e-ISSN: 2455-5703

Seismic Behaviour of R.C Frame Building with and Without Masonry Infill Walls

[1]Nikunj Mangukiya [2]Arpit Ravani [3]Yash Miyani [4]Mehul Bhavsar
[1,2,3]U. G Student [4]Assistant Professor
[1,2,3,4]Department of Civil Engineering
[1,2,3,4]Shree Swami Atmanand Saraswati Institute of Technology, Surat, Gujarat, India

Abstract

Reinforced concrete frame structure is very common in present times due to its ease in construction. Frame consists of vertical and horizontal elements. Vertical elements columns and horizontal elements are beams and slabs. These are the structural elements. These are designed to take the load and transfer it. Load taken by these elements are in the form of dead load, live load and lateral load. Other than these structural elements there are also non-structural elements like masonry walls also called infill walls. Infill walls are mostly used for the purpose of partitioning and to cover/separate the outer periphery of the frames/buildings. Design of R.C. frame with infill walls is practiced as 1) Infill walls are separated from frame 2) Infill walls are built integrally but considered as non-structural elements 3) Infill walls are built integrally and considered as structural element. This study is based on analysis of R.C. buildings with masonry infill walls which incorporates geometric nonlinearity in the analysis. The study will be performed on structural software ETABS.
Keyword- Geometric Nonlinearity, Infill Walls, Non-Structural Elements, R.C. Frame

I. INTRODUCTION

A. General

Masonry infills 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 structural effect of brick infill is generally not considered in the design of columns as well as other structural components of RC frame structures. The brick walls have significant in-plane stiffness contributing to the stiffness of the frame against lateral load. The lateral deflection is reduced significantly in the infilled frame compared to frame without infill. This leads to different steel requirements for frame structures considering infill. In order to understand the behaviour of frames and steel requirements of column having brick masonry infill and without infill a finite element investigation is performed by modelling a 8-storied three-dimensional building frame. Construction of multistorey buildings with open ground floor is a common trend of urbanization of cities of many parts of many countries. Social and functional need to provide parking space at ground level outweighs the seismic vulnerability of such buildings. Generally, these buildings are designed as RC framed structures without regards to structural action of masonry infill walls present in the upper floors. In the present paper an investigation has been made to study the behaviour of RC frames with various arrangement of infill wall when subjected to dynamic earthquake loading.

II. METHODOLOGY

A. Modelling of Equivalent Strut

For the accurate study of various parameters, we have considered 8 storied R.C. frame commercial building. In case of an infill wall located in a lateral load resisting frame the stiffness and strength contribution of the infill are considered by modelling the infill as an equivalent compression strut. Because of its simplicity, several investigators have recommended the equivalent strut concept. In the present analysis, a trussed frame model is considered. This type of model does not neglect the bending moment in beams and columns. Rigid joints connect the beams and columns, and pin joints at the beam-to-column junctions connect the equivalent struts.

Infill parameters (effective width, elastic modulus and strength) are calculated using the method recommended by Smith Main stone and Liaw & Kwan. The length of the strut is given by the diagonal distance "d" of the panel and its thickness is given by the thickness of the infill wall. The estimation of width "w" of the strut is calculated as below:

$Ws = 0.16 d_m (\lambda)^{-0.3}$ (Mainstone)

$Ws = \frac{0.95 H \cos\theta}{(H\lambda)^{0.5}}$ (Liaw and Kwan)

Where;

