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Comparative Study of Seismic Behavior of RCC Building Frames With and Without Masonry Infill Wall

Monika N[1], Chaitra D M[2], Kirankumar K L[3]

[1]M.Tech Structural Engineering, NCET Bangalore

[2]Assistant Professor, Dept of Civil Engineering, NCET Bangalore

[3]Structural Design Engineer, Chetana Engg. Services Pvt. Ltd, Bangalore

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Abstract - *In this study seismic analysis is carried out on 3D RC frames with and without masonry infill wall and also considering soft storey for G+15 storey. The masonry infill (MI) is represented by equivalent diagonal strut. The results such as, static base shear, displacement and inter storey drift are obtained from the analysis. All the results are discussed and concluded.*

***Key Words*: Base Shear, Inter Story Drift, Displacement…**

1. INTRODUCTION

Reinforced concrete (RC) frames consist of horizontal elements (beams) and vertical elements (columns) connected by rigid joints. RC frames provide resistance to both gravity and lateral loads through bending in beams and columns. Reinforced concrete frame buildings often incorporate masonry infill panels as partitions within a building or as cladding to complete the building envelope. However, the properties and construction details of MI frames can have a significant influence on the overall behaviour of a structure.

RC frames with masonry infills are common in developing countries with regions of high seismicity. Masonry Infills (MI), which generally have high stiffness and strength, play a crucial role in reinforced concrete (RC) frame buildings during earthquakes but these are normally considered as non-structural elements and their stiffness contributions are generally ignored in practice, such an approach can lead to an unsafe design. The MI though constructed as secondary elements behaves as a constituent part of the structural system and determines the overall behaviour of the structure especially when it is subjected to seismic loads.

2. OBJECTIVES

- To evaluate the response of bare frame and infilled frames subjected to seismic loads as per IS 1893-2002 codal provisions.
- To perform seismic analysis using equivalent static method and response spectrum method.
- To study the response of regular and irregular building frames with and without infill walls.
- To compare the equivalent strut width using Hendry and Mainstone method.
- To compare the results obtained by storey displacement , inter storey drift, base shear.

3. METHODOLOGY

- Model has done for building frames with and without infill walls using ETABS.
- The design of 3D RC frame by considering dead load, live load and earthquake load is carried out for 15 storey building models.
- Calculation of width of equivalent diagonal strut for masonry infill by using Mainstone and Hendry formulae.
- The equivalent static analysis is carried out to obtain static base shear, storey displacement, Inter storey drift.
- The results obtained are tabulated, discussed and conclusions are drawn.

4.DESCRIPTION ABOUT THE MODEL

Serial No.	Model name	Description
1	M1	Bare frame
3	M2	Frame with infill wall designed according to Mainstone.
3	M3	Frame with infill wall designed according to Hendry
4	M4	C shape bare frame
5	M5	C shape frame with infill wall designed according to Mainstone.
6	M6	C shape frame with infill wall designed according to Hendry
7	M7	T shape bare frame
8	M8	T shape Frame with infill wall designed according to Mainstone.
9	M9	T shape frame with infill wall designed according to Hendry
10	M10	Infill wall with soft storey designed according to Mainstone.
11	M11	Infill wall with soft storey designed according to Hendry

5. MODELLING

5.1 Following data is used in the analysis of the RC frame building models

Selection Of Building Parameters:

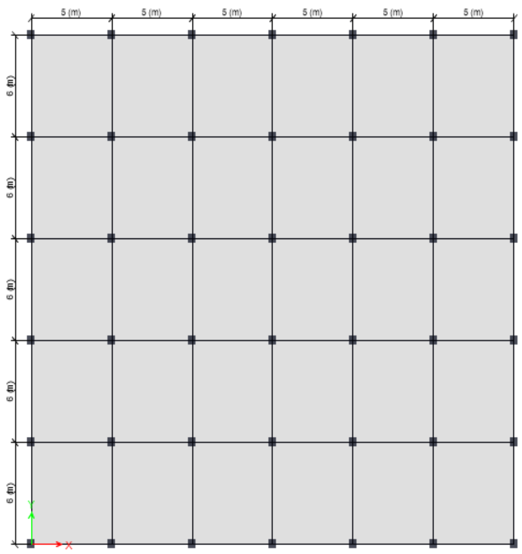
Number of stories	G+15
Storey height	Ground floor -4m Typical floor-3m
Column size	500mmx500mm
Beam size	230mmx450mm
Slab thickness	150mm
Wall thickness	230mm

