International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 08 | Aug 2020 www.irjet.net p-ISSN: 2395-0072

Pushover Analysis of R.C. Building with Effect of Brick Masonry Infill Wall

Jagtap Umesh Mahadeo[1], Satpute S.S.[2], Patil S.K.[3], Pujari A.B.[4]

[1]Post Graduate Student, at
K J College of Engineering and Management Research, Pune, Maharashtra, India.
[2]Assistant Professor of Civil Engineering Department, at
K J College of Engineering and Management Research, Pune, Maharashtra, India.
[3]Associate Professor and HOD of Civil Engineering Department, at
K J College of Engineering and Management Research, Pune, Maharashtra, India.
[4]Associate Professor of Civil Engineering Department, at
K J College of Engineering and Management Research, Pune, Maharashtra, India.

Abstract - *The pushover analysis is a course of action in which simplified nonlinear technique uses to estimate seismic structural deformation. Now a days in Reinforced concrete (R/C) frame we are using masonry infill's for architectural, aesthetic or economic reasons. In this project, we have to study the effect on the infill's on the failure patterns of the RC frames.*

The main intend of this study is to demonstrate that the addition of in infilled walls to RC frame effectively contributes strength and stiffness of the structure against seismic load and suggest the guideline for evaluating strength and stiffness of unreinforced infill panels. These guidelines are strictly based on FEMA-356. In this project we are using three types of bricks such as Red brick, Fly ash brick, Light weight brick i.e. siporex bricks. From output non-linear analysis, we compare Storey V/S i) Base shear, ii) Srorey displacement, iii) storey drift also Base Shear V/S Monitored Displacement and Spectral acceleration V/S Spectral Displacement. We are also study the effect of bare frame with shear wall using ETABS 2017 software.

Key Words: Pushover Analysis, Brick infill, FEMA-356, Displacement, Drift, Shear Wall, ETAB-2017.

1. INTRODUCTION

Now a days, it becomes important to find out the earthquake behavior of the structure with infill walls in earthquake engineering. For analysis of the frame there are several methods used for earthquake analysis, such as Seismic analysis, i.e. linear static method, Response spectrum analysis, i.e. linear dynamic method, Pushover analysis i.e. nonlinear static analysis, time history method i.e. nonlinear dynamic method. But here we use a nonlinear static method. The aim of pushover analysis is to determine and control the performance of structure under earthquake. In older IS 1893 code we don't consider the strength and stiffness of infill wall, but in upgraded IS code we have to consider strength and stiffness of infill wall.

In this project we are using 17 Storey model with different types of wall as an equivalent diagonal strut.
• Model 1: Bare frame as a structural model.
• Model 2: Structural model with Siporex brick infill wall model as equivalent diagonal struts
• Model 3: Structural model with fly ash brick infill wall model as equivalent diagonal struts
• Model 4: Structural model with red brick infill wall model as equivalent diagonal struts.
• Model 5: Bare frame with Shear wall as a structural model.

1.1 Pushover Analysis

It is a Nonlinear Static analysis under permanent vertical load. Here displacement is incrementally increased from zero to a prescribed ultimate displacement or until the structure is unable to resist further loads. In pushover analysis, we focous on the yielding plastic hinge formation and failure of different structural components are noted and the total force is plotted against displacement to define a capacity curve.

2. Objective of Study

a. To study the effect of various types of brick masonry infill walls, in RC framed building, using pushover analysis.
b. To study the effect of providing shear walls, in RC framed building, using pushover analysis.
c. To compare the seismic response of building in terms of Storey V/S i) Base shear, ii) Srorey displacement, iii) storey drift also Base Shear V/S Monitored Displacement and Spectral acceleration V/S Spectral Displacement
d. Determination of performance point of building for seismic performance.
e. To determine the best possible combination of structural system that would be both economical and effective.