Contact coefficient (λ) = $\frac{\sqrt[4]{E_m t \sin 2\theta}}{4 E_C I_C H}$

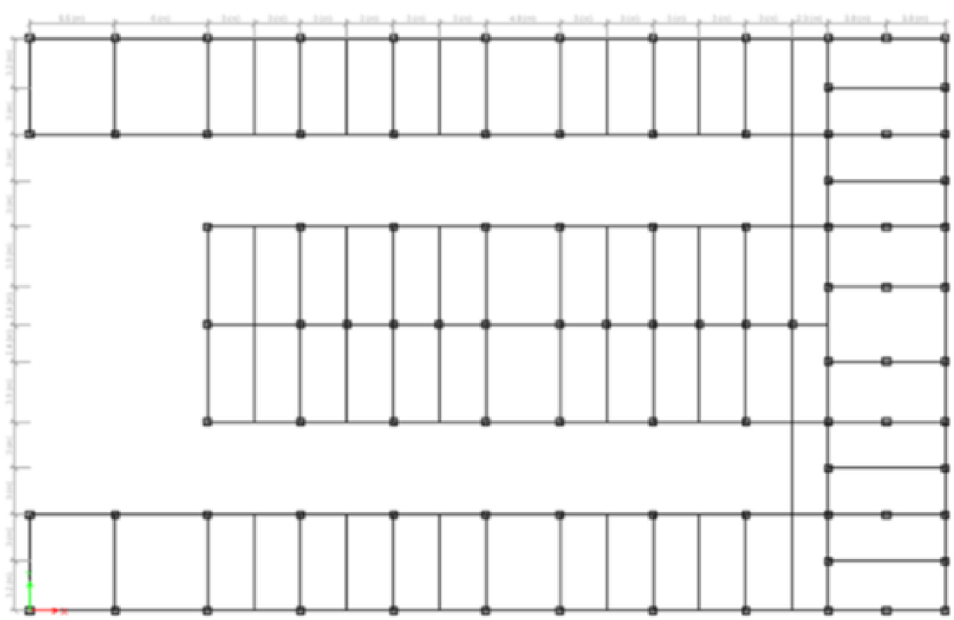
E_m = Modulus of elasticity of masonry
E_c = Modulus of elasticity of concrete
T = thickness of masonry wall
d_m = diagonal length of masonry wall
H = height of masonry wall
For comprehensive study of R.C. frame building with and without infill wall and its parameters, ETABS software is adopted for study.

III. DEFINITION OF PROBLEM

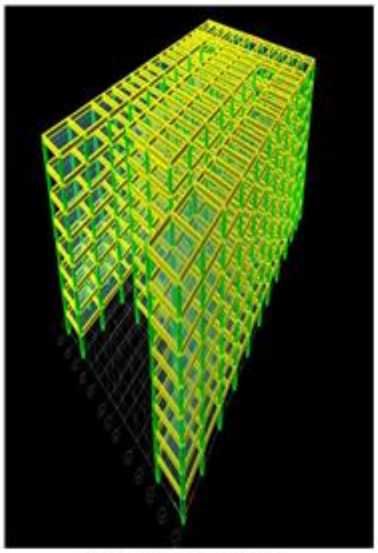
A. Details of The Problem Frame

SR .NO	*DESCRIPTION*	*VALUE*
1	*Type of building*	*Commercial*
2	*Location of building*	*Surat*
3	*Type of soil*	*Medium soil-II*
4	*No of story*	*8*
5	*Storey Height*	*3 m*
6	*Grade of concrete*	*M20*
7	*Grade of steel*	*Fe415*
8	*Size of Beam*	*230mm x 650mm*
9	*Size of column*	*650mm x 650mm*
10	*Thickness of slab*	*125mm*

