COMPARATIVE STUDY OF EFFECT OF INFILL WALLS ON FIXED BASE AND BASE ISOLATED REINFORCED CONCRETE STRUCTURES

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Abstract*— In Structural analysis, masonry infills are commonly considered to be non-structural elements. However the response of reinforced concrete buildings to earthquake loads can be substantially be affected by the influence of infill walls. The increase in overall stiffness and strength is the positive effect of the presence of infill walls. Scope of work is to compare the seismic response of the reinforced concrete Fixed and Base isolated buildings and to compare the influence of the masonry infill walls in Fixed and Base isolated buildings. In this work, masonry infill walls are modeled using the equivalent diagonal strut concept in order to assess their involvement in seismic resistance of reinforced concrete buildings. The influence of the masonry on global response of RC frame is analyzed using dynamic linear analysis. As a base isolated system Lead Rubber bearing isolator is used. The parametric study is carried out for G+5 and G+7 storey buildings. The Response spectrum analysis is carried out using ETABS® software.At the end building response parameters are compared.

***Index Terms*— Infill walls, Seismic performance, RC buildings, Diagonal strut, Base Isolation**

I. INTRODUCTION

A large proportion of the world's population lives in regions of seismic hazard, at risk from earthquakes of varying severity and varying frequency of occurrence. Since earthquakes are unpredictable they not only cause great destruction in terms of human casualties but also have a tremendous post-occurrence impact on affected areas. Various seismic construction designs and technologies have been developed to reduce the effect of earthquakes on structure. Base isolation is a technology of this kind.

Reinforced concrete frames infilled with masonry panels are very common construction in many countries situated in seismic regions. Usually classified as non-structural elements, the influence of their strength and stiffness are neglected. However, unlike most non-structural components, masonry infills can develop strong interaction with the bounding frames under seismic loads and therefore this approach can lead to substantial inaccuracy in predicting the actual seismic response of framed structures in terms of lateral stiffness, strength and ductility. The presence of infill can guarantee higher stiffness and strength, reducing the inter storey drift demand while increasing the maximum floor accelerations. A further positive influence of the infills can be recognized in the reduction of column inter storey shear contribution as well as in the possible delay of a soft storey mechanism which might instead develop in a bare frame structure.

The concern of this paper is to investigate the seismic behaviour of infilled frame structures in fixed base and base isolated buildings. In this study, fixed base and base isolated RC buildings with bare frame and infill panels with equal bay-size dimensions but different number of storeys were studied in order to evaluate the effect of infills' presence in their structural response when subjected to seismic actions.

II. EQUIVALENT STRUT MODEL FOR INFILLED FRAMES

According to FEMA 273 it is suggested that the stiffness of the infills is represented in the structural model by equivalent diagonal struts based on the work of Mainstone. The equivalent strut shall have the same thickness and elasticity as the infill panel. The equivalent strut width **a** is given by the following equation,

$$\boldsymbol{a} = \mathbf{0.175}(\boldsymbol{\lambda_1 hcol})^{-\mathbf{0.4}}\ \boldsymbol{rinf}$$

Where,

$$\lambda_1 = \frac{E_{me} t_{inf} \sin 2\theta}{4 E_{fe} I_{col} h_{inf}}$$

And,

hcol = Column height between centerlines of beams, in.,
hinf = Height of infill panel, in.,
Efe = Expected modulus of elasticity of frame material, psi.,
Eme = Expected modulus of elasticity of infill material, psi.,
Icol = Moment of inertia of column, in.4,
Linf = Length of infill panel, in.,
rinf = Diagonal length of infill panel, in.,
tinf = Thickness of infill panel and equivalent strut, in.,
θ = Angle whose tangent is the infill height-to-length Aspect ratio, radians,
$\lambda 1$ = Coefficient used to determine equivalent width of infill strut

