EFFECT OF INFILL WALL STIFFNESS VARIATIONS ON THE BEHAVIOUR OF RC BUILDING UNDER THE INFLUENCE OF SEISMIC DEMANDS

Sagar S Kumavat[1], Prof. Pravin A. Nikam[2]

[1]*P.G.Student (Structural Engineering)*
[2]*Assistant Prof. S.N.D. College of Engineering and Research Center, Yeola, Nashik.*

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Abstract – *Its easy to design a massive structure, but along with it should have adequate stability, strength and serviceability, to cope with the natural elements. Infill panels are widely used as partition walls as well as external walls of the building to fill the gap between RC frames. Masonry infill's in reinforced concrete buildings cause several undesirable effects under seismic loading: short-column effect, soft-storey effect, torsion, and out-of-plane collapse. Hence, seismic codes tend to discourage such constructions in high seismic regions. However, in several moderate earthquakes, such buildings have shown excellent performance even though many such buildings were not designed and detailed for earthquake forces. On-structural member may provide considerable stiffness to the building and hence may improve the performance of the RC building during ground motions. But In most of the cases, the ignorance of this property of masonry in designing of the RC frame may get an unsafe design. The aim of this study is to gain understanding the effect of infill wall stiffness variations under the uncertainty of seismic demands by considering seismic zone III, of Nasik City. The effect of ground motion on RC frame building has been carried out by considering the five storey RC building with five by five bay in X and Y Directions. A study will be carried out on RC building using Equivalent Lateral Force method and Response Spectrum method. The model has been generated using STAAD Pro and results obtained from the analysis are compared in terms of base shear, Fundamental Time period, Spectral acceleration, Different modes, Peak storey shear and Modal mass participation along with time history analysis for bare frame.*

Keywords— *Serviceability, torsion, Equivalent lateral force.*

1. INTRODUCTION

RC moment resisting frame buildings are the most preferred type of construction in developing countries like India; due to its relatively low cost, fast and rapid progressive construction. Other main and important factors like its aesthetic appearance and good functional behavior under earthquake loading makes it the ultimate choice. In addition to above, brick masonry has good Properties like thermal and acoustic insulation and fire resistance. RC moment resisting frame buildings consist of moment resisting frame with masonry wall as Infill's. These walls are considered as nonstructural elements in construction practices. Reinforced concrete frames with masonry infill walls are widespread systems in many earthquake-prone regions of the world. The infill walls are used for insulation and partition purposes rather than structural purposes and generally considered as nonstructural elements in structural design. The inherent uncertainties of the infill walls introduce difficulty to regard them as structural members. These uncertainties are associated to both the infill wall and the surrounding frame. In many buildings, RC frames is either partially filled with brick masonry having an opening or without openings. Brick masonry infill is used mostly used as interior partition walls and external walls which are protecting from outside environment to the building. Although this masonry infill contribute to stiffness and strength of the RC frame, however they are generally neglected in the design because of lack of knowledge of composite behavior of the in filled frame.

2. LITERATURE REVIEW

Mr. Rahul Sawant , Dr. M. N. Bajad, study focuses on a review of the influence of soil conditions on the seismic forces in RC buildings. The aim of this study is to gain understanding the effect of the local site conditions on the seismic forces in building. The study helps in creating awareness about the importance of the local site conditions, such as proximity to the source of earthquakes (faults) and the local geological and topographical features in the earthquake resistant design of buildings. The current Indian code of practice for seismic analysis IS 1893:2002, specifies seismic zones to consider different levels of intensity of ground shaking.

Nitesh Singh, V. K. Verma, in many buildings, RC frames is either partially filled with brick masonry having an opening or without openings. The effect of ground motion on RC frame building has been carried out by considering with and without the stiffness of infill wall. A comparative study is carried out with RC building using Equivalent Lateral Force method and Response Spectrum method. The masonry infill has been modeled as an equivalent diagonal strut element using Hendry formula. Pushover analysis is carried out on bare frame and frame with infill wall. The structures having relatively flexible lateral load resisting system, infill can play a significant role in total stiffness.

Prof. K.K. Tolani, Pravin A. Nikam, Lots of research is held in infill wall consideration in frame structure. In this study symmetrical R/C frame structure and its lump mass model is created. Static earthquake analysis and response spectrum method is applied for to get the seismic forces in the structures. Two cases are considered for analysis such as bare frame, equivalent strut and its lump mass models. All analysis carried out by SAP 2000 software. Results on base shear, modal mass participation, first fundamental frequencies, and frame displacement are calculated and compared for all models.

Tejashree Kulkarni, Sachin Kulkarni, with the immense increase in population, demand of land keeps on mounting which in turn leads the responsibility of civil engineer to greater extent. Earlier Horizontal system of construction was in use but now a day's vertical system of construction is preferred more due to a lesser amount of ground existing. In multistoried buildings one should apprehension about all the forces acting on a structure, its self weight as well as the SBC .Good quality of beam column reinforcement should be used to counter react the external forces satisfactorily acting on a structure. The soil beneath the structure should be hard enough to distribute the load uniformly to the foundation.