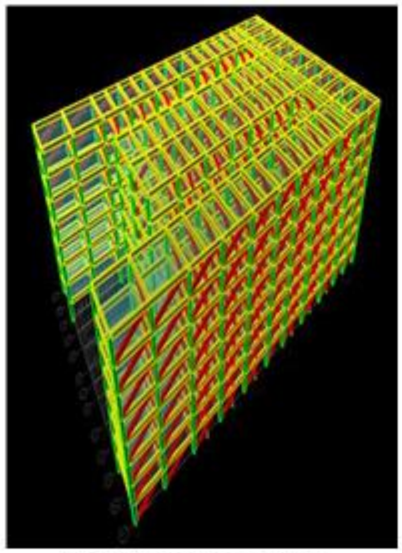
B. Plan for Proposed Building



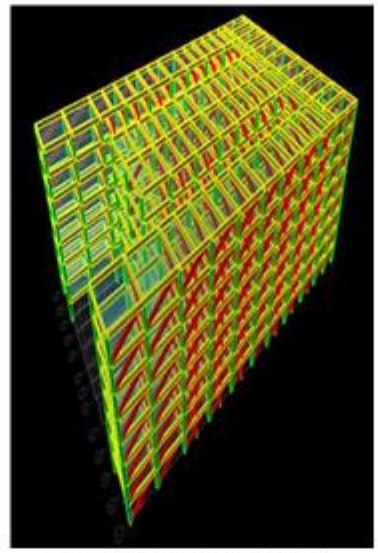
The whole study is divided into two phases. In first phase, following cases are considered for the analysis: 1) Bare frames, 2) Infill frame without soft story and 3) Infill frame with soft story. The isometric views of all cases are shown below:



BARE FRAME



INFILLED FRAME



INFILLED FRAME WITH SOFT STORY

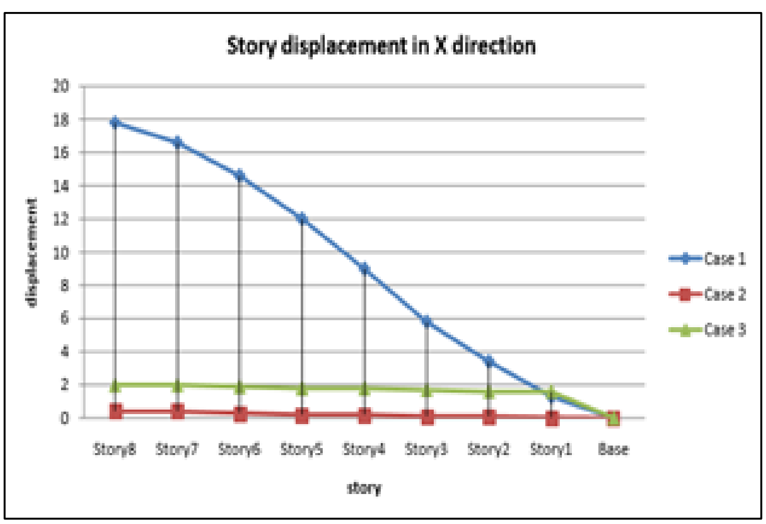
Parameters like story displacement, story shear, story stiffness, and time period are compared.

IV. RESULTS

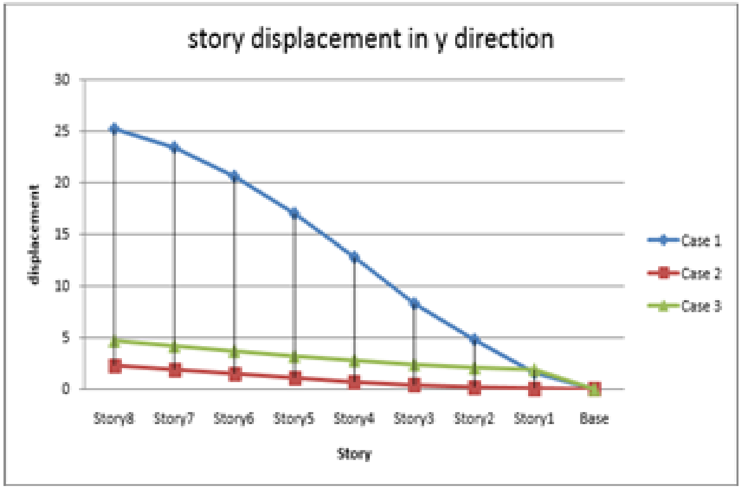
A. Story Displacement

Comparison of story drift for different cases for worst load case gave the following data.

