International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 07 | July 2018 www.irjet.net p-ISSN: 2395-0072

Seismic Evaluation Of Multistorey RC Buildings With Concrete Masonry Infill Wall and User Defined Hinges

Priyanka V.Gaonkar[1], Dr.S.S.Dyavanal[2]

[1]PG Student @ Civil Engg. Dept. KLE Technological University, Hubballi, India
[2]Professor @ Civil Engg. Dept. KLE Technlogical University, Hubballi, India

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Abstract - *In India many urban multistorey buildings have open first storey as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first storey. The presence of infill wall affects the distribution of lateral load in the frames of buildings because of the increase of stiffness of the frames. In the present paper an attempt has been made to study the behaviour of 2D RC special moment resisting frame with concrete masonry infill wall. The study is carried out on G+2 and G+5 storey buildings which are located in seismic zone III. The concrete masonry infill wall is modeled as pin-jointed single equivalent diagonal strut as proposed by Stafford smith and Hendry. Equivalent and response spectrum analyses are carried out using SAP 2000 V14.2 software. Nonlinear static pushover analysis is carried out using user defined hinge properties as per the FEMA 440 guidelines. The results are compared with the parameters namely: natural period, base shear, lateral displacement, and hinge status at performance point.*

***Key Words* : pushover analysis, natural period, base shear, lateral displacement, hinge status.**

1. INTRODUCTION

Recent earthquakes have caused loss of life and the most important challenge is to reduce such an unacceptably high loss of life from earthquakes. Sudden movement in a rupture zone arises seismic waves in the earth's crust. The point on the fault where slip starts is the focus or hypocenter, and the point vertically above this on the surface of the earth is the epicenter. The depth of focus from the epicenter, called as focal depth, is an important parameter in determining the damaging potential of an earthquake [6]. When earthquakes occur, buildings undergoes dynamic motion. This is because the buildings are subjected to inertia forces that act in opposite direction to the acceleration of earthquake excitations. These inertia forces, called seismic loads, are usually dealt with by assuming forces external to the buildings. So apart from gravity loads, the structure will experience dominant lateral forces of considerable magnitude during earthquake shaking. It is essential to estimate and specify these lateral forces on the structure in order to design the structure to resist an earthquake [3].

A composite structure which combines moment resisting plane frame and infill walls is known as infilled frame [9]. Masonry infill walls are used to construct a large number of reinforced concrete and steel buildings and are often used to fill the void between the vertical and horizontal resisting elements of the building frames with the assumption that these infill walls will not take part in resisting any kind of load either axial or lateral. Hence its significance in the analysis of frame is generally neglected. Another hurdle for its consideration in the analysis is non availability of realistic and simple analytical models of infill wall. In fact, an infill wall enhances considerably the strength and rigidity in comparison to the bare frames and their ignorance has become the cause of failure of many of the multi-storeyed buildings.[1]

2. ANALYSIS AND MODELLING

In the present study 2D RC special moment resisting frames of three and six storey are considered. Seismic analysis is carried out for dead load, live load and seismic load using SAP 2000 software for bare frame and soft storey structure.

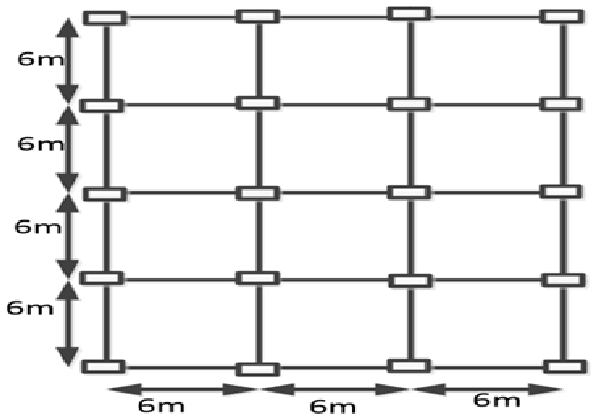

Fig.1: Plan of building model

2.1 BUILDING PROPERTIES

Input data for the building models

Structure :: SMRF

Response reduction factor :: 5

No. of storey :: G+2, G+5

Type of building use :: Official

Seismic zone :: III

Material Properties:

Young's modulus of M25 concrete, E_c :: 25 x 10^6 kN/m^2

Grade of concrete :: M25

Grade of steel :: Fe 415

Member Properties:

Thickness of slab :: 0.120 m

Beam size :: 0.3x0.45 m

Column size :: 0.3x0.5 m

Thickness of wall :: 0.20 m

Assumed Dead Load Intensities:

Roof finishes :: 1.5 kN/m^2

Floor finishes :: 1.0 kN/m^2

Live Load Intensities :

Roof :: 1.0 kN/m^2

Floor :: 3.0 kN/m^2

Earthquake Live Load:

Earthquake LL on slab as per clause 7.3.1 and 7.3.2 of IS:1893 (part 1) -2002.

