International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com

Vol.5., Issue.2, 2017
March-April

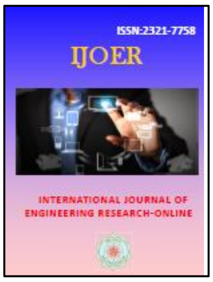
RESEARCH ARTICLE

ISSN: 2321-7758

COMPARATIVE STUDY OF INFILLED WALLS WITH DIFFERENT STIFFNESS RATIOS

ANURAG WAGHIDE[1] , Prof. S.C.GUPTA[2]

[1]M.Tech-Structural Engineering, University of petroleum and energy studies
Dehradun, Uttarakhand, India
awaghide@gmail.com
[2]Professor, Dept. of Civil Engineering, University of petroleum and energy studies
Dehradun, Uttarakhand, India



ABSTRACT

The effect of masonry infill panel on the response of RC frames subjected to seismic action is widely recognized and has been subject of numerous experimental investigations, while several attempts to model it analytically have been reported. Masonry infills in reinforced concrete buildings cause several undesirable effects under seismic loading: short-column effect, soft-storey effect, torsion, and out-of-plane collapse. Many researchers have changed various different parameters and analyzed the same. The objective of this study is to Observe the Bending Moment Patterns on every floor of a multi-Story Building with cases under consideration as Without Infill, With Infill and Stilt Floors. Different Stiffness ratios have been calculated and with the help of STAAD Pro the model has been analysed. The analysis method used here is Equivalent Static Method. Bending Moments are observed at three different portions of the beam and column i.e. End supports and Middle Span for cases like Without Infill i.e. bare frame, With Infill i.e. modelling an Equivalent Compression Strut placed diagonally between frames and Stilt Floors i.e. no Infill Wall on that particular floor. Due to change in Stiffness, bending moment values changes in columns and beams and the same is observed. There are a total of 10 cases of stiffness ratios but we have taken only 2 cases in this paper which are Case 2 and Case 5.

Keywords- Masonry Infill Panel, Seismic Action, Bending Moments, Equivalent Static method, Compression Strut, Stilt Floor, Stiffness Ratios.

INTRODUCTION

1.1 General

A large number of buildings are constructed with masonry infills for architectural needs or aesthetic reasons. However, because of complexity of the problem and absence of a realistic, yet simple analytical model, the combination of masonry infill panels is often neglected in the non-linear analysis of building structures. Such an assumption may lead to substantial inaccuracy in predicting the lateral stiffness, strength and ductility of the structure.

The behavior of masonry infilled frames has been extensively studied in the last four decades in attempts to develop a rational approach for design of such frames. In general design practices in India, the strength and stiffness of infill walls are ignored because of the idea of conservative design. In practical, infill walls provide considerable strength and rigidity to the structure and their absence may cause failure of many multi-storeyed buildings.

Infills do not contribute towards resisting gravity loads but contribute significantly in resisting lateral loads. However, in practice, infill stiffness is commonly ignored in frame analysis, resulting in an under estimation of stiffness and natural frequency. Infills have energy dissipation characteristics that contribute to improved seismic resistance.

Behavior of infill walls have been analyzed and studied by many researchers manipulating with various parameter and verticals of structural analysis and civil engineering by changing in percentage of openings in infills, with and without infills, open first storey, change in infill material, analysis with different software accompanied by different methods of analysis, etc.

Analysis Methods are-

1. Equivalent Static Analysis
2. Response Spectrum Analysis
3. Linear Dynamic Analysis
4. Non-Linear Static Analysis
5. Non-Linear Dynamic Analysis

1.2 Objective and Scope

The present project deals with seismic analysis of a G+10 Floors RC building, by Equivalent static method using Structural Analysis and Design (STAAD Pro.) software and considering Indian Standard code 1893 (Part 1) : 2002.

The objective of this project is to observe the change in Bending moments of each floor under different cases of Stiffness Ratios as well as the geometry of the structure such as with infill, without infill and Stilt on 1st and 5th Floor.

METHODOLOGY

Design horizontal seismic coefficient (Ah) for a structure shall be determined by the following expression

$$A_h = \frac{ZIS_a}{2\,Rg} \qquad (1)$$

Where,

Z=Zone factor (0.36)

I=Importance factor=1

R=Response reduction factor=5

Sa/g=Average response acceleration coefficient

For hard soil site

$$\frac{S_a}{g} = \begin{cases} 1+15T, & 0.00 \le T \le 0.1 \\ 2.5 & 0.1 \le T \le 0.4 \\ \frac{1.00}{T} & 0.4 \le T \le 4.00 \end{cases} \qquad (2)$$

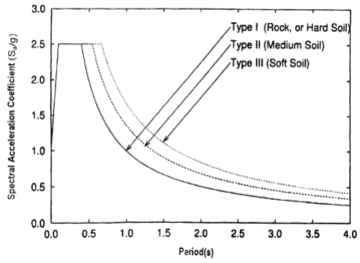


Fig.1.1 Response Spectra for Rock and Soil Sites for 5 percent Damping

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

$$T_a = \frac{0.09\,h}{\sqrt{d}}$$

Where,

h= Height of building in m, as defined in 7.6.1

d= Base dimension of the building at the plinth level, in m, along the considered direction of the lateral force.

Design Lateral Force

The total design lateral force or design seismic base shear (V b) along any principal direction shall be determined by following expression

$$V_B = A_h W$$

Where,

Ah= Design horizontal acceleration spectrum value as per 6.4.2 IS1893 using the fundamental natural period (T) as per 7.6 in the considered direction of vibration; and

W= Seismic weight of the building as per 7.4.2 IS1893 (2002).

Finally the calculated lateral force are applied to the building and analyzed by structural analysis and design (STAAD) or (STAAD Pro.) software.