3. DETAILS OF STRUCTURE CONSIDERED

Details of structure:
Structure Type = G+15 storey RCC building
Storey Height = 3 meter

Foundation Height = 3 meter
Plan dimensions = 25.5 X 16 meter
Remaining necessary data of models are in Table I

Table- I: Data of the Structures

Parameters	**Values**
Grade of Concrete	M35
Grade of Steel	Fe 500
Slab Thickness	150 mm
Beam Size	230*500 mm
Column Size	400*800 mm
Shear Wall Thickness	200 mm
Live load	2 KN/m2
Floor Finish	1.5 KN/m2
Density of Red Brick	18 N/mm2
Density of Fly ash Brick	17 N/mm2
Density of siporex Brick	4 N/mm2
Compressive strength of Red brick	5KN/mm2
Compressive strength of Fly ash brick	4KN/mm2
Compressive strength of siporex brick	3.5KN/mm2
Brick strut size	230X400 mm
Seismic Zone	III
Zone Factor	0.16
Importance Factor	1.2
Soil Type	I
Response Reduction Factor	5

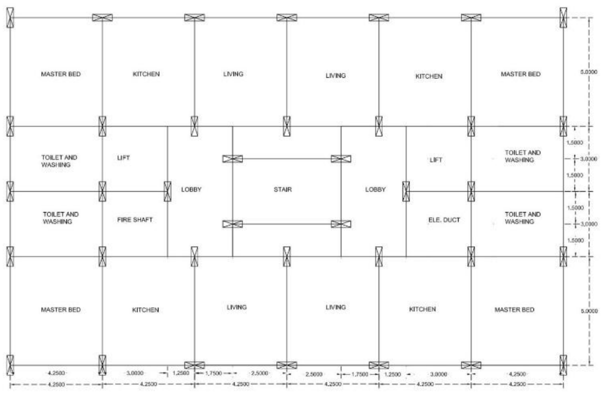


Fig. I: Basic plan for all model

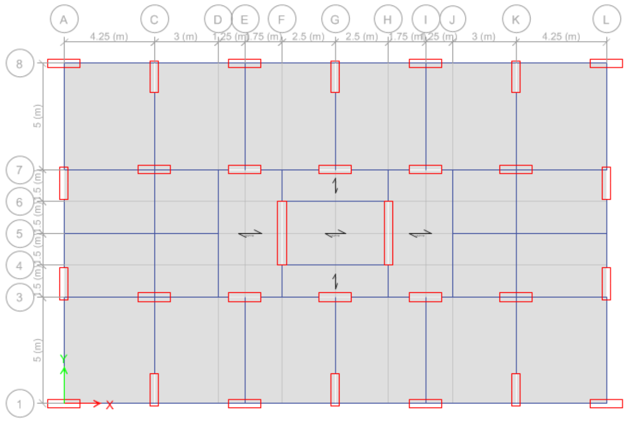


Fig. II: Shear wall position for Model-V

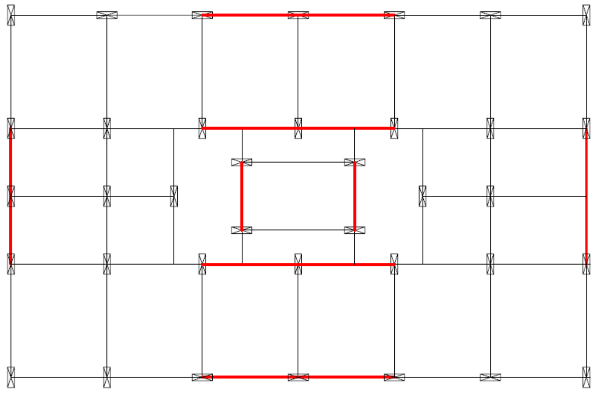


Fig. III: Strut position in plan for model II,III,IV

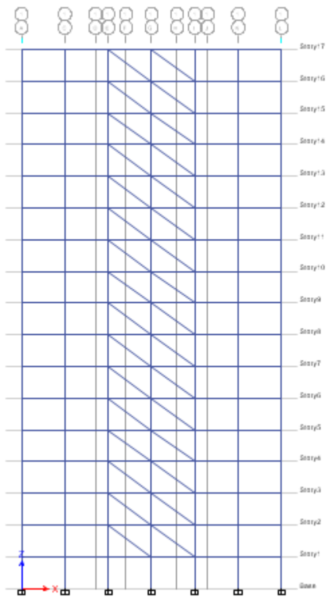


Fig. IV: Strut position in elevation for model II,III,IV

4. RESULTS AND DISCUSSION

The results are obtained based on Storey Drifts, Displacement, and Base Shear VS Monitored Displacement. Table 2 and Table 3 show Storey Drifts in X and Y direction respectively and Graph 1 and Graph 2 are respective graphs. The Displacement results show in Table 4 and Table 5 and its graphical representation in Graph 3 and Graph 4. Table 6 and table 7 shows Base shear VS Monitored Displacement results in X and Y direction and Graph 5 and Graph6 is its graphical representation in Xand Ydirection respectively.