Roof :: 0 kN/m^2

2.2 MODELLING

The building is considered to be located in seismic zone III Hubli-Dharwad region and intended for use as an office. In the seismic weight calculations, only 25% of the live load is considered. The elevations of the different building models considered are shown in figure. The support condition is considered as fully fixed. Solid concrete block walls are modelled as equivalent diagonal strut as proposed by Stafford smith and Hendry. M (moment hinge), PM (axial force and moment hinge), V (Shear hinge) and P (axial force hinge) hinges with hinge properties are assigned at both ends of beam, column, and strut elements by using user defined hinges.

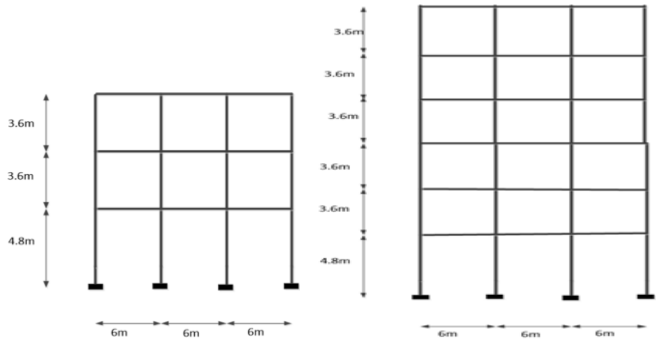

Fig.2: Elevation of three and six storey bare frame buildings

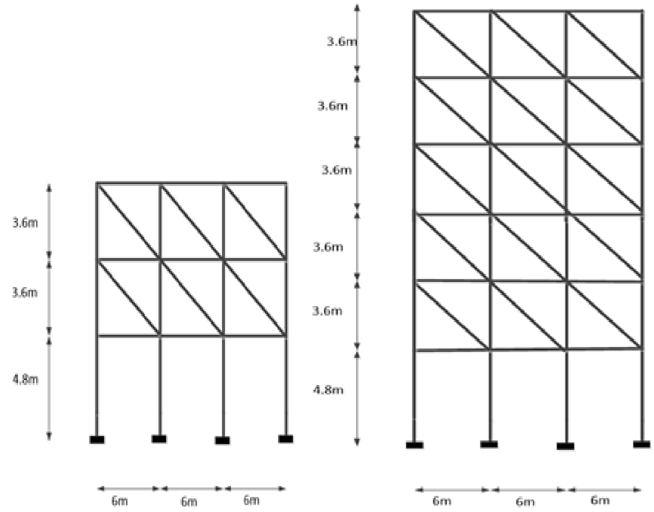

Fig.3: Elevation of three and six storey buildings with solid concrete block infill walls at the upper storey

2. RESULTS AND DISCUSSIONS

Table 1 : Codal and analytical natural periods

Bare frame			Infill wall as solid concrete block	
Model	Codal	Analytical	Codal	Analytical
3	0.48	0.795	0.25	0.674
6	0.78	1.387	0.48	0.908

The results show that there is significant change in the natural period of codal analysis as compared to analytical building models. For three and six storey bare frame buildings, the analytical values are 1.65 and 1.78 times the codal values respectively. For three and six storey infill as solid concrete block frame buildings, the analytical values are 1.69, and 1.89 times the codal values respectively, thus in turn there will be under estimation of the design lateral force in the models.

Table 2 : Base Shear and scaling factor for bare frame building models

Storey	$\overline{Vb}$	Vb	Scaling factor
3	74.97	47.535	1.57
6	105.558	53.175	1.98

Table 3 : Base Shear and scaling factor for infill wall as solid concrete block frame building models

Storey	$\overline{Vb}$	Vb	Scaling factor
3	106.724	89.923	1.18
6	231.121	138.146	1.67

The base shear is a function of mass, stiffness, height, and the natural period of the building structure. For three storeyed building models, the base shear by ESA and RSA are found less in bare frame building model compared to concrete block infill wall model by 29.75 % and 47.13%. For six storeyed building models, the base shear by ESA and RSA are found less in bare frame building model compared to concrete block infill wall model by 54.32 % and 61.5% .

