

Behaviour of RCC Multistorey Structure With and Without Infill Walls

Mohammed Nauman¹, Nazrul Islam²

Structure Engineer, Department of Civil Engineering, Faculty of Engineering and Technology, Jamia Millia Islamia,
New Delhi, India¹

Professor, Civil Engineering Department, Islamic University, Medinah Munawwarah, Kingdom of Saudi Arabia²

Abstract: Framed reinforced concrete structures are most commonly types of structures constructed all over the world due to ease of construction and rapid progress of work. Generally brick or block work masonry is done in these frames which act as an infill panels in the framed structure. Infill walls provide the lateral stiffness to the structure. Its behaviour is very different from the bare frame structure.

Keywords: Reinforced concrete, Brick masonry, infill panels, Bare frame

I. INTRODUCTION

Behaviour of masonry infilled concrete frames under the lateral load is studied. Investigations showed that, one of the most appropriate ways of analyzing the masonry infilled concrete frames is to use the diagonally braced frame analogy. RCC buildings are generally analyzed and designed as bare frame. But after the provision of infill walls, mass of the building increases and this will result in the increase of the stiffness of the structure. During the seismic activities, response of the structure with infill walls is quite different for the structure without infill walls. Infill walls changes the dynamic behaviour of the structure. In this study two G+11 storeyed structure models are generated. In one structure, brick infill walls are modelled as strut element. These struts act as a compression members. In the other structure, only bare frame structure is modelled. All the parameters i.e. beam sizes, column sizes, floor height; load parameters etc are same for both the structures

II. RELATED WORK

Paulay & Priestley proposed a theory about the seismic behaviour of masonry infilled frame and a design method for infilled frames. Authors said that although masonry infill may increase the overall lateral load capacity, it can result in altering structural response and attracting forces to different or undesired part of structure with asymmetric arrangement. This means that masonry infill may cause structural deficiencies. Infilled frames behave differently with respect to lateral load level. At low levels, both concrete frame and infill act in a fully composite manner.

Smith & Coull presented a design method for infilled frame based on diagonally braced frame criteria. The developed method considered three possible modes of failure of infill: shear along the masonry, diagonal cracking through masonry and crushing of a corner of infill. They assumed effective width of diagonal compression strut as equal to one-tenth of the diagonal length of the infill panel. At the initial design stage, frame must be designed on the basis of the gravity loading.

Smith & Carter examined multi-story infilled frames for the case of lateral loading. In the light of experimental results, authors proposed design graphs and design method based on an equivalent strut concept. First, they focused on the composite behavior of infilled frame and failure modes. Then, the factors that affect the effective width of diagonal compression strut were determined. Finally, with known factors and behaviour, the design curves to estimate equivalent strut width, cracking and crushing strength of infill panel were presented.

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III. MODELLING & ANALYSIS OF BUILDING

The analysis of G+11 storeyed RCC structure is carried out using STAAD V8i software for special moment resisting frame situated in zone 4. These RCC G+11 storeyed structures are analysed for infill panels and without infill. Bending moments, shear forces, storey shears, and axial forces are compared for both type of structural systems.

Structure	SMRF
No. of Stories	G+11
Type of Building	Residential
Young's Modulus for Concrete	$21.7 \times 10^6 \text{ kN/m}^2$
Young's Modulus for Brick Masonry	$3.85 \times 10^6 \text{ kN/m}^2$
Grade of Concrete	M25
Density of RCC	25 kN/m^3
Beam Size	0.3x0.45m
Column Size	0.3x0.75m
Dead Load Intensity	5 kN/m^2
Live Load Intensity	2.0 kN/m^2
Seismic Zone, Z	IV
Importance Factor, I	1
Height of the Structure	39 m
Response Reduction Factor, R_F	5
Time Period for Bare Frame in X Direction	1.17 sec
Time Period for Bare Frame in Z Direction	1.17 sec
Time Period for Infill frame in X Direction	0.66 sec
Time Period for Infill frame in Z Direction	1.08 sec