Distribution of Design Force

Vertical distribution of base shear to different floor

$$Q_i = V_B.\frac{W_i.h_i^2}{\sum_{j=1}^{n} W_j.h_j^2}$$

Where,

Qi = design lateral force at floor *i*

Wi = seismic weight of floor *i*

hi = height of floor i measured from base; and

n = number of storeys in the building (the number of levels at which the masses are located).

LITERATURE REVIEW

1.1 Seismic Evaluation of RC Frame with Brick Masonry Infill Walls (Nitesh Singh, Asst. Prof. V.K.Verma): Infill panels are only used in RC frame structure as partition walls and as external walls. These are considered as non-structural elements and can provide with considerable stiffness to the building improving the performance under-ground motions. In this paper two methods are used to analyze the behavior of Infill walls i.e. Equivalent Lateral Force method and Response Spectrum Method. Two models are considered one without infill and another with infill. The one with infill has been modeled as an equivalent diagonal strut element using Hendry formula. Both the models are analyzed with Pushover analysis. The software used is STAAD Pro and the results obtained are compared in terms of strength and stiffness with bare frame.

1.2 Influence of Masonry Infill Walls on Seismic Performance of RC Framed Structures- A Comparison of AAC and Conventional Brick Infill (Ms. Kajal Goel): This paper deals with the analysis of RC frame with different infill material one is AAC (Autoclaved Aerated Concrete) and the other is Conventional concrete block. This paper has used the STAAD Pro software for analysis. The methodology used in this paper is Equivalent Static Force Analysis. Comparison of these two materials with different parameters such as Base Shear, End Displacement and Deflection of frames are depicted in this paper.

1.3 Beneficial Influence of Masonry Infill Walls on Seismic Performance of RC Frame Building (C V R Murty and Sudhir K Jain): Masonry Infills contribute significant lateral stiffness, strength, overall ductility and energy dissipation capacity. With suitable arrangements to provide reinforcement in masonry that is well anchored in frame column, it is possible i=to also improve the out-of-plane response of such infills. Infills interfere with the lateral deformation of RC frame; separation of frame and infill takes place along one diagonal and compression strut forms along another. Therefore, infills add lateral stiffness to the building.

1.4 Effect of Infill Stiffness on Seismic Performance of Multi-Storey RC Framed Buildings in India. (Robin DAVIS, Praseetha KRISHNAN, Devdas MENON, Meher PRASAD): Most of the Multi-Storey buildings in India comprises of Reinforced Concrete frames with brick masonry as infills. The use of unreinforced masonry infill walls may not contribute towards resisting gravity loads but may significantly enhance stiffness and strength of the frame under earthquake or wind resulting in an under estimation of stiffness and natural frequency. It has been observed from the experiments that infills have energy dissipation characteristics that contribute to improved seismic resistance. In this paper two typical buildings located in moderate seismic zones of India are considered. The difference between two buildings are one exists with plan irregularity vertical irregularity (soft-storey) and the other exists with symmetricity. The infills were modelled using equivalent strut approach. Static analysis (for gravity and lateral loads), response spectrum analysis and non-linear pushover analysis (assigning the hinge properties to beams and column sections) were performed. It is observed that the seismic demand at the soft storey level is significantly large when infill stiffness is considered, with larger base shear and larger displacements. This effect, however, is not found to be significant in the symmetric building (without soft storey). Seismic performance was compared in the pushover analysis for the two cases. The results are described in detail in this paper.

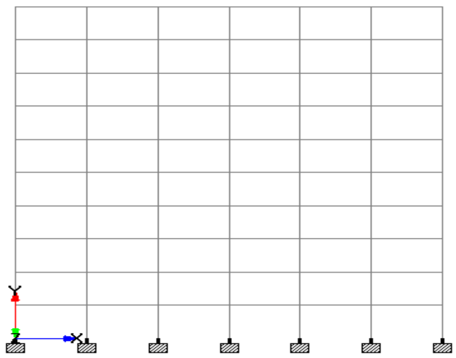
1.5 Earthquake Analysis of Highrise Buildings with and without Infill Walls (Wakchaure M.R., Ped S.P): The effect of masonry infill panel on the response of RC frames subjected to seismic action is widely recognized and has been subject of numerous experimental investigations, while several attempts to model it analytically have been reported. In analysis of buildings, infill walls are modeled as equivalent strut approach there are various formulae derived by research scholars and scientist for width of strut and modelling. Infill behaves like compression strut between column and beam and compression forces are transferred from one node to another. In this study the effect of masonry walls on high rise building is studied. Linear dynamic analysis on high rise building with different arrangement is carried out. For the analysis G+9 R.C.C. framed building is modelled. Earthquake time history is applied to the models. The width of strut is calculated by using equivalent strut method. Various cases of analysis are taken. All analysis is carried out by software ETABS. Base shear, storey displacement, story drift is calculated and compared for all models. The results show that infill walls reduce displacements, time period and increases base shear. So it is essential to consider the effect of masonry infill for the seismic evaluation of moment resisting reinforced concrete frame.

STRUCTURAL MODELLING

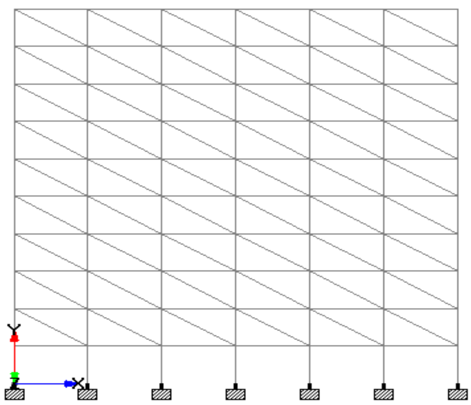
1. **OVERVIEW:** The structure is a RCC G+10 storey residential building located in seismic Zone V with seismic intensity being very severe (Z=0.36). Column Size is 350mmX750mm; Beam Size is 600mmX300mm. Height is 30 m with floor height as 3 m. Length of the structure is 30m where bay length along X-direction is 5m and Width is 12 m where bay length in Z-direction is 3m.