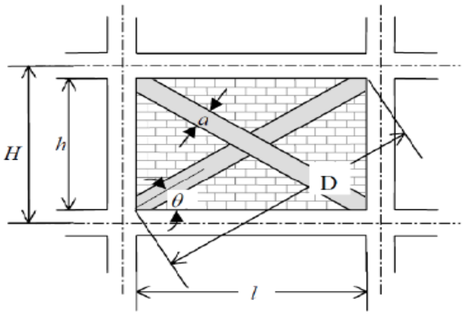


Figure 1. *Scheme of the infilled frame showing the equivalent strut model*

III. PRESENTATION OF THE CASE STUDY

Reinforced concrete buildings consisting of a regular framed structure having G+5 and G+7 storey and four bays are considered. The inter-storey height is 3 m and the bay length is 5 m. Both fixed and base isolated buildings are considered for the analysis. The design of the base isolation system (LRB) is done in accordance with IS 1893-2002.

Response spectrum analysis is carried out in accordance with IS 1893-2002. In RSA single direction bracing has to provided for the modeling of the infill walls. If we provide X type diagonal strut in RSA then the tension limit as 0 has to applied to the bracings as it is a compression strut. For that non-linear analysis is required but RSA does not support non-linear analysis. So single direction bracing should be modeled.

Building Data:

- Grade of concrete = M25
- Thickness of slab = 0.2 m
- Storey height = 3 m
- Live load = 3 kN/m^2
- Dead load = 1 kN/m^2
- Masonry wall load= 13.8 kN/m

Table 1. Geometrical data of buildings

No. of Storey	Beam Dimensions (mxm)	Column Dimensions (mxm)	Height of building(H_b) (m)	Plan area of building (m^2)	No. of bays in both the directions	Bay width Dimensions (m)
G+5	0.3x0.45	0.45x0.45	15	20x20	4	5
G+7	0.3x0.45	0.45x0.45	21	20x20	4	5

Earthquake loads are calculated as per IS 1893-2002. The building is located on hard soil and seismic zone V. Response reduction factor is taken as 5 for fixed base buildings and 1 for base isolated buildings. 3D and elevation view of the buildings are shown in following figures.