Seismic details as per code IS 1893-2002:

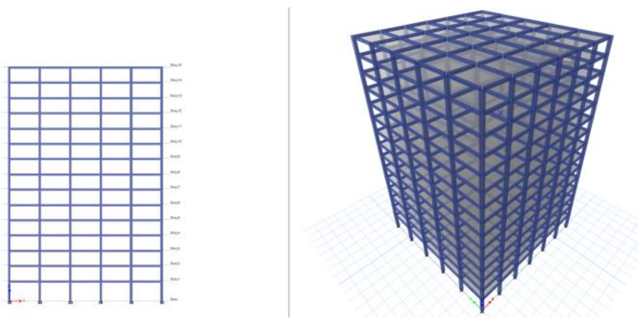
R (reduction factor) OMRF	3
I (importance factor)	1
Z (zone factor) III	0.16
Sa/g	Medium soil

Material properties :

Column	M25
Beam	M25
Slab	M25
Density of concrete	25kN/m^3
Density of masonry	21.2 kN/m^3



Plan



3D view of G+15 without infill wall

5.2 Modelling of infill wall

Equivalent Diagonal Strut Method is used for modelling the infill wall. In this method the infill wall is idealized as diagonal strut and the frame is modelled as beam or truss element. Frame analysis techniques are used for the elastic analysis. The idealization is based on the assumption that there is no bond between frame and infill. The width of the diagonal strut is given as

1. Width of Equivalent diagonal strut according to Mainstone

W = 0.16xd_{inf} x[λH]$^{-0.4}$

Where, **λ** is an empirical parameter expressing the relative stiffness of the column to the infill an is given by;

$$\lambda = \sqrt[4]{\frac{Em\ t\ \sin 2\theta}{4IcEch}}$$

2. Calculation of diagonal strut width according to Hendry,

$$W = \frac{1}{2}\sqrt{ah^2 + al^2}$$

Where,

$$ah = \frac{\pi}{2}\sqrt[4]{\frac{EfxIcxh}{2xEmxtxin2\theta}}$$

$$al = \pi\sqrt[4]{\frac{EfxIbxl}{2xEmxtxin2\theta}}$$

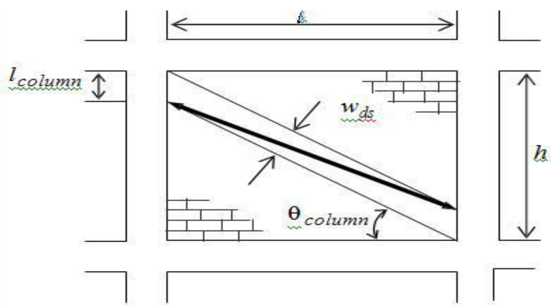
Where,

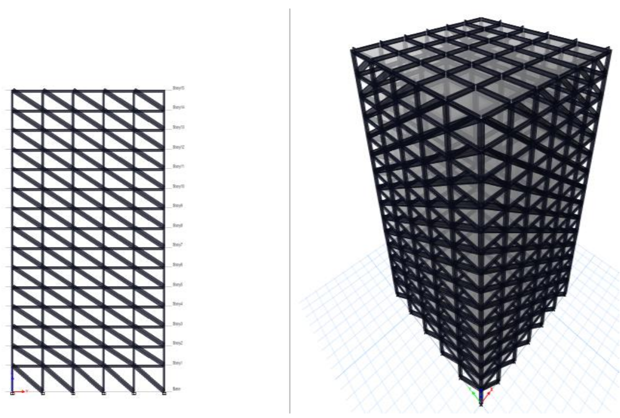
Em and Ef = Elastic modulus of the masonry wall and frame material (i.e., concrete), respectively

L, h, t = Length, height and thickness of the infill wall, respectively

Ic, Ib = Moment of inertia of column and the beam of structure, respectively

θ = tan-1(h / L) angle of inclination of diagonal strut.