2. CASES UNDER CONSIDERATION

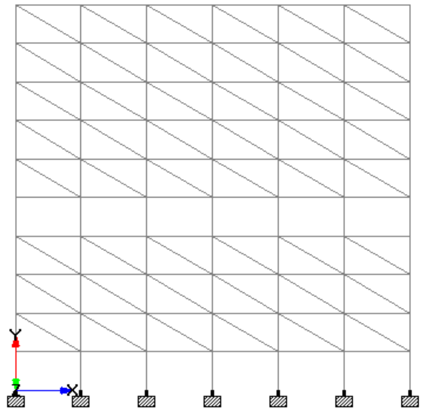
Case 1- Without Infill Wall



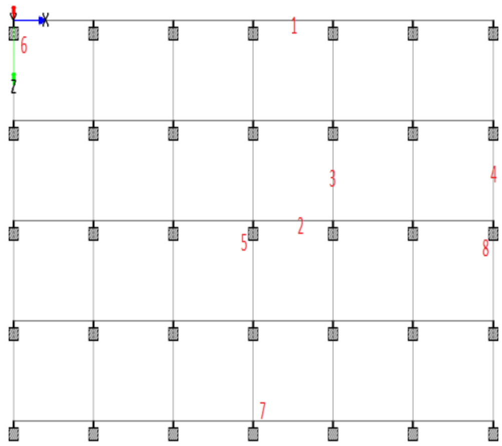
Case 2- With Infill Wall



Case 3- Infill Wall with Ground and 4^{th} Floor as Stilt



3.3 BEAMS AND COLUMNS UNDER CONSIDERATION



1. Outer Beam along global X-Direction
2. Intermediate Beam along global X-Direction
3. Intermediate Beam along global Z-Direction
4. Outer Beam along global Z-Direction
5. Centre Column
6. Outer Column
7. Column along length
8. Column along width

3.4 INPUTS FOR STAAD Pro.

3.4.1 Assigning materials- The building is a RCC frame structure where the columns and beams are assigned with concrete material with grade M25. The infilled wall is constructed from brick masonry which is modeled as equivalent compression strut (Smith [1]). The material assigned to the compression strut i.e. infilled walls are young's modulus as 4.2e+006 kN/m^2, poisson's ratio as 0.2 and Density as 20 kN/m^3. (Narayanan S.P [2]).

3.4.2 Modelling of Infilled Walls- Infilled walls are usually brick masonry walls where the binding material used is mortar. Now in STAAD Pro we cannot directly model Infilled wall as it is constructed on site. Many researchers have been studying the behavior of the walls and have come up with different formulae for modelling the Infilled walls, one of the conclusion was to model it as a compression strut which will be having a specific width and place that strut in diagonal position in frame structure. The formula derived (Paulay ande Priestley [3]) for width of infill wall was Diagonal/4 and by using this formula and considering thickness constant as 250 mm we have derived our 10 cases of infilled walls with different stiffness ratios. The ratio being Thickness/ Width of Infill wall.

Table 1 Stiffness Ratios

CASES	THICKNESS (mm)	WIDTH (mm)	RATIO= T/W
1	250	400	0.62
2	250	600	0.41
3	250	1000	0.25
4	250	1400	0.17
5	250	1800	0.13
6	250	2400	0.1
7	250	2600	0.09
8	250	2800	0.08
9	250	3200	0.078
10	250	3600	0.069

3.4.3 Providing supports- The supports has been provided as fixed at the foundation level.

3.4.4 Seismic Parameters- According to IS-1893 (Part 1) : 2002

$$V_B = A_h W$$

Where,

Vb is Design Base Shear;

Ah is Design horizontal Acceleration;

W is Seismic weight of building.

To provide these values to software we have to first define "Ah" and that is done in the seismic definition part. So we have generated the following values which will be substituted in following formula-

$$A_h = \frac{ZIS_a}{2\,Rg}$$

a) Zone- V; Zone factor- 0.36 Very Severe- IS 1893 (Part 1): 2002, Table 2

b) Response reduction Factor (RF)- 5 (Ductile Shear Wall with SMRF)- IS 1893 (Part 1): 2002, Table 7

c) Importance Factor as 1 for all other buildings- IS 1893 (Part 1): 2002, Table 6

d) Rock and Soil Site factor (SS)-2 i.e. Hard Soil

e) Type of Structure (ST) as 1 For RC Frame Building

f) Damping Ratio as 0.05% as it is critical damping ratio

g) Period in X-direction is 0.49 sec and in Y-direction as 0.77 sec. Formula used is Ta=0.09*h/sqrt d, where h=30m and d_x=30m and d_y=12m

h) To calculate Seismic Weight of the building (W) including accidental loads take **Selfweight** as factor of 1; **Member weight** will act as UDL of 12 kN/m (0.25*2.4*20) and this UDL will act only on beams till 9th Floor as there will be no infill wall on terrace. **Floor weight** for 125mm thick slab with floor finish is 0.125*25+0.075*20=5 kN/m^2 and with the addition of Live Load i.e. 3 kN/m^2 as per IS 1893 (Part 1): 2002, Table 8, Clause 7.3.1 percentage of Imposed load will be 25% of Imposed Load i.e. DL+0.25 LL; LL<=3 kN/m^2. Therefore, total Floor Weight will be 5+0.25*3=5.75 kN/m^2 which will be acting from 3 m to 27 m of height in Y Range and for 27m to 30 m height only 5 kN/m^2 will be acting as there will be no Live Loads acting on terrace. With the generation of these above values Design Seismic Base Shear will be calculated (Vb).

3.4.5 Load and Definitions- There are 4 load cases and 5 load combinations. The 4 load cases being Dead Load which is, Live Load, Seismic Load in X direction and Seismic Load in Z direction. The first load case is Seismic Load of factor 1 acting in X-Direction. The second Load Case is Seismic Load of Factor 1 acting in Z-Direction. The third case is Dead Load which consists of a UDL of 12 kN/m acting downwards, a Floor Load of 5 kN/m2 acting downwards for a height of 3m to 30 m and a selfweight of factor -1. The forth load case is Live Load which consist of a floor load of -3 kN/m2 for the height of 3m to 27 m and another floor load of -1.5 kN/m2 for a range of 27m to 30 m.

