 RC Frame with Brick Infill with Openings – DL+LL+EQ (Zone 4)

RC FRAME WITH BRICK INFILL WITH OPENINGS(ZONE–4)		RESULTS	
Loads considered	**DL + LL + EQ**	**BEAMS**	**COLUMNS**
Zone factor(Z)	0.24	B17 failed at Storey 1 B5 failed at Plinth level	None of the columns have failed.
Importance factor(I)	1		
Response reduction factor (R)	3		
Soil type	II		
Time period(T)	0.389 sec		
Beam cross section(mmxmm)	150 X 450mm		
Column cross section(mmXmm)	150 X 450mm		
Slab thickness(mm)	150mm		

3.4.4 RC Frame with Brick Infill with Openings – DL+LL+EQ (Zone 5)

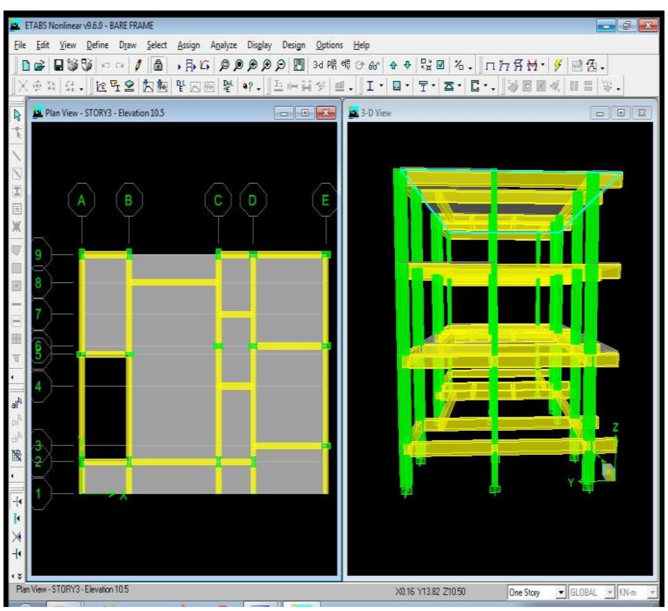
RC FRAME WITH BRICK INFILL WITH OPENINGS(ZONE–5)		RESULTS	
Loads considered	**DL + LL + EQ**	**BEAMS**	**COLUMNS**
Zone factor(Z)	0.36	B17 & B21 beams have been failed at Storey 1.	C3 , C15 ,C4 , C5 C6 & C7columns have failed at
Importance factor(I)	1		

Response reduction factor (R)	3	B3 ,B5, B11 & B24beams have been failed at Plinth level.	Storey 1. C13 ,C14 , C3& C4 columns have failed at Plinth level.
Soil type	II		
Time period(T)	0.389 sec		
Beam cross section(mmxmm)	150 X 450mm		
Column cross section(mmXmm)	150 X 450mm		
Slab thickness(mm)	150mm		

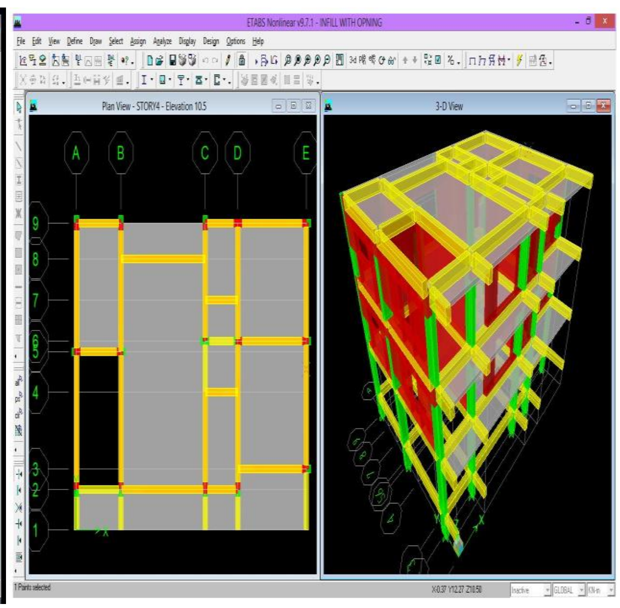
3.5 Case 5: RC Frame with Brick Infill with Openings (230x450mm)

CASE5: RC FRAME WITH BRICK INFILL WITH OPENINGS (230x450mm)	RESULTS	
	BEAMS(230x450mm)	COLUMNS(230x450mm)
1. DL+LL	None of the beams have failed	None of the columns have failed
2. DL+LL+EQ(ZONE 2)	None of the beams have failed	None of the columns have failed
3. DL+LL+EQ(ZONE 3)	None of the beams have failed	None of the columns have failed
4. DL+LL+EQ(ZONE 4)	None of the beams have failed	None of the columns have failed
5. DL+LL+EQ(ZONE 5)	None of the beams have failed	None of the columns have failed