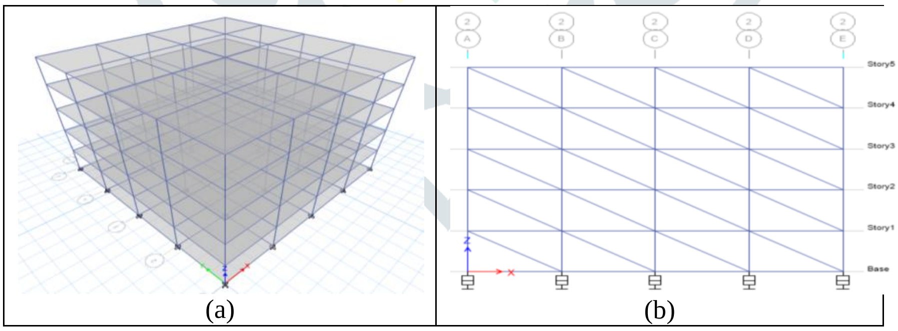


Figure 2. (a) Bare frame RC building (b) With Infill walls RC building for G+5

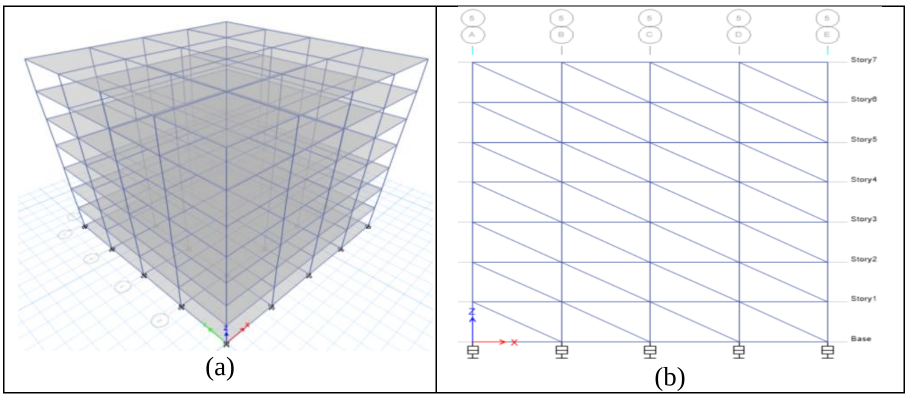


Figure 3. (a) Bare frame RC building (b) With Infills walls RC building for G+7

The bearing system is designed as per IS 1893-2002. For structural modeling of isolator in software, each bearing is modeled as an equivalent fixed ended link element connected between superstructure and substructure. The link element is assigned properties that match calculated properties of isolator. In ETABS®, various types of link elements are available such as multi-linear elastic and plastic, plastic wen, rubber isolator, friction pendulum isolator etc. The lead rubber bearing isolator is modeled using link "rubber isolator".

The three deformational directions U1, U2, U3 are with respect to Z, X, Y respectively. The deformation in z direction should be fixed. The isolator properties will be given in X or Y or in both direction. For linear analysis only effective stiffness and damping are given while for nonlinear analysis along with stiffness, yielding parameters i.e. yield force and post yield stiffness ratio are given as input. Modeling values to be added in ETABS® software as a link element for G+5 and G+7 are given in the following tables.

Table 2.Analysis Properties for ETABS® for G+5

Sr. No.	Isolator Property	U1 Direction	U2 & U3 Direction	Unit
1	Vertical Stiffness K_v	307599.41	--	kN/m
2	Effective Stiffness K_{eff}	--	1716.42	kN/m
3	Effective Damping	0	5191.04	kN-s/m
4	Initial Stiffness K_u	--	9649.41	kN/m
5	Yield Strength	--	33.331	kN
6	Post Yield Stiffness Ratio	--	0.12191	--

Table 3. Analysis Properties for ETABS® for G+7

Sr. No.	Isolator Property	U1 Direction	U2 & U3 Direction	Unit
1	Vertical Stiffness K_v	456608.1	--	kN/m
2	Effective Stiffness K_{eff}	--	1106.47	kN/m
3	Effective Damping	0	2776.88	kN-s/m
4	Initial Stiffness K_u	--	6560.31	kN/m
5	Yield Strength	--	20.11	Kn
6	Post Yield Stiffness Ratio	--	0.139001	--

IV. RESULT AND DISCUSSION

The infill section is considered to be uniform over all the infilled stories of the building for G+ 5 & G+7. Fig.2 gives the different configuration of infills that is considered. These include bare frame (a) and complete infilled buildings (b). The seismic parameters were calculated by analyzing the software using ETABS® software. The parameters were compared for base isolated and fixed base structure for with and without infill wall buildings.

(A) Results For G+5 storey Building

Table 5. Displacement values for G+5 Building

No. of Storey	Bare frame		With Infill(RSA)	
G+5	Fixed Base	Isolated Base	Fixed Base	Isolated Base
5F	12.468 mm	34.195 mm	0.124 mm	26.926 mm
4F	11.072 mm	33.374 mm	0.098 mm	26.836 mm
3F	8.782 mm	31.926 mm	0.071 mm	26.745 mm
2F	5.735 mm	29.775 mm	0.046 mm	26.656 mm
1F	2.297 mm	26.961 mm	0.022 mm	26.569 mm
GF	0 mm	24.033 mm	0 mm	26.496 mm

Table 6. Storey Drift Values for G+5 Building

No. of Storey	Bare frame		With Infill(RSA)	
G+5	Fixed Base	Isolated Base	Fixed Base	Isolated Base
5F	0.00055	0.000294	0.000009	0.00003
4F	0.00083	0.000514	0.000009	0.00003
3F	0.00105	0.000752	0.000009	0.00003
2F	0.00115	0.000966	0.000008	0.000029
1F	0.000766	0.000991	0.000007	0.000028
GF	0	0	0	0