Table-II: Storey drifts in X direction

Storey	Model 1	Model2	Model 3	Model 4	Model 5
Base	0	0	0	0	0
Story1	0.001589	0.0007	0.000498	0.000507	0.0012
Story2	0.003631	0.0015	0.000918	0.000925	0.003
Story3	0.004698	0.0029	0.000991	0.000992	0.004
Story4	0.005171	0.0040	0.000979	0.000978	0.0048
Story5	0.005282	0.0043	0.00093	0.000928	0.005
Story6	0.005173	0.0045	0.000867	0.000865	0.0049
Story7	0.00493	0.0042	0.000799	0.000797	0.0045
Story8	0.004604	0.0038	0.000729	0.000728	0.0042
Story9	0.004229	0.0036	0.000659	0.000657	0.0039
Story10	0.003825	0.0033	0.000587	0.000586	0.0035
Story11	0.003405	0.0029	0.000515	0.000514	0.0032
Story12	0.002981	0.0024	0.000443	0.000442	0.0027
Story13	0.002562	0.0021	0.000371	0.000371	0.0024
Story14	0.002158	0.0019	0.0003	0.000299	0.002058
Story15	0.001787	0.0014	0.000229	0.000229	0.0017
Story16	0.001471	0.0010	0.000164	0.000163	0.001371
Story17	0.001248	0.0007	0.000111	0.000111	0.00118

Table- III: Storey drifts in Y direction

Storey	Model 1	Model 2	Model 3	Model 4	Model 5
Base	0	0	0	0	0
Story1	0.001744	0.001588	0.001604	0.001628	0.00143
Story2	0.004086	0.002915	0.002924	0.002937	0.002775
Story3	0.005518	0.003454	0.003456	0.00346	0.003336
Story4	0.006338	0.003577	0.003573	0.003572	0.003481
Story5	0.006726	0.003499	0.003491	0.003488	0.003419
Story6	0.006814	0.003326	0.003315	0.003311	0.003256
Story7	0.00669	0.003107	0.003093	0.00309	0.003043
Story8	0.00642	0.002866	0.002848	0.002847	0.002805
Story9	0.006048	0.002612	0.002592	0.002592	0.002554
Story10	0.00561	0.002352	0.002329	0.00233	0.002296
Story11	0.00513	0.002088	0.002063	0.002065	0.002035
Story12	0.00463	0.001822	0.001794	0.001798	0.001772
Story13	0.004131	0.001557	0.001527	0.001531	0.00151
Story14	0.003652	0.001295	0.001263	0.001268	0.001253
Story15	0.003216	0.001043	0.001009	0.001015	0.001006
Story16	0.002856	0.000814	0.00078	0.000786	0.000782
Story17	0.0026	0.000636	0.000603	0.000609	0.000608

Table-IV: Storey displacement in X direction

Storey	Model 1	Model 2	Model 3	Model 4	Model 5
Base	0	0	0	0	0
Story1	4.498	3.545	3.502	2.6	2.629
Story2	14.48	9.774	9.751	7.27	8.863
Story3	27.624	17.293	17.305	12.919	17.265
Story4	42.308	25.147	25.21	18.837	26.939
Story5	57.697	33.075	33.196	24.82	37.313
Story6	73.295	40.952	41.132	30.769	48.004
Story7	88.774	48.696	48.934	36.621	58.746
Story8	103.894	56.231	56.524	42.32	69.331
Story9	118.447	63.478	63.825	47.808	79.593
Story10	132.243	70.353	70.748	53.021	89.381
Story11	145.091	76.76	77.201	57.892	98.559
Story12	156.803	82.598	83.079	62.345	107.001
Story13	167.198	87.759	88.275	66.3	114.597
Story14	176.118	92.131	92.677	69.677	121.265
Story15	183.465	95.615	96.187	72.401	126.973
Story16	189.264	98.161	98.754	74.433	131.78
Story17	193.79	99.884	100.495	75.848	135.893