Smita Singh, Dilip Kumar, It is common misconception that masonry infill in structural steel or reinforced concrete frames can only increase the overall lateral load capacity, and therefore must always be beneficial to seismic performance. If the masonry infill is ignored in the design phase, it may be assumed that each frame in each direction is subjected to very similar seismic lateral forces, because of the structural symmetry. The true influence of the infill on frames will be to stiffen these frames relative to the other frames .The consequence will be that the natural period of the structure will decrease, and seismic forces will correspondingly increase.

Shweta Laddha, Nikhil S. Agrawal, attempt to access the performance of masonry infilled reinforced concrete (RC) frames with open first storey of with and without opening by performing its static and dynamic analysis. The static analysis is performed by using STAAD-Pro software whereas; dynamic analysis is performed with the help of ETABS software, because of some limitation in Staad-Pro.for dynamic analysis. In this research work, symmetrical frame of college building (G+5) located in seismic zone-III is considered by modeling of initial frame.

3. METHODOLOGY

Significant studies and research is reported in the literature since five decades, which attempts to understand the behavior of infilled frames. Different types of analytical models based on the physical understanding of the overall behavior of an infill panel were developed over the years to mimic the behavior of infilled frames. The single strut or equivalent method is the most widely used as it is simple and evidently most suitable for large structures.

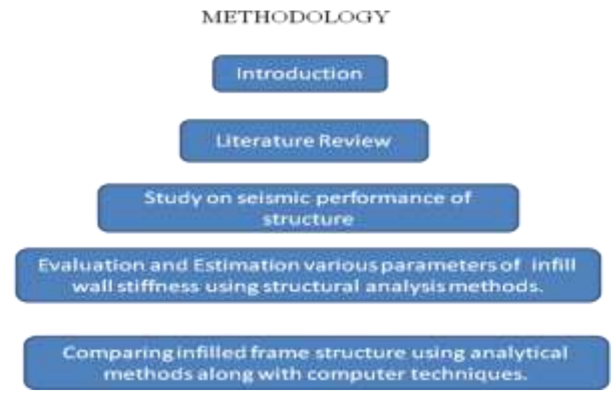

Fig.1 Flow Chart Showing Methodology of my work

4. DATA FOR SEISMIC ANALYSIS

In seismic design force earthquake shaking is random and time variant and depends upon the zone. But, most design codes represent the earthquake-induced inertia forces as the net effect of such random shaking in the form of design equivalent static lateral force. This force is called as the Seismic Design Base Shear VB and remains the primary quantity involved in force-based earthquake-resistant design of buildings. This force depends on the seismic hazard at the site of the building represented by the Seismic Zone Factor Z.

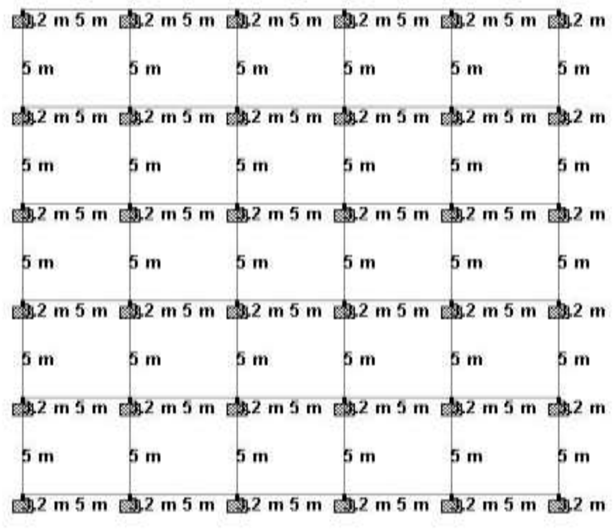

Fig.2 Regular Plan of Building

Table.No.01.Data used for Staad Pro Modeling

Sr.No	Particulars	Dimension /Size /Value
1	Model	G+5
2	Sesimic Zone	III
3	City	Nasik
4	Plan size	25*25m

5	Floor Height	3.20m
6	Size of columns	0.6*0.6m
7	Size of beam	0.4*0.3
8	Walls	External 0.23m,Internal 0.115m
9	Thickness of Slab	150mm
10	Type of soil	Type-II, Medium Soil
11	Earthquake Load	As per IS1893-2002
12	Static Analysis	Equivalent Lateral force
13	Dynamic Analysis	Response Spectrum Method
14	Support conditions	Fixed
16	Specific Weight of RCC	25kN/m2
17	Specific Weight of infill	20KN/m2
18	Live Load	4KN/m2 and 12 kN/m2
19	Importance Factor	1 (Normal Building)
20	Response Reduction Factor	3.0,5.0
21	Software Used	STAAD Pro

5. STAAD PRO MODELING

A study was undertaken which involved seismic analysis of RC frame buildings with different models that include bare Frame, infilled frame considering equivalent strut method. The parameters such as base shear, time period, natural frequency, and node displacements are found.