Table 7. Storey Shear Values for G+5 Building

No. of Storey	Bare frame		With Infill(RSA)	
G+5	Fixed Base	Isolated Base	Fixed Base	Isolated Base
5F	378.08 kN	153.55 kN	438.52 kN	186.62 kN
4F	587.66 kN	313.17 kN	776.91 kN	378.33 kN
3F	729.20 kN	476.83 kN	1016.88 kN	569.53 kN
2F	858.72 kN	648.07 kN	1178.36 kN	760.26 kN
1F	954.64 kN	832.19 kN	1265.19 kN	950.58 kN
GF	0 kN	0 kN	0 kN	0 kN

(B) Results for G+7 storey Building

Table 8. Displacement Values for G+7 Building

No. of Storey	Bare frame		With Infill(RSA)	
G+7	Fixed Base	Isolated Base	Fixed Base	Isolated Base
7F	17.66 mm	54.97 mm	0.458 mm	44.49 mm
6F	16.567 mm	54.27 mm	0.372 mm	44.37 mm
5F	14.782 mm	53.07 mm	0.288 mm	44.26 mm
4F	12.377 mm	51.32 mm	0.21 mm	44.15 mm
3F	9.421 mm	48.99 mm	0.142 mm	44.04 mm
2F	5.983 mm	46.08 mm	0.084 mm	43.94 mm
1F	2.352 mm	42.64 mm	0.037 mm	43.84 mm
GF	0 mm	39.29 mm	0 mm	43.77 mm

Table 9. Storey Drift Values for G+7 Building

No. of Storey	Bare frame		With Infill(RSA)	
G+7	Fixed Base	Isolated Base	Fixed Base	Isolated Base
7F	0.000485	0.000247	0.000029	0.000038
6F	0.000737	0.000422	0.000028	0.000037
5F	0.000919	0.000614	0.000026	0.000037
4F	0.001057	0.000811	0.000023	0.000036
3F	0.001176	0.001007	0.00002	0.000035
2F	0.001215	0.00117	0.000016	0.000033
1F	0.000784	0.001137	0.000012	0.000031
GF	0	0	0	0

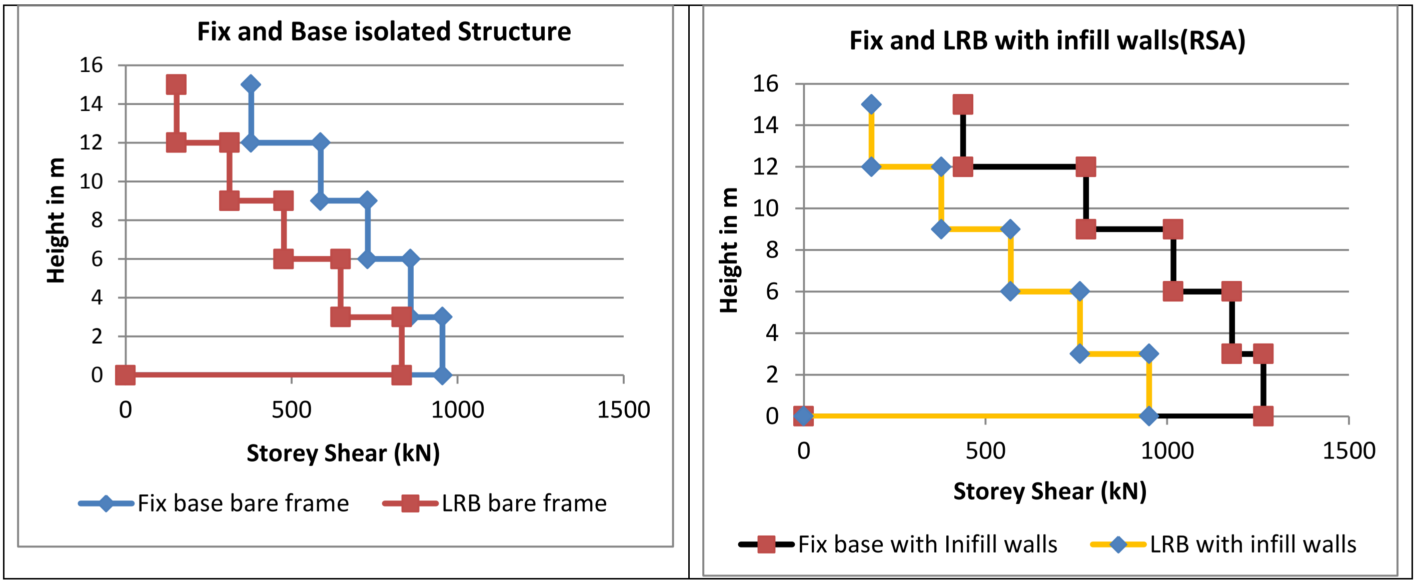
Table 10. Storey Shear Values for G+7 Building