3D view of G+15 with infill wall

6. RESULTS AND DISCUSSIONS

6.1 Base Shear

Base shear is maximum in case of infilled frame compared to bare frame. As observed from the results base shear is maximum in M3 model and minimum in M11 model. Base shear of M7 model has 60% less compared to M3 model, M8 model has 51% less , M4 and M9 models having 48% lesser base shear compare to M3 model, M5 has 42% less, M6 model has 38% less, M10 model has 3% less, M2 model has 2.5% less and M11model has 1% less respectively.

6.2 Displacement

The displacements are maximum at top stories. The displacement of bare frame is more compared to infilled frames. The displacement is maximum in M1 model and minimum in M6 model. The displacement of M6 model is 86% less compared to M1 model , M5 model is 83% less , M9 is 80% less , M8 is 75% less , M3 is 71% less, M11 is 68% less , M2 is 64% less , M10 is 58% less , M4 is 38% less and M7 is 11% less respectively.

6.3 Inter Storey Drift

Inter storey drift is maximum in case of bare frame compare to other models except soft storey conditions. In soft storey condition, the storey drift is maximum at the soft storey level itself. The inter storey drift maximum in M1 model at storey-4 and minimum in M6 and M9 models at storey-6. Inter storey drift of M6 and M9 models at storey-6 are having 88% lesser compared to M1 model at storey-4, M5 model at storey- 5 has 84% less , M8 at storey-6 has 77% less, M3 at storey-5 has 73% less, M2 at storey5 has 64% less, M11 at storey-1 has 44% less , M10 at storey-1 has 40% less , M4 at storey-5 has 38% less and M7 at storey-4 has 10% less storey drift compared to M1 at storey-4 respectively.

Table -1: Base shear

Model	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
Base shear (kN)	2755	3532	3626	1859	2079	2214	1564	1755	1850	3509	3616

Chart -1: Base Shear in kN

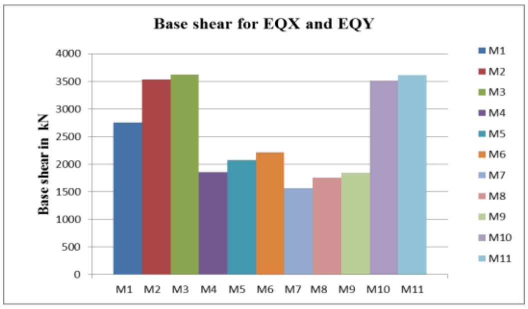


Table -2: Inter Storey Drift

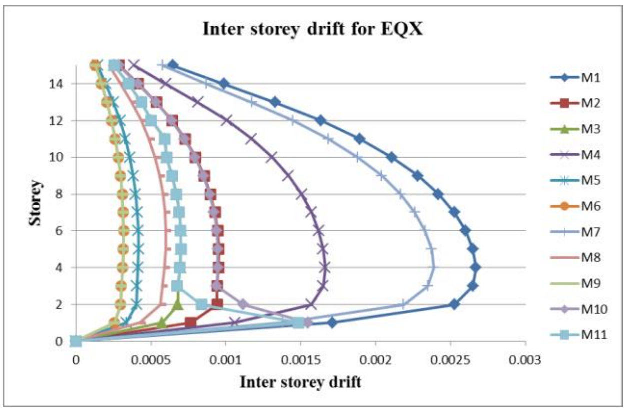
ST. No.	M1	M2	M3	M4	M5
15	0.00076	0.00029	0.00027	0.00053	0.00031
14	0.00115	0.00043	0.00038	0.00075	0.00039
13	0.00155	0.00055	0.00048	0.00098	0.00046
12	0.00191	0.00066	0.00056	0.00119	0.00053
11	0.00222	0.00075	0.00067	0.00137	0.00058
10	0.00248	0.00083	0.00068	0.00152	0.00062
9	0.00269	0.00089	0.00072	0.00163	0.00065
8	0.00285	0.00093	0.00076	0.00173	0.00068
7	0.00298	0.00096	0.00078	0.00179	0.00069
6	0.00307	0.00098	0.00079	0.00184	0.00069
5	0.00313	0.00099	0.0008	0.00186	0.00068
4	0.00315	0.00099	0.0008	0.00186	0.00067
3	0.00311	0.00098	0.00079	0.00183	0.00065
2	0.00292	0.00098	0.00078	0.00171	0.00063
1	0.00188	0.00076	0.00063	0.00111	0.00048
0	0	0	0	0	0