Table-V: Storey displacement in Y direction

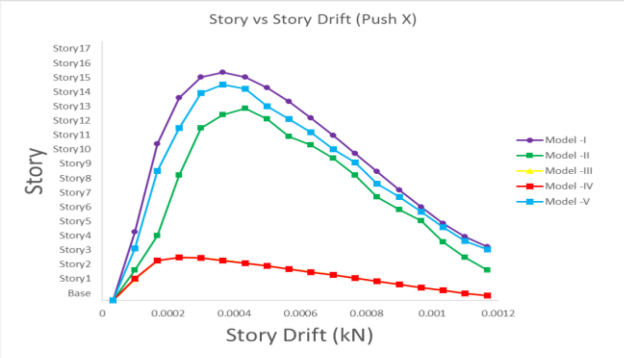
Storey	Model 1	Model 2	Model 3	Model 4	Model 5
Base	0	0	0	0	0
Story1	2.843	2.534	2.487	1.841	2.176
Story2	9.105	6.821	6.76	5.027	7.482
Story3	17.975	12.625	12.531	9.326	14.938
Story4	28.306	18.942	18.819	14.014	23.858
Story5	39.477	25.474	25.324	18.866	33.741
Story6	51.057	32.056	31.878	23.758	44.205
Story7	62.733	38.581	38.376	28.611	54.955
Story8	74.264	44.967	44.733	33.363	65.752
Story9	85.451	51.137	50.873	37.958	76.396
Story10	96.12	57.013	56.718	42.34	86.714
Story11	106.117	62.515	62.188	46.45	96.557
Story12	115.301	67.559	67.201	50.228	103.801
Story13	123.556	72.061	71.671	53.612	110.347
Story14	130.795	75.94	75.521	56.546	117.131
Story15	136.991	79.137	78.692	58.984	121.144
Story16	142.207	81.643	81.175	60.919	125.144
Story17	146.658	83.571	83.084	62.426	129.144

Table-VI: Base Shear VS Monitored Displacement in X Direction

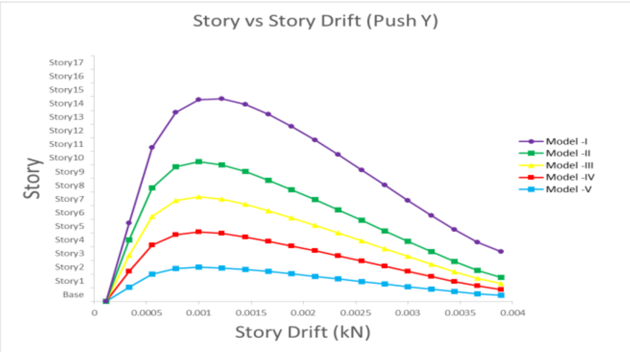
Model I		Model II		Model III		Model IV		Model V	
Monitored Displ	**Base Force**	**Monitored Displ**	**Base Force**	**Monitored Displ**	**Base Force**	**Monitored Displ**	**Base Force**	**Monitored Displ**	**Base Force**
mm	kN	mm	kN	mm	kN	mm	kN	mm	kN
0	0	0	0	0	0	0	0	0	0
-30	737.5479	-30	846.4912	-30	868.2535	-30	890.7834	-6.765	3308.853
-60	1475.096	-60	1692.982	-60	1736.507	-60	1781.567	-24.833	13644.61
-90	2212.644	-90	2539.474	-90	2604.761	-90	2672.35	-29.847	13646.05
-103.345	2540.732	-102.57	2894.163	-101.762	2945.172	-101.754	3021.357	-34.877	13647.93
-133.506	3250.086	-133.951	3739.762	-133.004	3807.487	-132.377	3891.789	-45.734	14004.4
-169.09	3627.691	-164.592	4206.049	-163.261	4286.024	-163.993	4421.98		
-202.238	3825.492	-197.076	4531.521	-197.792	4641.236	-197.043	4783.658		
-233.089	3948.934	-227.742	4768.043	-232.678	4914.316	-235.777	5108.413		
-268.863	4063.007	-259.808	4973.008	-267.259	5135.567	-276.615	5377.403		
-299.481	4137.672	-293.267	5145.959	-297.49	5294.54	-300	5516.403		
-300	4138.773	-300	5178.542	-300	5307.617				