No. of Storey	Bare frame		With Infill(RSA)	
G+7	Fixed Base	Isolated Base	Fixed Base	Isolated Base
7F	320.075 kN	121.52 kN	598.8 kN	149.08 kN
6F	506.78 kN	247.50 kN	1077.38 kN	302.17 kN
5F	622.61 kN	375.62 kN	1434.25 kN	454.8 kN
4F	708.23 kN	506.9 kN	1690.03 kN	607.07 kN
3F	796.18 kN	642.32 kN	1866.75 kN	759.03 kN
2F	889.17 kN	782.51 kN	1979.72 kN	910.75 kN
1F	960.40 kN	930.20 kN	2035.29 kN	1062.28 kN
GF	0 kN	0 kN	0 kN	0 kN

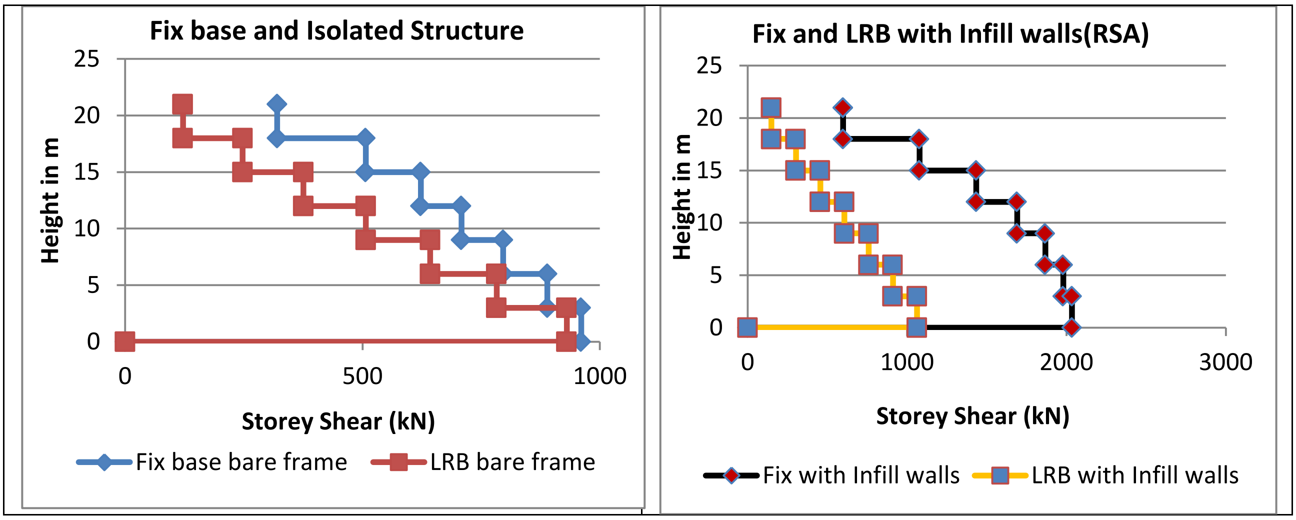
(C) Comparison of results

(1) **Storey Shear comparison**