Table 4 : Lateral displacements in longitudinal direction by ESM for three storey building in mm

Storey	Bare frame	Infill wall as solid concrete block
3	9.58	5.15
2	7.36	4.84
1	4.58	4.27

Table 5 : Lateral displacements in longitudinal direction by ESM for six storey building in mm

Storey	Bare frame	Infill wall as solid concrete block
6	23.56	11.28
5	21.42	10.8
4	17.93	9.91
3	13.43	8.8
2	7.91	7.76
1	5.86	4.33

Table 6 : Lateral displacements in longitudinal direction by RSM for three storey building in mm

Storey	Bare frame	Infill wall as solid concrete block
3	8.56	4.92
2	6.82	4.68
1	4.56	4.19

Table 7 : Lateral displacements in longitudinal direction by RSM for six storey building in mm

Storey	Bare frame	Infill wall as solid concrete block
6	19.74	9.89
5	18.24	9.61
4	15.69	9.12
3	12.29	8.39
2	10.37	5.68
1	5.82	4.19

The lateral displacement of a building is a function of the stiffness, the lateral displacement of the building decreases with the increase in the lateral stiffness; hence the displacement of the soft storey is less than the bare frame. Comparing the roof displacement in the longitudinal direction obtained from equivalent static method, a decrease by 46.24 % for infill as solid concrete wall is observed in comparison with bare frame for the three storey framed building and decrease of 52.12% was observed as compared to the bare frame model for the six storey building.

Comparing the roof displacement in the longitudinal direction obtained from response spectrum method, a decrease by 42.52% for infill as solid concrete wall is observed in comparison with bare frame for the three storey framed building and decrease of 49.89 % was observed as compared to the bare frame model for the six storey building.

Table 8 : Storey drift in longitudinal direction by ESM for three storey building in mm

Storey	Bare frame	Infill wall as solid concrete block
3	2.22	0.31
2	2.78	0.57
1	4.58	4.27

Table 9 : Storey drift in longitudinal direction by RSM for three storey building in mm

Storey	Bare frame	Infill wall as solid concrete block
3	1.74	0.24
2	2.26	0.49
1	4.56	4.19

Table 10 : Storey drift in longitudinal direction by ESM for six storey building in mm

Storey	Bare frame	Infill wall as solid concrete block
6	2.14	0.48
5	3.49	0.89
4	4.5	1.11
3	4.52	1.04
2	5.05	2.83
1	5.86	4.33

Table 11 : Storey drift in longitudinal direction by RSM for six storey building in mm

Storey	Bare frame	Infill wall as solid concrete block
6	1.5	0.28
5	2.55	0.49
4	3.4	0.73
3	3.92	0.85
2	4.55	2.71
1	5.82	4.19

As per the clause 7.11.1 of IS 1893 (Part 1):2002 the storey drift should be within the 0.004 times the story height i.e. is 19.2 mm for the bottom storey and 14.4 mm for the upper storeys respectively. The storey drift for all models are within the limit for all the frames. Comparing the storey drift for all models at the first storey, it is found that for three storey bare frame building there is increase in storey drift as compared to the concrete block infill wall building by 6.76 % by equivalent static method and 8.11 % for results obtained by response spectrum method. For six storey building variation for concrete block as infill wall is 26.1 % from the results obtained by equivalent static method and 28% from results obtained by response spectrum method as compared to the bare frame.

Table 12 : Equivalent static pushover analysis with user defined hinges

Performance point and location of hinges for bare frame								
Model	Base force (KN)	Displacement (mm)	A to B	B to IO	IO to LS	LS to CP	C P to E	Total
3	289.14	54.42	50	10	0	0	0	60
Ultimate	481.84	140.83	38	0	13	8	1	60
6	320.582	99.81	80	6	16	18	0	120
Ultimate	592.77	291.32	80	12	10	15	3	120