Table-VII: Base Shear VS Monitored Displacement in Y Direction

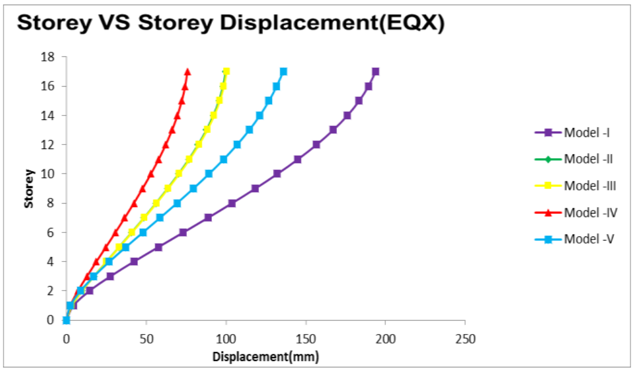
Model I		Model II		Model III		Model IV		Model V	
Monitored Displ	**Base Force**	**Monitored Displ**	**Base Force**	**Monitored Displ**	**Base Force**	**Monitored Displ**	**Base Force**	**Monitored Displ**	**Base Force**
mm	kN	mm	kN	mm	kN	mm	kN	mm	kN
0	0	0	0	0	0	0	0	0	0
6.97E-05	2829.936	0.032	3151.068	0.015	3194.921	0.019	3245.133	0.003	3596.819
0.00012	4329.902	0.033	3258.06	0.016	3454.495	0.02	3385.381	0.003	3648.186
0.001	4344.864	0.036	3284.039	0.018	3480.625	0.025	3444.308	0.003	3699.07
0.001	4429.091	0.037	3407.272	0.018	3506.571	0.03	4150.137	0.004	4247.949
0.004	4446.465	0.041	3432.313	0.018	3506.827	0.033	4173.413	0.004	4310.106
0.015	4466.039	0.048	3958.143	0.019	3525.743	0.034	4289.015	0.005	4926.7
0.015	4478.479	0.051	3982.898	0.021	3954.401	0.034	4289.349	0.005	4986.446
0.042	4483.276	0.051	4029.963	0.025	3976.256	0.034	4300.891	0.005	5049.451
0.047	4546.554	0.054	4050.613	0.026	4000.155	0.037	4342.717	0.005	5106.795
0.143	4619.714	0.058	4270.861	0.027	4120.443	0.041	4387.235	0.005	5107.431
0.143	4619.723	0.061	4290.368	0.029	4141.575	0.042	4415.285	0.005	5125.165
0.143	4619.75	0.063	4393.787	0.03	4257.435	0.042	4435.356		
0.143	4619.76	0.067	4421.852	0.032	4280.597	0.043	4466.09		
0.143	4619.821	0.068	4442.185	0.034	4299.262	0.043	4462.906		
		0.076	4468.824	0.034	4309.244	0.043	4464.039		
		0.077	4538.088	0.035	4468.539	0.044	4474.552		
		0.077	4538.522	0.035	4465.446	0.046	4496.161		
				0.035	4466.193	0.046	4513.537		
				0.041	4475.853	0.048	4535.115		
				0.041	4478.026	0.048	4535.401		
				0.042	4609.827	0.048	4535.118		
				0.043	4630.494	0.048	4536.549		
				0.043	4632.401	0.048	4535.727		
				0.043	4632.396	0.048	4536.312		
						0.048	4536.617		