For G+5

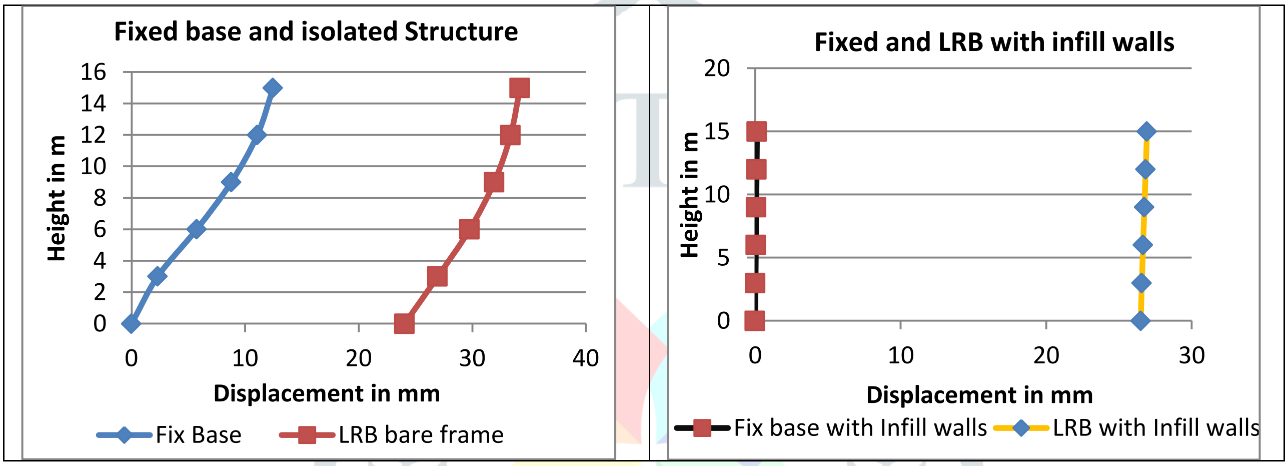


For G+7

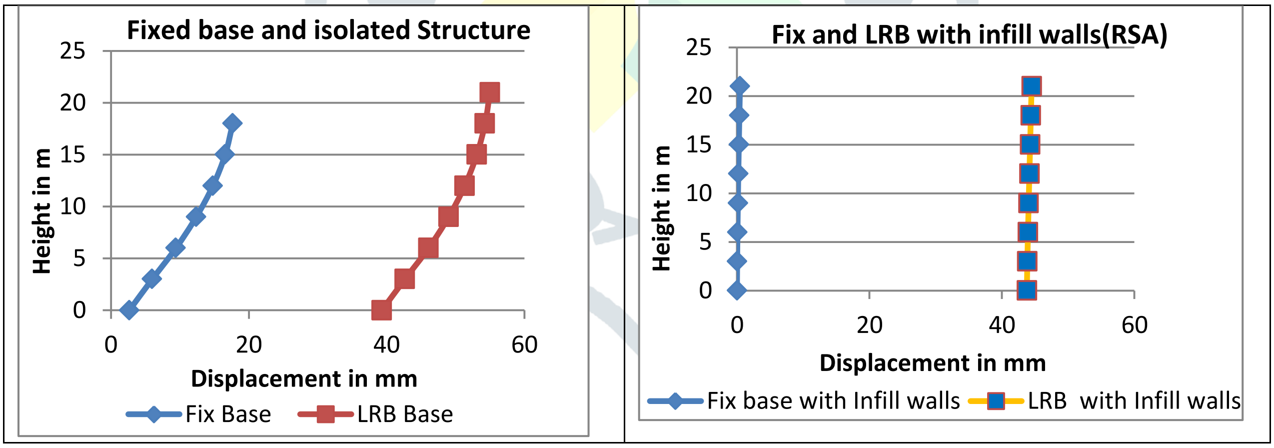


(2) Displacement comparison

For G+5

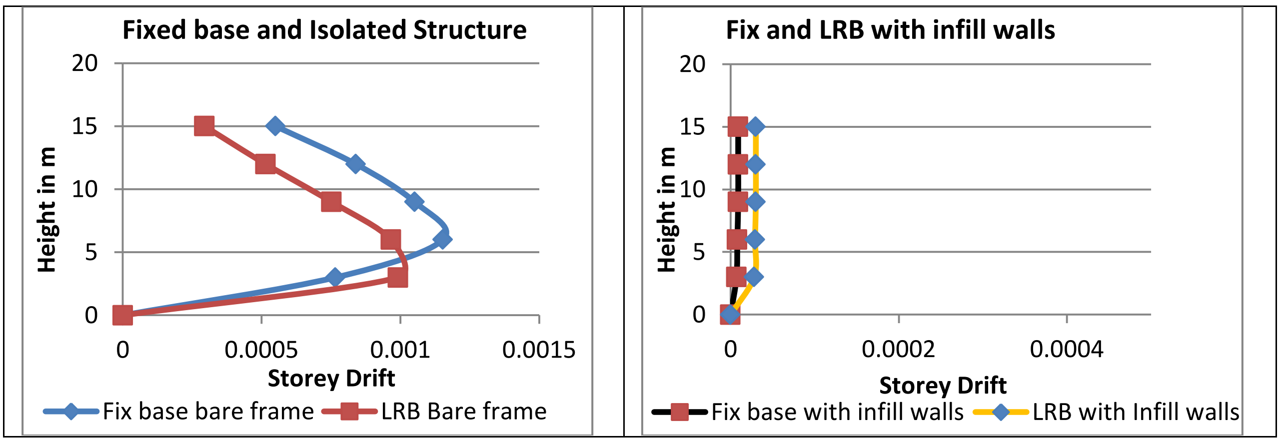


For G+7

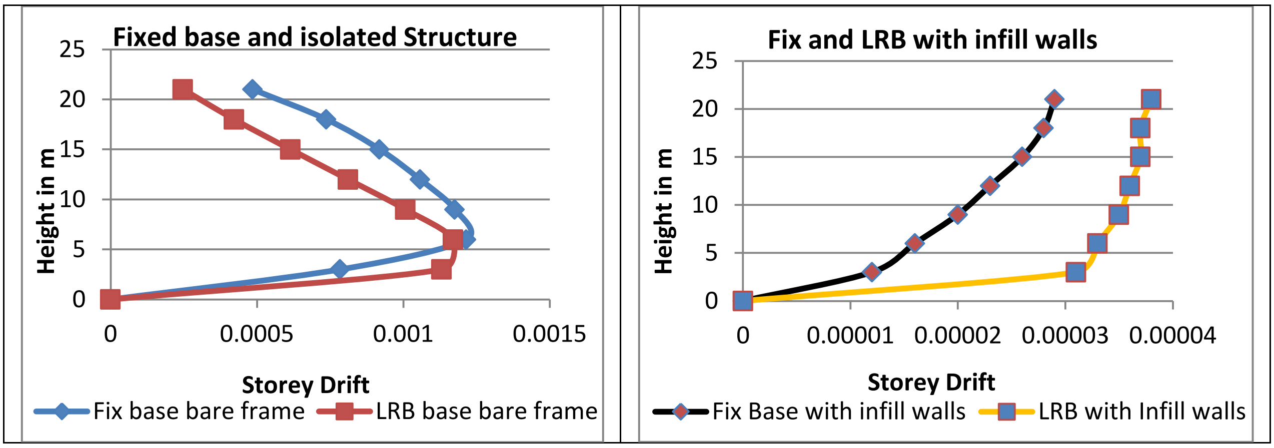


(3) Storey Drift Comparison

For G+5



For G+7



V. CONCLUSION

The effect of infills on seismic performance of fixed base structure and base isolated structure was analyzed. The results were obtained using the concept of equivalent diagonal strut method with which we can model the infill mechanical behavior.

Analytically it can be shown that with the inclusion of the infill walls in fixed base and isolated base, the maximum displacement value is reduced and is almost constant which shows that the structure shows a stiff behavior. However, storey drift values increases but the difference is not much higher. Also, the storey shear value reduces significantly in LRB base structure as compared to fixed base structure with the inclusion of infill walls.

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