Fig. 1 Modelling Data

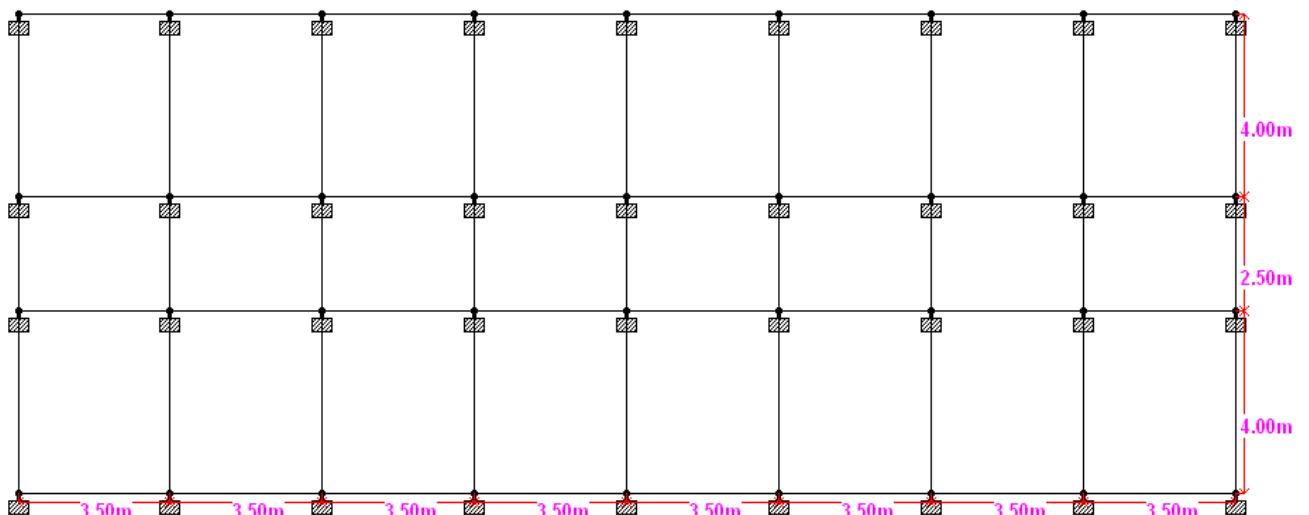


Fig. 2 Plan of Structure

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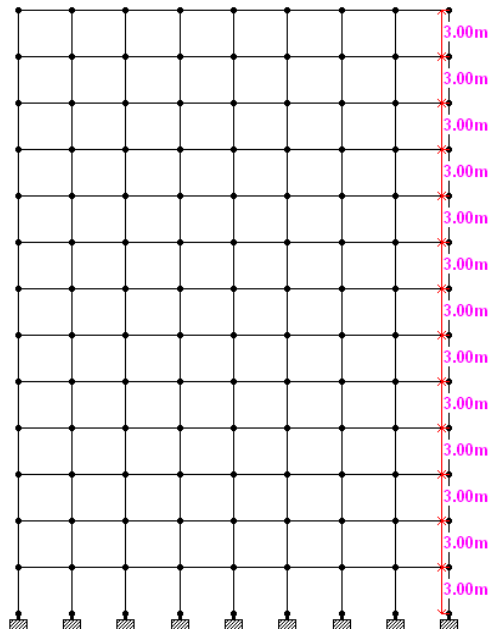