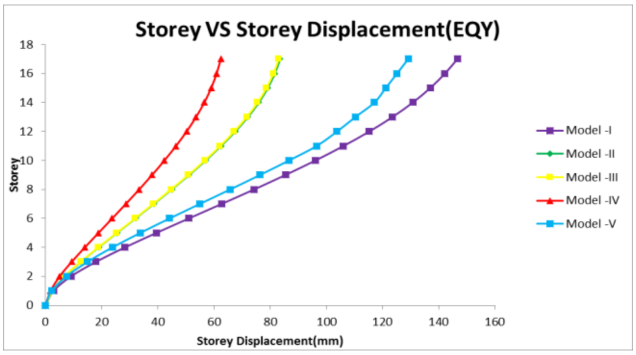
Graph-1: Storey Drift in X direction



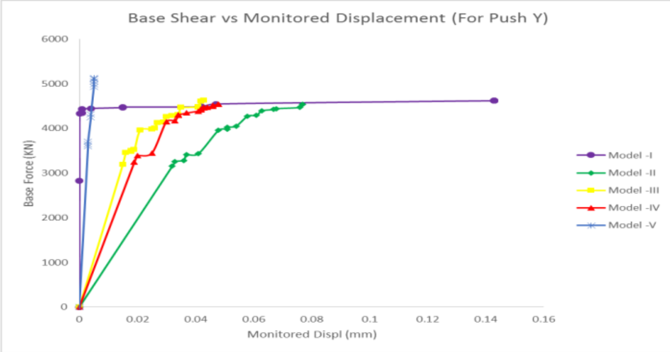
Graph-II: Storey drifts in Y direction



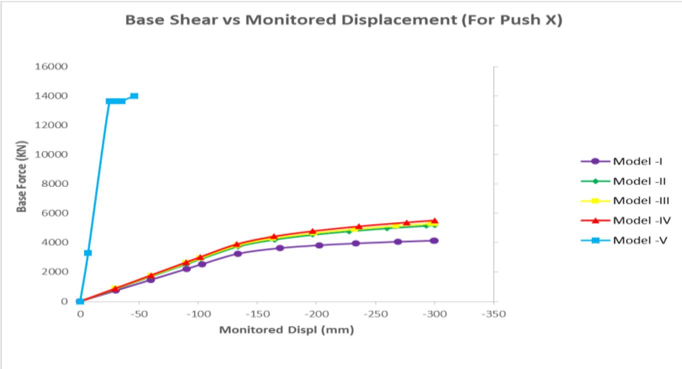
Graph-III: Storey Displacement in X Direction



Graph-IV: Storey Displacement in Y Direction



Graph-V: Base Force VS Monitored Displacement in X Direction



Graph-VI: Base Force VS Monitored Displacement in Y Direction

5. CONCLUSIONS

A) In present work to study the inelastic behavior of the structure total five analytical models of 17-storey RC frame buildings have been investigated for the effect of various masonry infill wall like red brick, light weight block and fly ash brick and separate model for shear wall. Present study provide idea about nonlinear static analysis of 17 storey building using Etabs 17.0. Based on the analytical investigation, the following inferences have been drawn: Table II and Table III show storey drift results of all models. Based on storey drift investigations following conclusions are drawn:

1. Storey drift variation in X direction for model III and IV are nearly same it may due to building have uniform stiffness in x direction. In Y direction stiffness variation and response of structure is changing, it is clear from storey drift values observed in Y direction.
2. Model IV performed well in X and Y direction and shows less storey drift values as compared to all other models and bare frame shows higher storey drift values it may due to less stiffness and higher displacement.

3. Model I also shows higher value of storey drift in X and Y than model IV and II which is due to lesser stiffness of beam column structure and absence of infill and shear wall.

4. Model II also shows average drift values even if shear available it may due to quantity of shear wall available in Y direction and modifiers are applied as per codal provision.

B) Table IV and Table V show storey displacement results of all models. Based on storey displacement investigations following conclusions are drawn:

1. From above table and graph it is observed that performance of model-I is poor as compare to other four model and model-IV performed well showing more than 60% reduction in displacement. It is due to increased stiffness of inclusion of red brick masonry in X and Y direction.

2. Model II and model III are performed well and reduced almost 50% displacement as compared to model I.

3. Model - V shows 30% reduction in X direction and 12% reduction in Y direction it is due to stiffness offered by shear wall with minimum thickness of 200 mm and modifiers applied as per IS 1893: 2016.