ST. No.	M6	M7	M8	M9	M10	M11
15	0.00028	0.00048	0.0002	0.00017	0.00029	0.00027
14	0.00034	0.00072	0.00027	0.00022	0.00042	0.00038
13	0.00039	0.00097	0.00033	0.00027	0.00055	0.00048
12	0.00044	0.00119	0.00039	0.00031	0.00066	0.00056
11	0.00048	0.00139	0.00043	0.00034	0.00075	0.00066
10	0.00051	0.00154	0.00047	0.00037	0.00082	0.00068
9	0.00053	0.00167	0.0005	0.00039	0.00088	0.00072
8	0.00055	0.00177	0.00052	0.0004	0.00093	0.00076
7	0.00056	0.00185	0.00053	0.00041	0.00096	0.00078
6	0.00056	0.0019	0.00054	0.00041	0.00098	0.00079
5	0.00055	0.00194	0.00054	0.00041	0.00099	0.0008
4	0.00053	0.00195	0.00054	0.0004	0.00099	0.0008
3	0.00051	0.00193	0.00053	0.00039	0.00098	0.00078
2	0.00049	0.00183	0.00052	0.00038	0.00118	0.00097
1	0.00038	0.00123	0.00042	0.00032	0.00161	0.00156
0	0	0	0	0	0	0

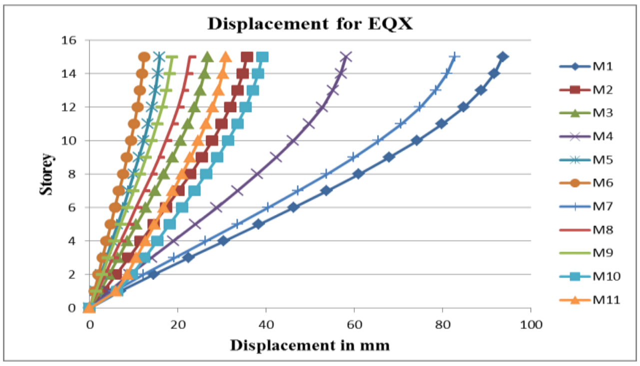
Table 2: Displacement in mm

ST. No.	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
15	93	35	26	58	16	12	82	22	18	39	31
14	91	34	26	56	15	11	80	22	18	38	30
13	88	33	25	55	14	11	78	21	17	36	29
12	84	31	23	52	14	10	74	20	16	35	27
11	79	29	22	49	13	10	70	18	15	33	26
10	74	27	20	46	12	9	65	17	14	31	24
9	67	25	18	42	11	8	59	15	12	29	22
8	60	22	16	37	10	7	53	14	11	26	20
7	53	20	14	33	9	6	47	12	10	23	18
6	46	17	12	28	7	5	40	10	8	20	16
5	38	14	10	23	6	4	33	8	7	18	14
4	30	11	8	18	5	3	26	6	5	15	12
3	22	8	6	13	3	3	19	5	4	12	10
2	14	5	4	8	2	2	12	3	3	9	8
1	6	3	2	4	1	1	5	2	1	6	6
0	0	0	0	0	0	0	0	0	0	0	0

Graph-1: Inter Storey Drift



Graph-2: Displacement



7. CONCLUSIONS

- The displacement of infilled frames are drastically reduced when compare to bare frames in both Hendry and Mainstone method due to its higher redundancy by the presence of diagonal strut and also in case of regular and irregular building models.
- The inter storey drift are reduced in infilled frame models as compare to bare frame models due to its higher stiffness by the presence of infills.
- The inter storey drift obtained at soft storey levels are high compare to other respective stories which shows inter storey drift is also one of the major parameter to check soft storey effect.
- The base shear obtained in masonry infill frame models are higher than bare frame models due to the presence of additional mass of infill in both Hendry and Mainstone method.

8. ACKNOWLEDGEMENT

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