Fig. 3 Elevation of Without Infill (Bare Frame) Structure

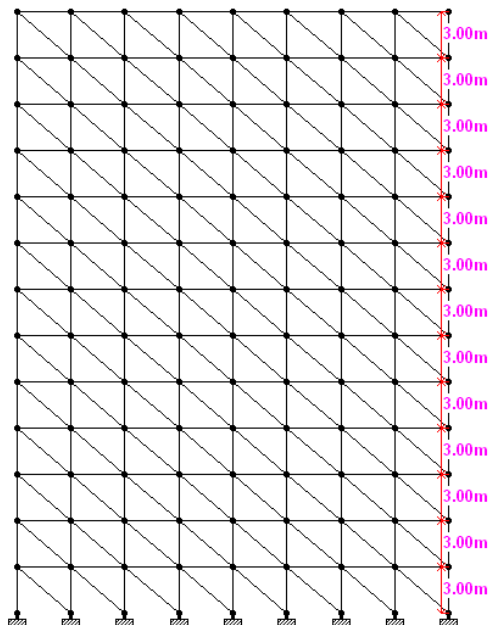


Fig. 4 Elevation of Infill Framed Structure

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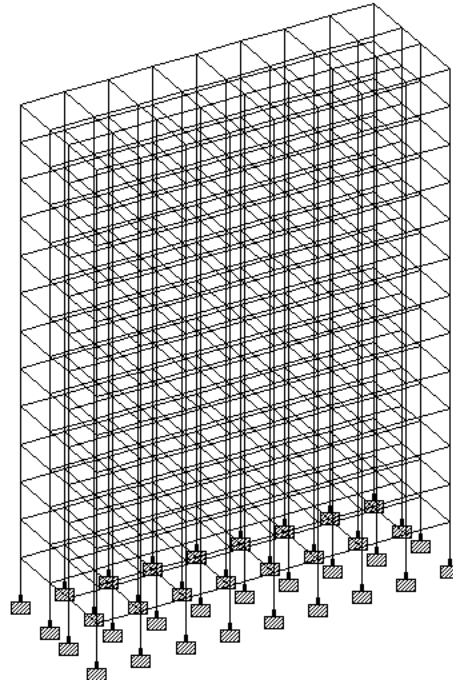


Fig. 5 Isometric View of Without Infill (Bare Frame) Structure

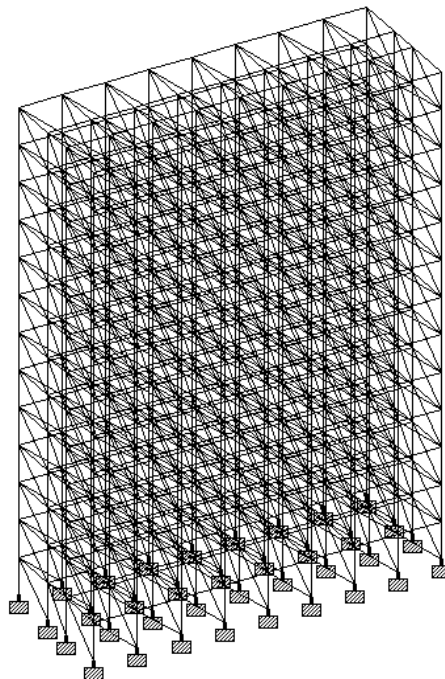


Fig. 6 Isometric View of Infill Framed Structure

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IV. RESULTS

Level	Without Infill	With Infill	Percentage Reduction
Base	0	0	0.00
Ground Floor	1.355	0.529	60.96
1 st Floor	3.525	1.2	65.96
2 nd Floor	5.89	1.917	67.45
3 rd Floor	8.301	2.671	67.82
4 th Floor	10.697	3.446	67.79
5 th Floor	13.036	4.228	67.57
6 th Floor	15.279	5.002	67.26
7 th Floor	17.383	5.754	66.90
8 th Floor	19.299	6.466	66.50
9 th Floor	20.977	7.121	66.05
10 th Floor	22.36	7.703	65.55
11 th Floor	23.393	8.195	64.97
Terrace Floor	24.05	8.583	64.31

Table. 1 Maximum Lateral Deflection (mm) in X- Direction

Level	Without Infill	With Infill	Percentage Reduction
Base	0	0	0.00
Ground Floor	1.569	0.46	70.68
1 st Floor	4.502	1.161	74.21
2 nd Floor	7.841	1.991	74.61
3 rd Floor	11.3	2.931	74.06
4 th Floor	14.77	3.96	73.19
5 th Floor	18.196	5.057	72.21
6 th Floor	21.508	6.198	71.18
7 th Floor	24.646	7.362	70.13
8 th Floor	27.542	8.526	69.04
9 th Floor	30.121	9.668	67.90
10 th Floor	32.305	10.765	66.68
11 th Floor	34.033	11.797	65.34
Terrace Floor	35.318	12.751	63.90

Table. 2 Maximum Lateral Deflection (mm) in Z- Direction

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Level	Without Infill	With Infill	Percentage Reduction
Base	0	0	0.00
Ground Floor	1.355	0.529	60.96
1 st Floor	2.17	0.67	69.12
2 nd Floor	2.365	0.718	69.64
3 rd Floor	2.411	0.754	68.73
4 th Floor	2.396	0.775	67.65
5 th Floor	2.339	0.782	66.57
6 th Floor	2.243	0.774	65.49
7 th Floor	2.104	0.751	64.31
8 th Floor	1.917	0.712	62.86
9 th Floor	1.678	0.656	60.91
10 th Floor	1.383	0.582	57.92
11 th Floor	1.034	0.492	52.42
Terrace Floor	0.657	0.394	40.03