International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com

**Vol.5., Issue.2, 2017
March-April**

The 5 load combinations are considered according to the code IS 1893 (Part1) : 2002, clause 6.3.1.2 i.e. Partial Safety Factors for limit state design of reinforced concrete and prestressed concrete structures.

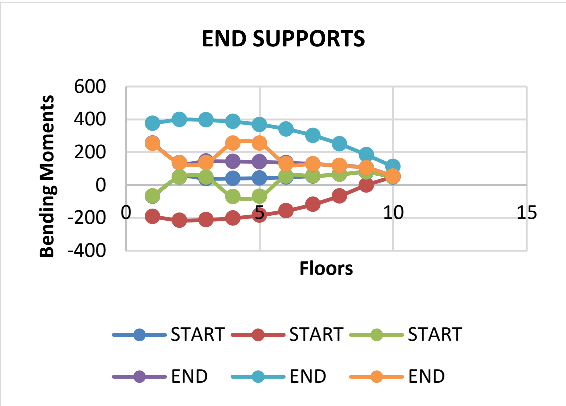
3.4.6 Analysis- The model is analyzed by Equivalent Static Method

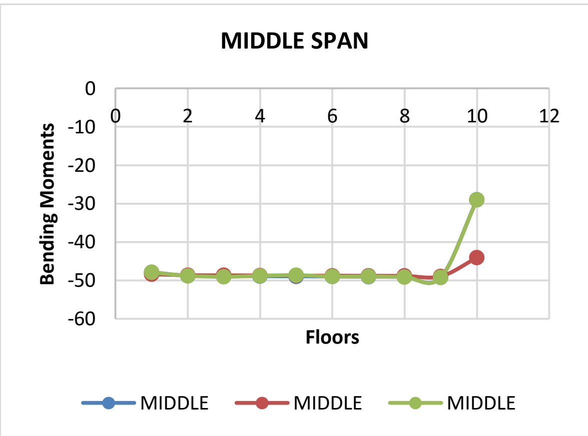
RESULTS AND DISCUSSIONS

BENDING MOMENTS ON EVERY FLOOR FOR CASE 2 WITH INFILL, WITHOUT INFILL AND STILT

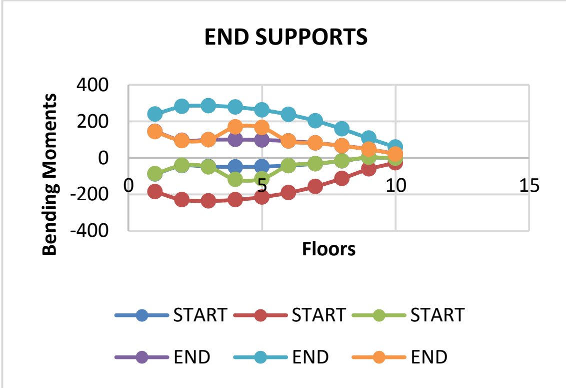
The graphs deals with the Bending Moments of different sections of a beam and column for each floor i.e. at both the end supports and the middle portion. These are sub divided with three different cases each i.e. With Infill walls, Without Infill Walls and Stilt. There are two graphs for each case, the first one is end supports and the second is for Middle Span.

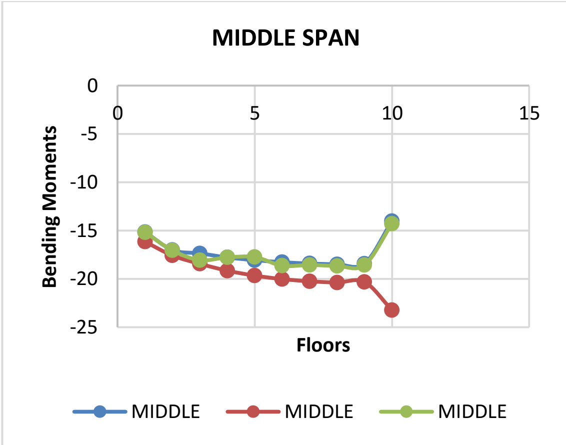
5.1.1 Intermediate Beam Along Global X-Direction, EQK +VE X



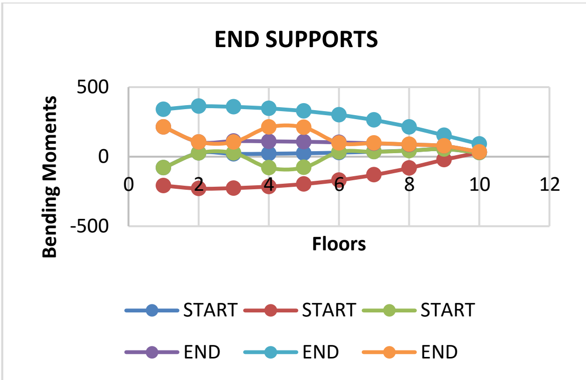


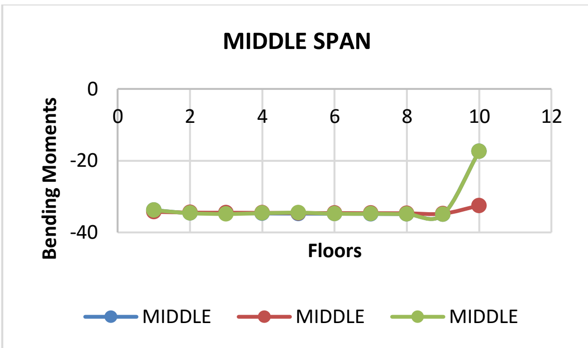
5.1.2 Intermediate Beam Along Global Z-Direction, EQK +VE Z