4. All models with infill wall and shear wall showing reduction of displacement based on configuration and material used.

C) Table VI and Table VII show storey Shear VS monitored displacement results of all models. Based on storey Shear VS monitored displacement investigations following conclusions are drawn:

1. Model II,III IV and V has performed well in X direction and resist max base shear with almost same displacement than model I which may due to inclusion of infill and shear wall.

2. Model I shows maximum stiffness in Y direction due to very less displacement. It is primarily due to 70% columns are available in y direction.

3. Model II resist less base shear than any other model in Y direction and model V resist maximum base shear with negligible displacement.

4. The infill walls contribute significantly to the stiffness of the building. This is primarily due to diagonal action of infill increases lateral resistance and initial stiffness of the frames and have a significant effect on the reduction of the global lateral displacement. It is essential to consider the effect of masonry infills for the seismic evaluation of moment resisting RC frames, and new RC frame, especially for the prediction of its ultimate state.

5. It is beneficial to consider well planned infill walls and shear wall in analysis because it can share significant amount of lateral shear without undergoing significant damage.

6. Model v shows maximum stiffness and very less displacement value it is due to maximum moment of inertia in considered direction available due to provision of shear wall.

7. provision of shear wall instead of column will be better option as per new codal provision however less value of R than SMRF and applied modifiers. It is clear from model V results which shows high stiffness and very less displacement values when analysed in X and Y direction.

ACKNOWLEDGMENT

It is with immense pleasure that we express my sincere sense of gratitude and humble appreciation to Prof.Satpute S.S for his invaluable guidance, whole-hearted co-operation, constructive criticism and continuous encouragement in the preparation of this thesis. Without his support and guidance, the present work would not be a possible.

We take this opportunity to thank all our scholar friends & family for their valuable support and encouragement throughout the preparation of this work. We also thank all those who have directly or indirectly helped in completion of this seminar report.

REFERENCES

1] IS 1893 (Part 1)–2002, "Indian Standard Criteria for Earthquake Resistant Design of Structures, Part 1: General Provision and Buildings", Bureau of Indian Standards, New Delhi.
2] FEMA 356 (2000) "Pre-standard and Commentary for the Seismic Rehabilitation of Buildings", Federal Emergency Management Agency, Washington, DC, USA.
3] ATC-40 (1996) "Seismic Analysis and Retrofit of Concrete Buildings", vol. I, Applied Technology Council, Redwood City, CA, USA.
4] Alessandra Fiore, Girolamo Spagnoletti, Rita Greco, "On the prediction of shear brittle collapse mechanisms due to the infill-frame interaction in RC buildings under pushover analysis" Elsevier journals Accepted 20 April 2016.
5] Beatrice Belletti , Cecilia Damoni, Antonello Gasperi "Modeling approaches suitable for pushover analyses of RC structural wall buildings"
6] Kasım Armagan KORKMAZ, Fuat DEM_R and Mustafa S_VR "Earthquake Assessment of R/C Structures with Masonry Infill Walls" International Journal of Science & Technology Volume 2, No 2, 155-164, 2007
7] Ning Ning, Dehu Yu, Chunwei Zhang * and Shan Jiang "Pushover Analysis on Infill Effects on the Failure Pattern of Reinforced Concrete Frames"
8] Praveen Rathod, Dr.S.S.Dyavanal, "Pushover Analysis of Seven Storeyed RC Buildings with Openings in Infill Walls" International Journal of Engineering Trends and Technology (IJETT) – Volume 14 Number 3 – Aug 2014

AUTHORS PROFILE

Jagtap Umesh Mahadeo is a PG student of Structural Engineering at Civil Engineering Department, KJ College of Engineering and Management Research,Pune,Maharashtra.

Satpute S.S. is working as Assistant Professor in Civil Engineering Department, KJ College of Engineering and Management Research,Pune,Maharashtra.

Dr Santosh K Patil is HOD of Civil Engineering Department, KJ College of Engineering and Management Research, Pune,Maharashtra.

Dr Atul B. Pujari is working as Associate Professor in Civil Engineering Department, at KJ Collegeof Engineering and Management Research, Pune, Maharashtra.