Table. 3 Drift(mm) in X- Direction

Level	Without Infill	With Infill	Percentage Reduction
Base	0	0	0.00
Ground Floor	1.569	0.46	70.68
1 st Floor	2.933	0.701	76.10
2 nd Floor	3.339	0.83	75.14
3 rd Floor	3.459	0.94	72.82
4 th Floor	3.473	1.029	70.37
5 th Floor	3.422	1.096	67.97
6 th Floor	3.312	1.141	65.55
7 th Floor	3.139	1.164	62.92
8 th Floor	2.896	1.164	59.81
9 th Floor	2.578	1.141	55.74
10 th Floor	2.184	1.097	49.77
11 th Floor	1.728	1.032	40.28
Terrace Floor	1.285	0.954	25.76

Table. 4 Drift (mm) in Z- Direction

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Level	With Infill	Without Infill	Percentage Reduction
Base	3044.27	1059.05	65.21
Ground Floor	3044.27	1059.05	65.21
1 st Floor	2996.56	1038.54	65.34
2 nd Floor	2916.84	999.68	65.73
3 rd Floor	2800.56	949.59	66.09
4 th Floor	2652.48	894	66.30
5 th Floor	2474.46	835.57	66.23
6 th Floor	2266.41	774.82	65.81
7 th Floor	2028.18	709.8	65.00
8 th Floor	1759.62	636.93	63.80
9 th Floor	1458.96	551.27	62.21
10 th Floor	1122.29	447.66	60.11
11 th Floor	746.1	320.01	57.11
Terrace Floor	331.56	163.04	50.83

Table. 5 Storey Shear (kN) in X- Direction

Level	With Infill	Without Infill	Percentage Reduction
Base	1860.33	1059.08	43.07
Ground Floor	1860.33	1059.08	43.07
1 st Floor	1824.44	1036.43	43.19
2 nd Floor	1765.7	991.55	43.84
3 rd Floor	1685.91	935.66	44.50
4 th Floor	1593.83	876.36	45.02
5 th Floor	1493.33	819.2	45.14
6 th Floor	1384.03	766.25	44.64
7 th Floor	1263.71	713.05	43.57
8 th Floor	1128.38	653.55	42.08
9 th Floor	970.29	578.97	40.33
10 th Floor	777.69	480.96	38.16
11 th Floor	539.2	353.94	34.36
Terrace Floor	249.97	188.28	24.68

Table. 6 Storey Shear (kN) in Z- Direction

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Floor	With Infill	Without Infill	Percentage Reduction
Base to Ground	503.695	272.06	45.99
Ground to 1 st	469.07	245.251	47.72
1 st to 2 nd	418.96	212.826	49.20
2 nd to 3 rd	367.53	180.407	50.91
3 rd to 4 th	315.76	149.353	52.70
4 th to 5 th	267.35	120.069	55.09
5 th to 6 th	219.76	92.84	57.75
6 th to 7 th	173.50	68.029	60.79
7 th to 8 th	129.45	46.118	64.37
8 th to 9 th	97.45	27.709	71.57
9 th to 10 th	72.36	15	79.27
10 th to 11 th	46.47	9.065	80.49
11 th to Terrace	25.39	4.162	83.61

Table. 7 Axial Force (kN) for Earthquake in X Direction

Floor	With Infill	Without Infill	Percentage Reduction
Base to Ground	562.353	288.689	48.66
Ground to 1 st	522.286	266.68	48.94
1 st to 2 nd	466.058	238.373	48.85
2 nd to 3 rd	408.62	208.528	48.97
3 rd to 4 th	352.68	178.614	49.35
4 th to 5 th	298.95	149.287	50.06
5 th to 6 th	246.08	121.041	50.81
6 th to 7 th	195.40	94.381	51.70
7 th to 8 th	147.76	69.868	52.71
8 th to 9 th	104.06	48.127	53.75
9 th to 10 th	65.69	29.833	54.58
10 th to 11 th	36.24	15.642	56.84
11 th to Terrace	14.37	5.841	59.35

Table.8 Axial Force (kN) for Earthquake in Z Direction

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Floor	Without Infill	With Infill	Percentage Reduction
Base to Ground	43.253	34.756	19.64
Ground to 1 st	43.849	21.483	51.01
1 st to 2 nd	43.702	22.086	49.46
2 nd to 3 rd	43.094	22.14	48.63
3 rd to 4 th	42.256	22.09	47.72
4 th to 5 th	41.038	21.77	46.96
5 th to 6 th	39.272	21.02	46.48
6 th to 7 th	36.819	19.84	46.12
7 th to 8 th	33.559	18.19	45.79
8 th to 9 th	29.378	16.07	45.31
9 th to 10 th	24.149	13.51	44.04
10 th to 11 th	18.017	10.60	41.19
11 th to Terrace	11.475	5.97	48.00