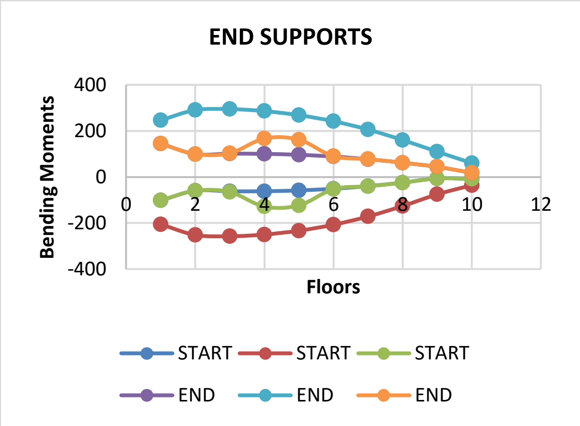


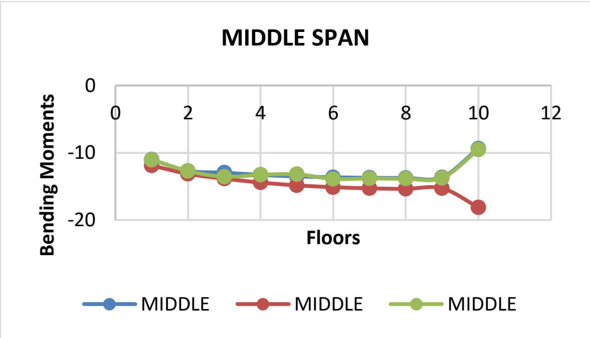
5.1.3 Outer Beam-Along Global X-Direction, EQK +VE X



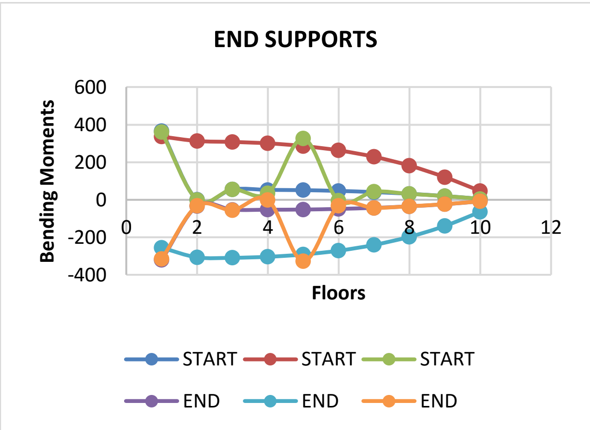


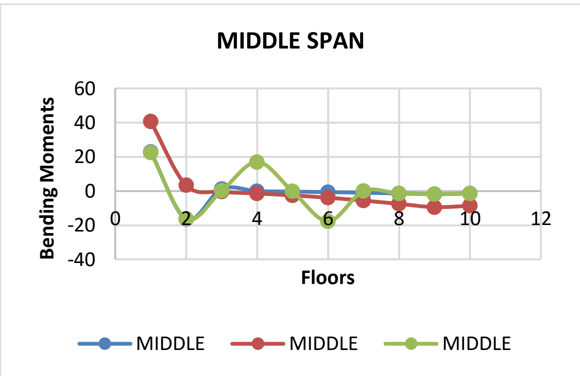
5.1.4 Outer Beam-Along Global Z-Direction, EQK +VE Z



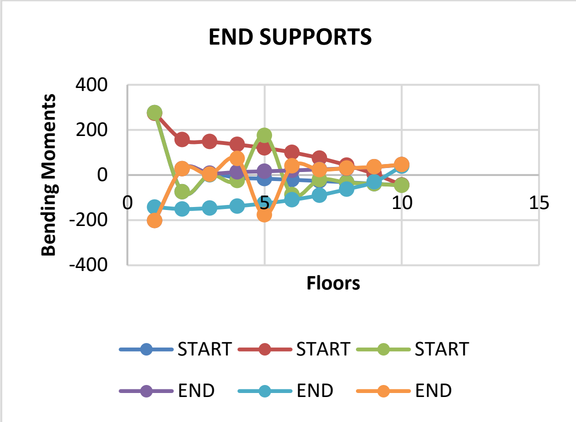


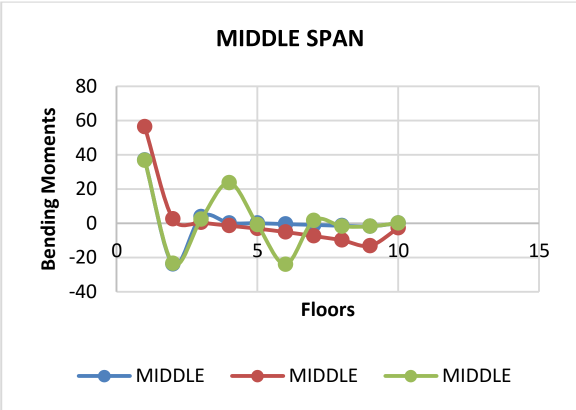
5.1.5 Centre Column EQK +VE X-Direction



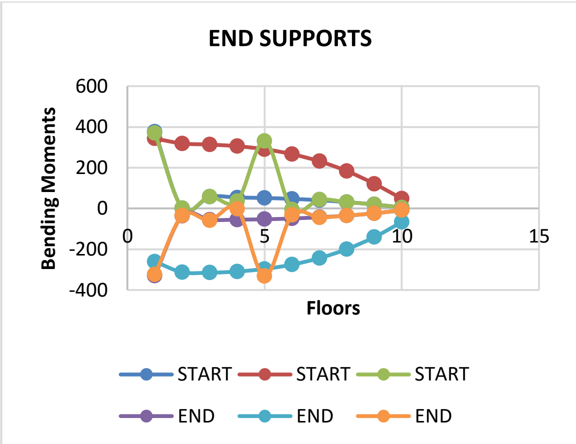


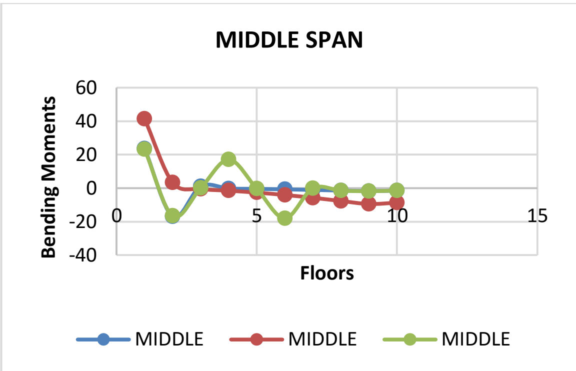
5.1.7 Outer Column with EQK +VE X-Direction