STORY DISPLACEMENT IN X-DIRECTION			
Story	*CASE :1*	*CASE :2*	*CASE :3*
Story8	*17.8*	*0.4*	*2*
Story7	*16.6*	*0.4*	*2*
Story6	*14.6*	*0.3*	*1.9*
Story5	*12.0*	*0.2*	*1.8*
Story4	*9.00*	*0.2*	*1.8*
Story3	*5.8*	*0.1*	*1.7*
Story2	*3.4*	*0.1*	*1.6*
Story1	*1.3*	*0.03*	*1.6*
Base	*0*	*0*	*0*



STORY DISPLACEMENT IN Y-DIRECTION			
Story	*CASE :1*	*CASE :2*	*CASE :3*
Story8	*25.2*	*2.3*	*4.7*
Story7	*23.4*	*1.9*	*4.2*
Story6	*20.6*	*1.5*	*3.7*
Story5	*17.0*	*1.1*	*3.2*
Story4	*12.8*	*0.7*	*2.8*
Story3	*8.3*	*0.4*	*2.4*
Story2	*4.8*	*0.2*	*2.1*
Story1	*1.6*	*0.1*	*1.9*
Base	*0*	*0*	*0*



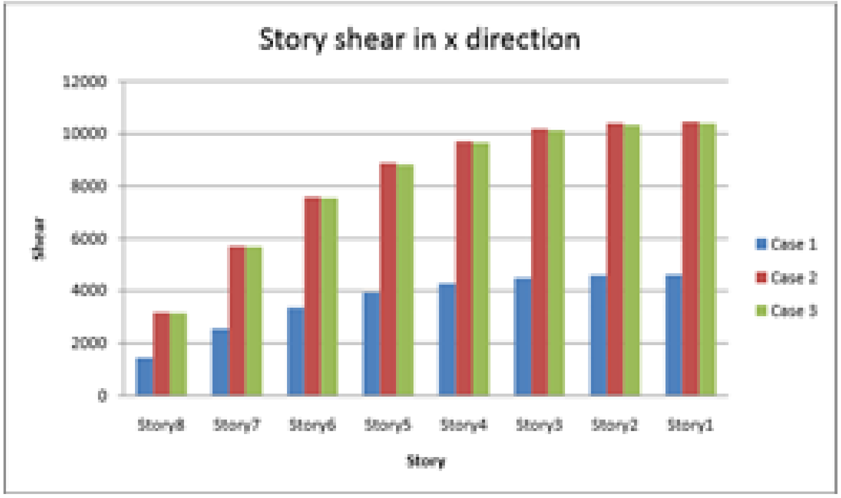
B. Story Shear

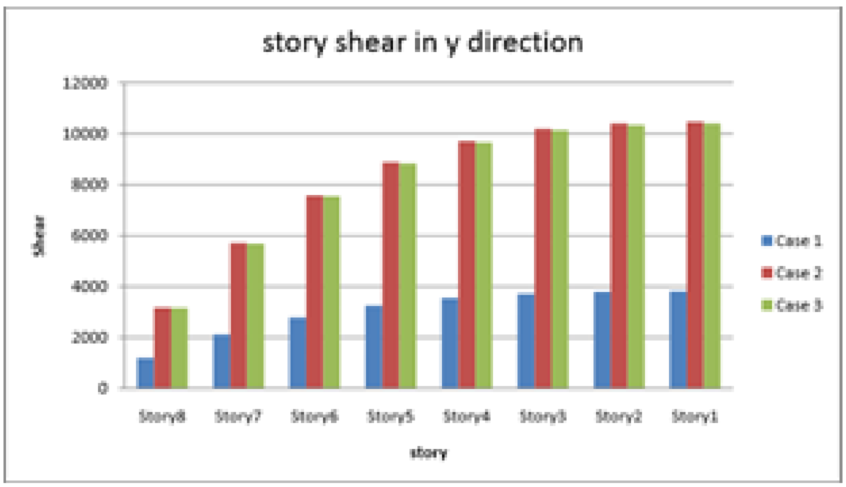
Comparison of story shear for different cases for worst load case gave following data.