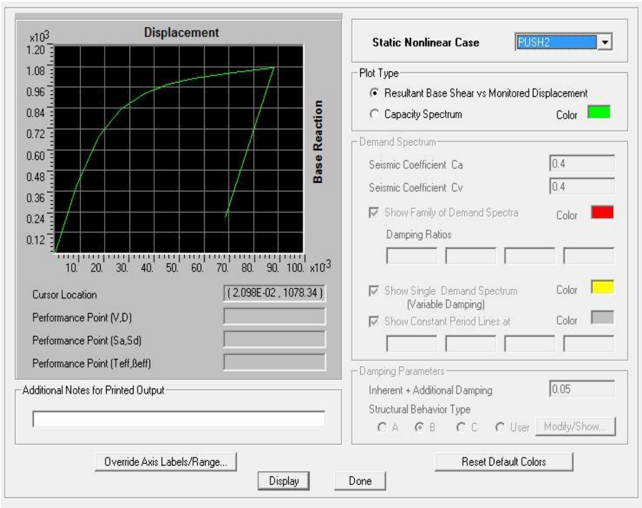
3.6 Case6: Pushover Analysis

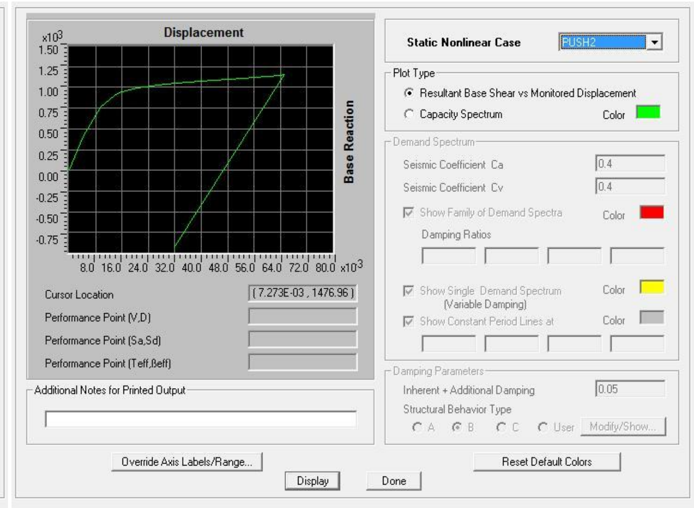


RC Bare Frame



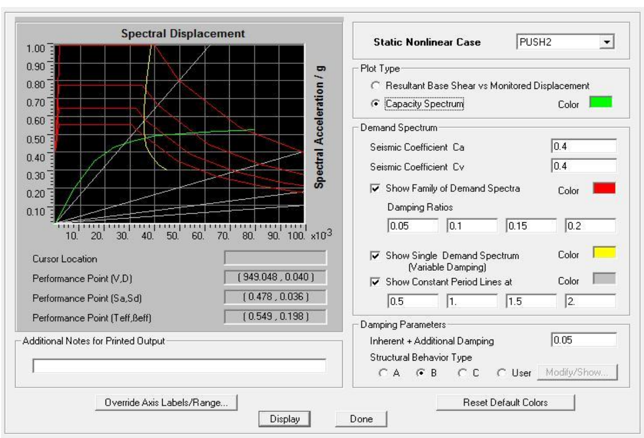
RC frame with infill with openings

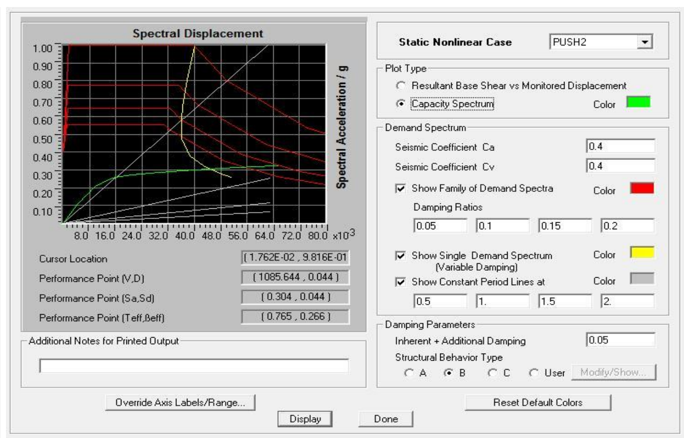




Pushover curve for RC bare frame

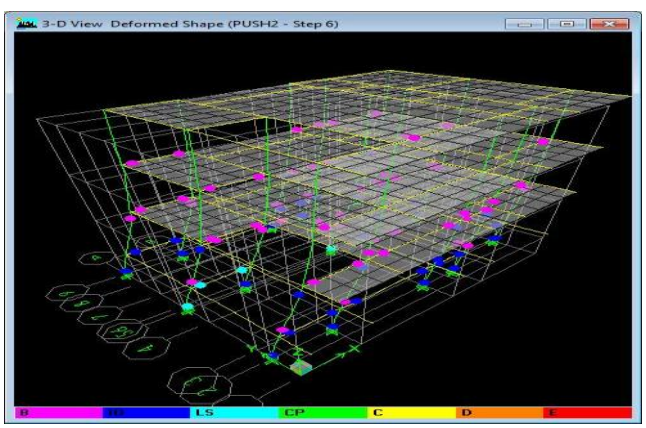
Pushover curve for RC frame with brick infill with openings