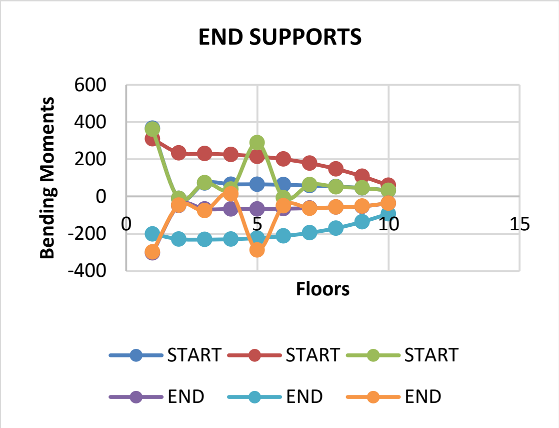


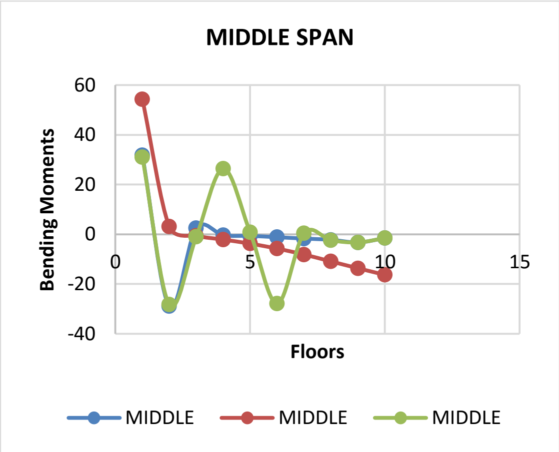
5.1.9 Column Along Length EQK +VE X-Direction





5.1.10 Column Along Width EQK +VE X-Direction





From all the graphs it is observed that the structure without Infill has more Bending Moments than in case With Infill and Stilt. The reason behind these reduction in Bending Moments is more Stiffness offered by Infill.

In Stilt case we can observe that on 4th and 5th Floor beams the Bending Moments are increased and this is caused due to reduction in Stiffness of that portion of the building.

DISCUSSION

From the above tabulations and graphs, it is observed that infilled walls do contribute on a large scale in reducing bending moments on every floor for a multi-storey building. The reduction in bending moments is advantageous for structural engineer, as the section sizes can be reduced thus economizing the project as a whole.

In this paper we have used parameters such as different stiffness ratios, analyzing bending moments of different beams and columns according to their location and on each floor with their changing pattern in bending moment diagram to get desired results.

In case of stiffness ratios, Case 1 being of more stiffness and case 10 being of least stiffness. So as the stiffness ratios are decreasing we are getting more values of bending moments and that can be observed from the tables and graphs. Thus proving the point that with more stiffness we can achieve less bending moment values and so can redesign economic sections.

The observation with the Infill, No Infill and Stilt case is that-

In No Infill case the bending moments are on higher scale the reason being is less stiffness and more ductility.

In Infill case, the bending moments are reduced steeply this is because of the extra stiffness which is provided in the form of compression strut along every frame diagonally and due to this alignment the earthquake forces which are acting in X and Z direction separately are more efficiently reduced. The reduction in bending moments on Start and End Supports in beams are 57% and 55% respectively when compared to Bare frame.

In the stilt case, we have not provided infilled walls on ground floor and 4th floor due to which the bending moments have increased drastically for columns and have reduced in case of beams.

In case of columns, the bending moment values have a sudden increase in the stilt portion, i.e. on ground floor columns and 4th floor columns; whereas in case of with infill and without infill they have a moderate increase. Confirming that if there are absence of infill walls on particular floors, the bending moment values takes a leap. The percentage increase in bending moments in case of Stilt are between 10%-13% approximately in case of Centre Column, and 28%- 32% increase in case of Outer Column.

In case of beams in the stilt case the bending moment values have reduced compared to No Infill case but have increased when compared to With Infill case. The reason being is, in stilt case the portion with less stiffness attracts more forces, so on 4th and 5th floors the bending moment values are more as compared to with infill case but less than in No Infill case.

So Infilled walls and its stiffness plays a crucial role in resisting the lateral loads in multi-storey buildings and so should be considered while designing.

Note- the above graphs and tables in annexure are of Stiffness Ratio case 2 only. There are total of 10 cases. According to above discussion, as the stiffness ratio decreases bending moment increases, the same results are depicted from the rest of the stiffness ratios.

ANNEXURE

The following tables consists of Number of Floors and their Bending moments on End supports and middle portion for Infill, without Infill Walls and Stilt Cases. The graphs of these tables are shown above.