STORY SHEAR IN X-DIRECTION			
Story	*CASE :1*	*CASE :2*	*CASE :3*
Story8	*1445.561*	*3170.462*	*3153.158*
Story7	*2551.567*	*5712.944*	*5681.763*
Story6	*3364.142*	*7580.890*	*7539.514*
Story5	*3928.430*	*8878.074*	*8829.619*
Story4	*4289.575*	*9708.272*	*9655.286*
Story3	*4497.683*	*10185.63*	*10130.07*
Story2	*4592.731*	*10403.12*	*10346.34*
Story1	*4616.493*	*10457.49*	*10398.05*

STORY SHEAR IN Y-DIRECTION			
Story	*CASE :1*	*CASE :2*	*CASE :3*
Story8	*1995.661*	*3170.462*	*3153.158*
Story7	*2110.468*	*5712.944*	*5681.763*
Story6	*2780.569*	*7580.890*	*7539.514*
Story5	*3249.306*	*8878.074*	*8829.619*
Story4	*3548.018*	*9708.272*	*9655.286*

Story3	3720.150	10185.63	10130.07
Story2	3798.768	10403.12	10346.34
Story1	3818.420	10457.49	10398.05

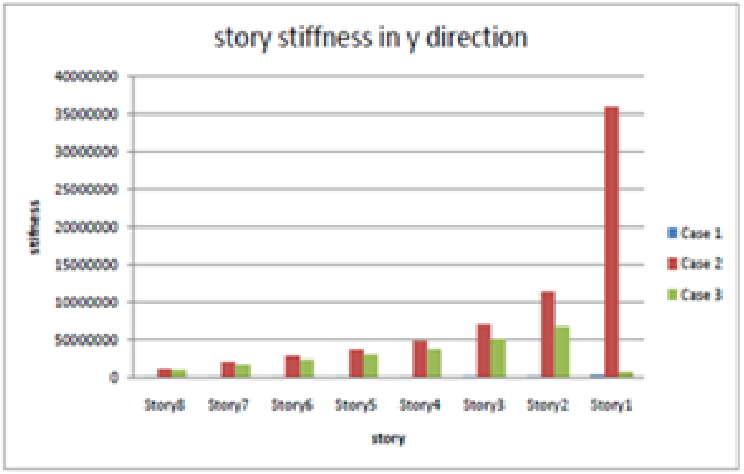




C. Story Stiffness

STORY STIFFNESS IN X-DIRECTION			
Story	CASE :1	CASE :2	CASE :3
Story8	1233271.65	62315681	55336063
Story7	1390568.16	113168029	101888547
Story6	1297479.07	150868732	135191183
Story5	1301281.83	180492650	160653617
Story4	1316929.94	208296482	180718700
Story3	1934530.79	308632154	259952366
Story2	2123586.79	377304919	215839628
Story1	4174105.27	514629328	6543368

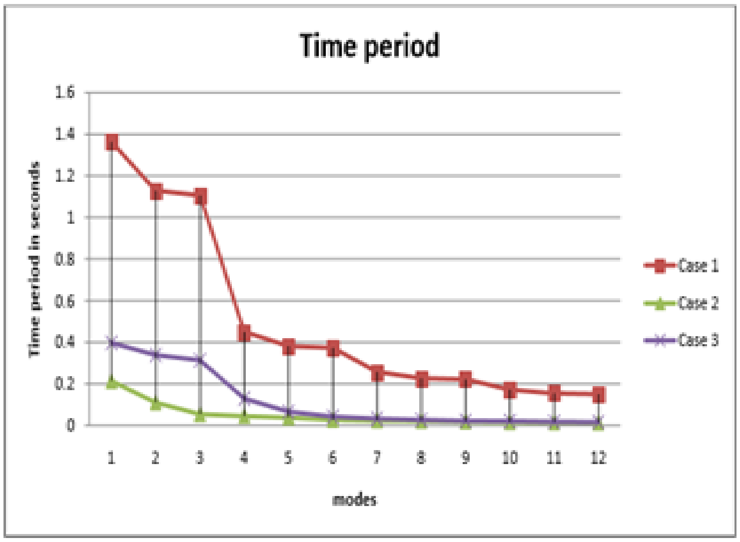
STORY STIFFNESS IN Y-DIRECTION			
Story	*CASE :1*	*CASE :2*	*CASE :3*
Story8	*807086.324*	*10761153*	*9019507*
Story7	*896169.642*	*20256457*	*1831570*
Story6	*914402.745*	*28391725*	*2335886*
Story5	*925387.216*	*36663187*	*29661213*
Story4	*953740.171*	*47727758*	*37234107*
Story3	*1302469.47*	*69970218*	*50348291*
Story2	*1495862.52*	*113625152*	*67501686*
Story1	*2498807.40*	*360181146*	*6021669*