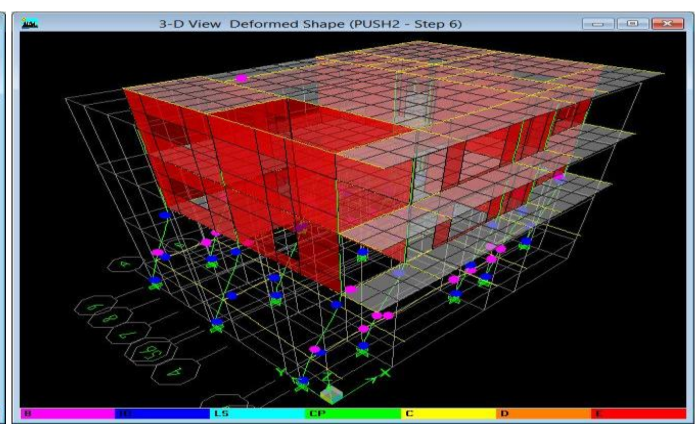




Capacity curve for RC bare frame

Capacity curve for RC frame with brick infill with openings





Hinge levels of RC bare frame

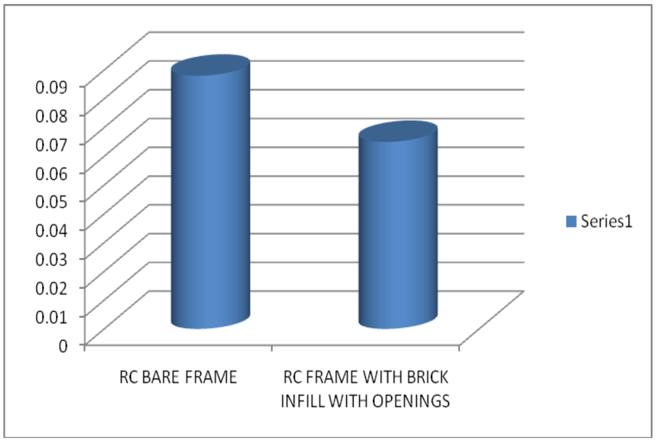
Hinge levels of RC frame with brick infill with openings

Results showing the Displacement and Base force

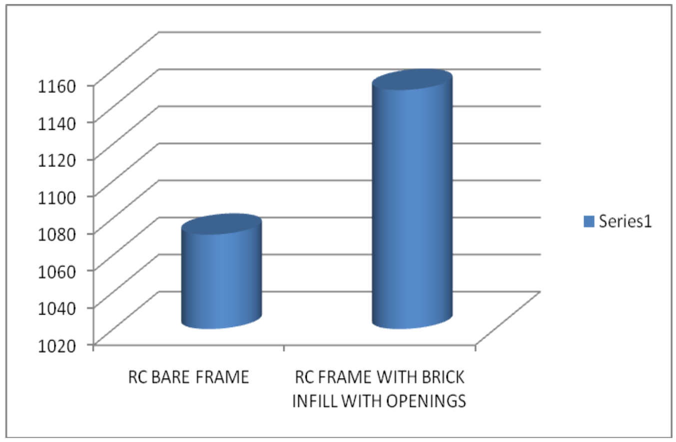
Sl.No	Designation	Max Displacement (m)	Max Base force (kN)
1	RC Bare frame	0.088	1070.94

Results showing the Displacement and Base force

Sl.No	Designation	Max Displacement (m)	Max Base force (kN)
1	RC Frame with Brick infill with openings	0.065	1149.02



Graph showing comparison between the displacements of RC bare frame and RC frame with brick infill with openings



Graph showing comparison between the Base shear of RC bare frame and RC frame with brick infill with openings

4. CONCLUSIONS

- The structure which selected for the present study is very slender in dimension and is not acceptable under seismic condition
- As per the Code, the Bangalore region comes under seismic Zone II. Few Framed Structures are built in the above said zone with smaller dimensions of beams and columns like 150mm x 450mm. which becomes critical under normal DL+ LL.
- For DL+LL case the beams (150x450mm) fail during analysis, i.e. beams are insufficient to carry DL and LL. From the points mentioned above it is understood that the cross section of beams is highly insufficient to carry service load. And these buildings are not safe when subjected to earthquake load.
- These types of buildings when built in high seismic zones, the structure fails. Hence, we should provide the Suitable dimensions for the frames and ductile detailing of reinforcement
- The structure which has been considered in the present study is analysed taking beams and columns dimensions as 230x450mm and it has been found that none of the beams and columns have failed. Hence it can be proposed to consider the above mentioned dimension as minimum dimensions for beams for building.
- The RC bare frame which is analysed for the static non linear pushover cases can carry lower base force and at higher displacement it fails
- The RC frame with brick infill with openings which is analysed for the static non linear pushover cases can carry higher base force and at lesser displacement it fails

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