Table 2 Bending moments of Intermediate beam for load in +ve X-Direction

FLOORS	INTERMEDIATE BEAM-ALONG GLOBAL X-DIRECTION, EQK +VE X								
	START			MIDDLE			END		
	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT
1	-69.85	-192.54	-67.17	-47.86	-48.41	-47.89	254.33	375.92	251.59
2	46.76	-215.57	47.43	-48.77	-48.63	-48.8	135.9	398.52	135.17
3	38.34	-213.03	46.98	-48.76	-48.65	-49.05	144.34	395.93	135.12
4	39.23	-203.15	-71.81	-48.89	-48.7	-48.8	143.19	385.95	254.41
5	41.75	-185.46	-70.39	-48.92	-48.73	-48.61	140.61	368.19	253.37
6	46.68	-158.17	53.86	-48.97	-48.76	-48.98	135.58	340.84	128.38
7	54.03	-119.32	54.17	-49.02	-48.79	-48.99	128.12	301.95	128.06
8	64.13	-67.03	64.65	-49.08	-48.81	-49.1	117.92	249.6	117.35
9	77.37	-1.21	77.82	-49.2	-48.93	-49.22	104.44	183.56	103.95
10	48.17	50.32	48.45	-28.98	-44.06	-29.02	54.37	112.06	54.02

Table 3 Bending moments of Intermediate beam for Load in +ve Z-Direction

FLOORS	INTERMEDIATE BEAM-ALONG GLOBAL Z-DIRECTION, EQK +VE Z								
	START			MIDDLE			END		
	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT
1	-89.07	-185.08	-87.14	-15.13	-16.14	-15.17	145.86	239.84	143.84
2	-42.62	-229.41	-41.46	-17	-17.57	-17.04	95.66	281.32	94.43
3	-47.42	-235.64	-49.2	-17.35	-18.43	-18.05	99.77	285.83	100.15
4	-49.14	-229.64	-118.06	-17.77	-19.14	-17.76	100.63	278.4	169.58
5	-47.42	-214.8	-114.68	-18.05	-19.65	-17.73	98.37	262.54	166.26
6	-41.88	-190.84	-42.62	-18.26	-20.01	-18.62	92.4	237.87	92.43
7	-31.75	-156.88	-31.43	-18.4	-20.24	-18.55	81.99	203.44	81.39
8	-16.59	-112.29	-15.96	-18.47	-20.36	-18.64	66.69	158.61	65.73
9	2.1	-61.1	2.67	-18.41	-20.31	-18.55	48.11	107.53	47.27
10	-2.99	-26.46	-2.9	-14.01	-23.22	-14.27	21.51	58.96	20.91

Table 4 Bending moments of Outer beam for load in +ve X-Direction

FLOORS	OUTER BEAM-ALONG GLOBAL X-DIRECTION, EQK +VE X								
	START			MIDDLE			END		
	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT
1	-80.83	-208.85	-80.49	-33.74	-34.21	-33.76	214.35	341.42	213.98
2	26.34	-230.28	25.81	-34.58	-34.43	-34.6	105.49	362.41	105.99
3	19.61	-226.49	25.73	-34.58	-34.46	-34.82	112.23	358.57	105.62
4	21.37	-215.46	-80.43	-34.68	-34.51	-34.61	110.27	347.43	212.21
5	24.3	-196.94	-78.38	-34.71	-34.55	-34.44	107.27	328.85	210.51
6	28.94	-169.47	33.91	-34.76	-34.57	-34.76	102.54	301.32	97.58
7	35.39	-131.59	34.45	-34.81	-34.6	-34.77	95.99	263.39	97.01
8	43.82	-82.19	43.56	-34.85	-34.63	-34.86	87.47	213.94	87.71
9	54.36	-22.12	54.28	-34.95	-34.72	-34.96	76.74	153.68	76.81
10	27.92	30.16	27.97	-17.35	-32.48	-17.37	33.52	91.03	33.44

Table 5 Bending moments of Outer beam for load in +ve Z-Direction

FLOORS	OUTER BEAM-ALONG GLOBAL Z-DIRECTION, EQK +VE Z								
	START			MIDDLE			END		
	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT
1	-101.81	-205.21	-101.37	-11.01	-11.89	-11.04	145.23	246.86	144.72
2	-59.29	-251.61	-59.58	-12.68	-13.14	-12.7	99.37	290.78	99.62
3	-62.01	-257.29	-65.07	-12.95	-13.85	-13.55	101.55	295.03	103.42
4	-61.64	-249.79	-128.33	-13.29	-14.42	-13.27	100.5	286.36	167.24
5	-58.09	-233.03	-123.08	-13.5	-14.84	-13.19	96.54	268.78	162.15
6	-50.79	-207.05	-52.47	-13.64	-15.11	-13.89	88.96	242.26	90.13
7	-39.4	-171.37	-40.17	-13.71	-15.28	-13.81	77.42	206.25	77.98
8	-24.13	-125.93	-24.47	-13.74	-15.36	-13.86	62.09	160.66	62.19
9	-6.08	-75.17	-6.27	-13.64	-15.27	-13.74	44.24	110.07	44.25
10	-7.98	-35.47	-8.28	-9.35	-18.11	-9.53	18.27	60.65	18.22

Table 6 Bending moments of Centre Column for load in +ve X-Direction

	START			MIDDLE			END		
	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT
1	366.31	336.53	360.59	22.93	40.62	22.55	-320.43	-255.29	-315.48
2	0.2	313.11	-0.14	-16.43	3.35	-16.15	-33.12	-306.4	-32.17
3	55.58	308.07	55.37	1.24	-0.36	0.17	-53.09	-308.8	-55.03
4	52.71	300.65	34.29	-0.054	-1.41	17	-52.82	-303.48	-0.29
5	51.32	286.35	326.47	-0.31	-2.53	-0.21	-51.94	-291.43	-326.9
6	47.21	263.16	-3.77	-0.64	-3.91	-17.67	-48.51	-270.99	-31.58
7	40.92	229.12	43.26	-0.99	-5.57	0.002	-42.91	-240.26	-43.25
8	32.01	182.24	31.41	-1.39	-7.49	-1.43	-34.8	-197.23	-34.28
9	20.14	120.65	19.75	-1.83	-9.4	-1.82	-23.81	-139.46	-23.4
10	5.3	47.22	4.99	-1.43	-8.63	-1.4	-8.18	-64.49	-7.81