D. Time Period

TIME PERIOD			
MODE	*CASE :1*	*CASE :2*	*CASE :3*
1	*1.363*	*0.213*	*0.397*
2	*1.128*	*0.110*	*0.339*
3	*1.105*	*0.053*	*0.313*
4	*0.450*	*0.044*	*0.128*

5	0.381	0.037	0.065
6	0.373	0.026	0.041
7	0.257	0.023	0.032
8	0.226	0.021	0.026
9	0.221	0.018	0.021
10	0.171	0.015	0.020



In the second phase two different equations for designing the strut are used. Case 2 and Case 3 as described earlier are analyzed and different parameters like story displacement, story shear, time period are compared.

E. Story Displacement

STORY DISPLACEMENT IN X-DIRECTION				
Story	CASE 2 (Mainstone)	CASE 3 (Mainstone)	CASE 2 (liaw and kwan)	Case 3 (liaw and kwan)
Story8	0.4	2	0.4	2.1
Story7	0.4	2	0.4	2.1
Story6	0.3	1.9	0.3	2
Story5	0.2	1.8	0.2	2
Story4	0.2	1.8	0.2	1.8
Story3	0.1	1.7	0.1	1.8
Story2	0.1	1.6	0.1	1.7
Story1	0.03	1.6	0.026	1.7
Base	0	0	0	0
STORY DISPLACEMENT IN Y-DIRECTION				
Story	CASE 2 (Mainstone)	CASE 3 (Mainstone)	CASE 2 (liaw and kwan)	Case 3 (liaw and kwan)
Story8	2.3	4.7	2.5	4.9
Story7	1.9	4.2	2	4.4
Story6	1.5	3.7	1.7	3.9
Story5	1.1	3.2	1.6	3.4
Story4	0.7	2.8	1	3
Story3	0.4	2.4	0.8	2.6
Story2	0.2	2.1	0.4	2.3
Story1	0.1	1.9	0.3	2
Base	0	0	0	0

F. Story Shear

STORY SHEAR IN X-DIRECTION				
Story	*CASE 2 (Mainstone)*	*CASE 3 (Mainstone)*	*CASE 2 (liaw and kwan)*	*Case 3 (liaw and kwan)*
Story8	*3170.46*	*3153.16*	*3257.72*	*3239.43*
Story7	*5712.94*	*5681.76*	*5963.55*	*5930.07*
Story6	*7580.89*	*7539.51*	*7951.5*	*7906.86*
Story5	*8878.07*	*8829.62*	*9332.03*	*9279.64*
Story4	*9708.27*	*9655.29*	*10215.6*	*10158.2*
Story3	*10185.6*	*10130*	*10723*	*10662.8*
Story2	*10403.1*	*10346.3*	*10953.9*	*10892.4*
Story1	*10457.5*	*10398.1*	*11011.6*	*10947.2*
STORY SHEAR IN Y-DIRECTION				
Story	*CASE 2 (Mainstone)*	*CASE 3 (Mainstone)*	*CASE 2 (liaw and kwan)*	*Case 3 (liaw and kwan)*
Story8	*3170.46*	*3153.16*	*3257.72*	*3239.43*
Story7	*5712.94*	*5681.76*	*5963.55*	*5930.07*
Story6	*7580.89*	*7539.51*	*7951.5*	*7906.86*
Story5	*8878.07*	*8829.62*	*9332.03*	*9279.64*
Story4	*9708.27*	*9655.29*	*10215.6*	*1015802*
Story3	*10185.6*	*10130*	*10723*	*10662.8*
Story2	*10403.1*	*10346.3*	*10953.9*	*10892.4*
Story1	*10457.5*	*10398.1*	*11011.6*	*10947.2*