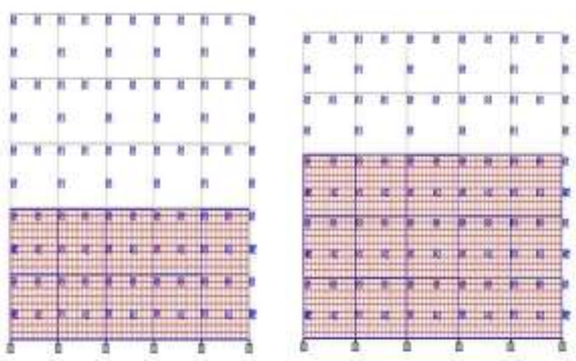

Fig.3 showing infill parameters applied with sectional properties.

6. RESULTS AND DISCUSSION

The seismic analysis of all the frame models that includes bare frame, infilled frame (for various floors) was done by using STAAD PRO and the following results are found after carrying analysis.

Table. no.2, showing fundamental time period & base shear

Model	Time Period (SEC)	Base Shear (KN)
Bare Frame	0.627	510.415
G+1	0.600	839.57
G+2	0.600	866.87
G+3	0.600	921.42
G+4	0.600	940.17

Table. no.3, showing Lateral Load generated at each floor

Mode	storey	Bare frame	G+1 Infill	G+2 Infill	G+3 Infill	G+4 Infill
6	19.2	310.21	402.97	405.43	404.32	403.26
5	16	239.32	274.41	285.83	283.54	283.79
4	12.8	150.43	181.23	182.93	181.66	181.97
3	9.6	84.61	101.9	103.0	102.2	102.3
2	6.4	37.60	45.39	45.90	45.50	45.94
1	3.2	9.40	11.37	11.44	11.376	11.373

Table. no.4, showing Frequency and time period generated at each mode for G+1 & G+2 infilled frame

	Response Spectrum Method			
Mode	Frequency	Period	Frequency	Period
	(Cycle/sec)	(Sec)	(Cycle/sec)	(Sec)
1	0.615	1.627	0.670	1.493
2	0.616	1.624	0.747	1.339
3	0.818	1.221	0.855	1.168
4	1.416	0.706	1.202	0.831
5	1.424	0.702	1.291	0.774
6	1.430	0.699	1.435	0.696

Table.no.5, showing Peak storey in X direction generated

Storey	Peak Storey Generated in X Direction (KN) Infilled				
	Bare Frame	G+1	G+2	G+3	G+4
5	5718.73	9605.38	16953.78	14574.15	12315
4	13837.9	17177.38	27433.03	23125.90	21561
3	20446.3	22705.74	34276.81	28961.87	29073
2	24858.4	25920.48	38676.42	34600.08	34330
1	26428.1	27362.47	40511.69	36714.71	36816
G	26709	27362.4	38676.6	36714.7	3681

Table. no.8, showing model mass participation

Infill Type		Model Mass Participation (%)		
	Mode	X	Y	Z
Bare	1	0.00	0.00	71.76
	2	70.67	0.00	0.00
	3	1.47	0.00	0.00
G+1	1	0.00	0.00	76.71
	2	76.69	0.00	0.00
	3	1.34	0.00	1.46
G+2	1	0.00	0.00	69.24
	2	69.09	0.00	0.00
	3	0.00	0.00	0.00
G+3	1	32.62	0.00	32.75
	2	32.75	0.00	32.62
	3	0.21	0.00	0.21
G+4	1	28.66	0.00	32.64
	2	32.64	0.00	28.66
	3	0.94	0.00	0.03

7. CONCLUSIONS

Earthquakes in different parts of the world demonstrated the disastrous consequences and vulnerability of inadequate structures. Many reinforced concrete (RC) framed structures located in zones of high seismicity in India are constructed without considering the seismic codal provisions. The seismic analysis is carried out by equivalent static and response spectrum method. Design forces have been worked out by considering all the load combinations and analyzed with and without considering the infill wall panels using STAAD Pro Software.

1. Bare frame model shows longer time period as predicted whereas the infill frame model predicts less fundamental time period which increases as the stiffness in the wall increases.

2. The base shear calculated on the basis of infill frame model predicted much greater value than the bare frame model gave.

3. Lateral load computed is more in infill structure as compared to the bare frame structure.

4. Frequencies generated are estimates that were calculated at various modes for the corresponding fundamental time period which helps in spectral acceleration computation based on design seismic coefficient generated.

5. The peak storey calculated is minimum at top and maximum at the bottom of the structure and same is been seen in our all cases.

6. From the results, we obtained that masonry infill affects the building displacement at various node due to lateral loads (seismic), which decreases the natural time period.

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