Table 13 : Equivalent static pushover analysis with user defined hinges

Performance point and location of hinges for frame with solid concrete block infill masonry								
Model	Base force (KN)	Displacemen t (mm)	A to B	B to IO	IO to L S	LS to C P	C P to E	Tota l
3	681.61	62.89	62	1 0	0	0	0	72
Ultimat e	832.79	119.32	58	6	1	4	3	72
6	926.92	59.22	14 0	1 0	0	0	0	150
Ultimat e	1203.1 3	121.72	12 9	1 3	4	2	2	150

For three storeyed building models, the base force is found more in concrete block infill frame building compared to bare frame building by 48.14 % and 56.12 % at the ultimate state for default hinges and user defined hinges for equivalent static pushover analysis. In three storeyed bare frame building model by equivalent static pushover analysis hinges are formed 63.33%, 0%, 21.66%, 13.33%, 1.66% between A to B, B to IO, IO to LS, LS to CP and CP to E respectively and most of the hinges are formed in the beams and columns of bottom storey at ultimate state. Similarly for concrete block infill wall 80.55%, 8.33%, 1.38%, 5.55 % and 4.16 % between A to B, B to IO, IO to LS, LS to CP and C to D respectively at ultimate state and most hinges are formed in the beams and columns of bottom storey at ultimate state.

For six storeyed building models, the base force is found more in concrete block infill frame building compared to bare frame building by 52.81 % and 50.73 % at the ultimate state for default hinges and user defined hinges for equivalent static pushover analysis. In six storeyed bare frame building model by equivalent static pushover analysis hinges are formed 71.66 %, 13.33%, 15%, 0%, 0% between A to B, B to IO, IO to LS, LS to CP and CP to E respectively and most of the hinges are formed in the beams and columns of bottom storey at ultimate state. Similarly for concrete block infill wall 86%, 8.66%, 2.66%, 1.33 % and 1.33 % between A to B, B to IO, IO to LS, LS to CP and C to D respectively at ultimate state and most hinges are formed in the beams and columns of bottom storey at ultimate state.

4. CONCLUSIONS

Based on the results obtained from different analysis for the building models, the following conclusion is drawn.

1. The fundamental natural periods are longer in bare frame buildings as compared to infill frame buildings.

2. Underestimation of design base shear in case of bare frame models as compared to the infill wall model, the design base shear increases with increases in mass and stiffness of infill wall and vice versa.

3. Storey drift is found within the 0.004 times the storey height for all the models. The drift at the first storey is found more as compared to the upper storeys this is due to the soft storey. Therefore neglecting the infill wall will lead to increase in the storey drift which will be vulnerable to earthquake load.

4. The base force at performance point is higher than the base shear obtained by equivalent static and response spectrum method.

5. Flexural hinges are found within the life safety range at the ultimate state and plastic hinge formation takes place in beams and columns of open ground storey of building model.

REFERENCES

[1] Agarwal, P. and Shrikhande, M. (2006), “Earthquake design of structures” , Prentice Hall of India Private Limited New Delhi India.

[2] Rathod, P. and Dyavanal, S.S. (2014), ” Seismic Evaluation of Multistorey RC Building with openings in Unreinforced Masonry Infill Walls with User Defined Hinges”, International Journal of Mechanical And Production Engineering, Vol. 2, pp.71-76.

[3] Mindaye, G. and Yajdani, S. (2016), “Seismic Analysis of a Multistorey RC

[4] Frame Building in Different Seismic Zones”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, pp.17210-17221.

[5] Federal Emergency Management Agency, FEMA-356 (2000), “Pre standard and commentary for seismic rehabilitation of buildings”. Washington (DC).

[6] IS 1893(Part 1):2002, Criteria for earthquake resistant design of structure, General Provision and Building.

[7] Murthy, C.V.R. (2002) “ What are magnitude and intensity”, Earthquake tip 03, IITK –BMTPC.

[8] Shekhappa, H. and Dyavanal, S.S. (2015), ”Nonlinear Static Analysis of G+6 RC Building with Infill walls and User defined hinges”, International Research Journal of Engineering and Technology , Vol.2, pp.2060-2065.

[9] Davis, R., Krishnan.P., Menon. D., and Meher Prasad, A. (2004), “Effect Of Infill Stiffness On Seismic Performance Of Multi-storey RC Framed Buildings In India”, 13th World Conference on Earthquake Engineering, couver, B.C., Canada, Paper No.1198.

[10] Mohibul Hasan, M., Chowdhury M., and Rafid, R. (2017), “Seismic analysis of infill reinforced concrete building frames”, American Journal of Engineering Research, Vol.6, pp.263-268.