Table 7 Bending moments of Outer Column for load in +ve X-Direction

FLOORS	OUTER COLUMN-ALONG GLOBAL X-DIRECTION, EQK +VE X								
	START			MIDDLE			END		
	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT
1	276.53	273.17	275.64	36.9	56.36	36.83	-202.73	-142.45	-201.96
2	-74.84	156.18	-74.85	-23.82	2.53	-23.49	27.18	-151.12	27.87
3	0.54	147.83	1.51	3.9	0.42	2.29	7.26	-146.97	3.08
4	-12.59	135.23	-24.88	0.17	-1.4	23.75	12.94	-138.04	72.38
5	-16.27	120.12	175.99	0.05	-3.09	-0.79	16.37	-126.31	-177.58
6	-21.28	100.39	-87.62	-0.45	-5.11	-23.95	20.37	-110.62	39.71
7	-26.49	75.09	-20.25	-0.93	-7.42	1.59	24.63	-89.94	23.44
8	-32.37	43.21	-33.74	-1.44	-9.86	-1.7	29.49	-62.95	30.28
9	-38.99	4.66	-39.51	-1.79	-13.09	-1.78	35.4	-30.84	35.94
10	-45.24	-44.2	-45.93	0.1	-2.78	0.177	45.45	38.63	46.29

Table 8 Bending moments of Column Along Length for load in +ve X-Direction

FLOORS	COLUMN-ALONG LENGTH, EQK +VE X								
	START			MIDDLE			END		
	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT
1	376.31	343.34	370.25	23.64	41.38	23.24	-329.02	-260.58	-323.75
2	1.98	319.23	1.82	-16.86	3.35	-16.55	-35.72	-312.53	-34.93
3	57.81	313.84	57.91	1.15	-0.44	0.09	-55.5	-314.73	-57.73
4	54.1	305.98	36.13	-0.186	-1.5	17.12	-54.47	-309	-1.87

5	51.8	291.03	331.16	-0.414	-2.65	-0.34	-52.62	-296.35	-331.85
6	47.34	266.94	-4.05	-0.7	-4.06	-17.99	-48.75	-275.07	-31.93
7	40.77	231.79	43.51	-1.038	-5.73	-0.034	-42.84	-243.27	-43.58
8	31.68	183.72	31.28	-1.41	-7.64	-1.46	-34.5	-199.01	-34.21
9	19.89	121.39	19.68	-1.8	-9.43	-1.8	-23.49	-140.26	-23.28
10	5.68	48.75	5.46	-1.42	-8.68	-1.4	-8.52	-66.12	-8.27

Table 9 Bending moments of Column Along Width for load in +ve X-Direction

FLOORS	COLUMN-ALONG WIDTH, EQK +VE X								
	START			MIDDLE			END		
	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT	INFILL	NO INFILL	STILT
1	366.58	309.95	361.08	31.79	54.38	31.09	-303.03	-201.19	-298.88
2	-9.9	234.96	-9.93	-28.94	3.07	-28.24	-47.99	-228.81	-46.56
3	73.03	230.49	73.78	2.51	-0.578	-0.99	-68.01	-231.56	-75.76
4	66.12	225.26	39.33	-0.4	-2.13	26.39	-66.99	-229.52	13.45
5	65.7	216.05	289.06	-0.63	-3.75	0.75	-66.97	-223.56	-287.56
6	63.06	201.07	-6.5	-1.17	-5.75	-27.93	-65.4	-212.58	-49.36
7	59.06	179.05	64.29	-1.71	-8.13	0.4	-62.49	-195.33	-63.47
8	53.31	148.67	52.42	-2.21	-10.91	-2.39	-57.74	-170.5	-57.22
9	46.13	108.55	45.96	-3.26	-13.66	-3.26	-52.67	-135.88	-52.49
10	32.92	60.02	32.41	-1.56	-16.32	-1.54	-36.04	-92.67	-35.49

REFERENCES

[1]. Smith, S. B. and Carter, C. (1969), "A method of analysis of in-filled frames" Proceedings, Institution of Civil Engineers, London, Vol. 44, pp. 31-48.

[2]. Properties of Brick Masonry for fE Modelling, Narayanan S.P, Sirajuddin M, American Journal Of Engineering Research.

[3]. Paulay, T., and Priestley, M. J. N., 1992. Seismic Design of Reinforced Concrete and Masonry Buildings, John Wiley & Sons, Inc., New York, NY

[4]. C V R Murthy and Sudhir K Jain, "Beneficial Influence of Masonry Infill Walls on Seismic Performance of RC Frame Building", 12WCEE 2000.

[5]. Robin DAVIS, Praseetha KRISHNAN, Devdas MENON, A.Meher PRASAD, "Effect of Infill Stiffness on Seismic Performance of Multi Storey RC Frame Building in India", 13th World Conference on Earthquake Engineering, Vancouver, B.C., Canada.

[6]. A Madan, A.M. Reinhorn, Fellow, ASCE, J.B.Mander, Member ASCE, R.E.Valles, "Modelling of Masonry Infill Panels for Structural Analysis".

[7]. Wakchaure M.R, Ped S.P., " Earthquake Analysis of High Rise Building With and Without Infill", IJEIT, ISSN:2277-3754

[8]. S. Muthu Kumar, G Saranya, M. Lakshmipathy, K.S. Satyanarayanan, "Modelling and study of behavior of Infilled Frames with Different Interface Materials under Static Loading", Indian Journal of Science and Technology, Vol 9 (23).

[9]. Mohammed Nauman,Nazrul Islam, "Behaviour of RCC Multi Storey Structure with and without Infill Walls ",International Journal of Innovative Research in Science, Engineering and Technology, IJIRSET.

[10]. Yogendra Singh, Dipankar Das, "Effect of URM Infills on Seismic Performance of RC Frame Building", 4th International Conference in Earthquake Engineering, Taipei, Taiwan, 2006