G. Time Period

STORY DISPLACEMENT IN X-DIRECTION				
MODE	*CASE 2 (Mainstone)*	*CASE 3 (Mainstone)*	*CASE 2 (liaw and kwan)*	*Case 3 (liaw and kwan)*
1	*0.213*	*0.397*	*0.216*	*0.407*
2	*0.11*	*0.339*	*0.111*	*0.347*
3	*0.053*	*0.313*	*0.054*	*0.32*
4	*0.044*	*0.128*	*0.044*	*0.13*
5	*0.037*	*0.065*	*0.038*	*0.066*
6	*0.026*	*0.041*	*0.026*	*0.042*
7	*0.023*	*0.032*	*0.023*	*0.032*
8	*0.021*	*0.026*	*0.021*	*0.027*
9	*0.018*	*0.021*	*0.018*	*0.022*
10	*0.015*	*0.02*	*0.015*	*0.02*

V. CONCLUDING REMARK

- All the data is compared with case-1 and conclusion is obtained.
- From the results it can be seen that story displacement, story shear, story stiffness, time period are reduced to a great extent in case-2 and case-3 as compare to case-1.
- It can be seen that stiffness of the building in Y direction is more due to the arrangement of the walls in Y direction.
- From the results of phase-2 it can be seen that the strut designed using different equations does not have much different properties.
- After comparing different parameters of different model cases, it is concluded that case-2 is most efficient during earthquake in all cases.
- It can be concluded from the results and graph that walls place a vital role in the performance of the building during earthquake. Therefore, before changing the arrangement of walls owner should consult a structural engineer.

REFERENCES

[1] Asteris PG (2003), "Lateral stiffness of brick masonry infilled plane frames", ASCE J. Structure Engineering, 129(8), 1071-9, Bangladesh National Building Code (BNBC) (1993), 6.27 - 6.47.
[2] V. Mulgund, d. M. Patil, p. B. Murnal, a. B. Kulkarni, "Seismic assessment of masonry infill R.C. framed building with soft ground floor".
[3] Haroon Rasheed Tamboli and Umesh. N.Karadi, "Seismic Analysis of RC Frame Structure with and without Masonry Infill Walls".
[4] Hossain Mohammad Muyeed-Ul-Azam and Khan Mahmud Amanat, "Effect of Infill as a Structural Component on the Column Design of Multi-Storied Building".
[5] Madan A, Reinhorn AM, Mander JB and Valles RE (1997). "Modeling of masonry infill panels for structural analysis". ASCE J. Str. Engg., 123 (10), 1295-7.
[6] Mosalam KM, White RN and Gergely P (1997). "Static response of infilled frames using quasi-static experimentation". ASCE J. Str. Engg., 123 (11), 1462-9.
[7] Mulgund g. V., dr. Kulkarni a. B., "Seismic assesement of rc frame buildings with brick masonry infills".
[8] Papia M (1998). "Analysis of infilled frames using a coupled Finite Element and Boundary Element solution scheme". Intl. J. Num. Meth. Engg., 26, 731-42.
[9] Saneinejad A and Hobbs B (1995). "Inelastic design of infilled frames". ASCE J. Str. Engg., 121 (4), 634-43.