Table. 9 Shear Force (kN) for Earthquake in X Direction

Floor	Without Infill	With Infill	Percentage Reduction
Base to Ground	39.413	24.493	37.86
Ground to 1 st	27.291	8.062	70.46
1 st to 2 nd	24.465	8.775	64.13
2 nd to 3 rd	23.556	8.64	63.34
3 rd to 4 th	23.013	8.50	63.05
4 th to 5 th	22.35	8.28	62.97
5 th to 6 th	21.396	7.92	62.98
6 th to 7 th	20.06	7.42	63.02
7 th to 8 th	18.274	6.75	63.07
8 th to 9 th	15.961	5.89	63.07
9 th to 10 th	13.005	4.83	62.85
10 th to 11 th	9.253	3.57	61.43
11 th to Terrace	2.868	1.43	50.00

Table. 10 Shear Force (kN) for Earthquake in Z Direction

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Floor	Without Infill	With Infill	Percentage Reduction
Base to Ground	109.997	73.03	33.61
Ground to 1 st	77.379	32.695	57.75
1 st to 2 nd	68.028	34.081	49.90
2 nd to 3 rd	64.855	33.83	47.84
3 rd to 4 th	64.662	33.56	48.09
4 th to 5 th	63.645	32.78	48.49
5 th to 6 th	61.891	31.71	48.77
6 th to 7 th	59.254	30.27	48.91
7 th to 8 th	55.549	28.16	49.30
8 th to 9 th	50.567	25.35	49.87
9 th to 10 th	43.931	21.94	50.07
10 th to 11 th	35.533	18.20	48.79
11 th to Terrace	25.804	11.21	56.55

Table. 11 Moment (kN-m) for Earthquake in X Direction

Floor	Without Infill	With Infill	Percentage Reduction
Base to Ground	34.389	10.324	69.98
Ground to 1 st	49.644	10.54	78.77
1 st to 2 nd	52.317	11.059	78.86
2 nd to 3 rd	52.398	10.44	80.08
3 rd to 4 th	51.36	9.96	80.61
4 th to 5 th	49.574	9.40	81.04
5 th to 6 th	47.285	8.74	81.51
6 th to 7 th	44.128	7.95	81.98
7 th to 8 th	39.973	7.16	82.09
8 th to 9 th	34.687	6.18	82.19
9 th to 10 th	28.188	5.07	82.01
10 th to 11 th	19.704	3.75	80.97
11 th to Terrace	14.058	2.21	84.29

Table. 12 Moment (kN-m) for Earthquake in Z Direction

V. DISCUSSION

As the structure is modelled in staad pro, figure 1 shows the modelling data of the structure. Figure 2,3,4,5& 6 show the different views of the infilled and bare frame structure. Table 1 and table 2 show the comparison of maximum lateral deflection for infilled and bare framed structure under the earthquake load in X and Z direction respectively. Table 3 and table 4 show the storey drift for infilled and bare frame structure for earthquake load in X and Z direction respectively. Table 5 and table 6 show the storey shears for different storeys for infilled and bare frame structure for earthquake load in X and Z direction respectively. Table 7 and table 8 show comparison of axial forces due to earthquake load in X and Z direction for infilled and bare frame structure. Similar comparison has been shown in table 9, 10, 11 and 12 for shear forces and bending moments for infilled and bare frame structure.

VI. CONCLUSION

Lateral deflection in both the direction decreases considerably with the introduction of in fill walls. It indicates that the stiffness of the structure is increased. Remarkable reduction in the storey drift has also been observed. Maximum reduction in the storey drifts in X and Z direction is 69.64% and 76.1% respectively.

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Drastic reduction in the storey shears has been observed in both the structures. Storey shears increases considerably after the addition of infill walls. After the addition of infill walls the building become stiff as compared to the bare frame structure, it will attract large amount of lateral forces as compared to the bare frame structure. Notable reduction in axial force for the columns has been observed for the seismic forces in both the direction after the application of the infill walls.. Maximum share of the axial force has been taken by the infill walls. Shear forces and bending moments in the columns has also been reduced considerably after the addition of infill walls in the structure. The results show that the infill framed structure always enhances the seismic performance of the building. Also it increases the stiffness of the structure hence it will have the lesser deflection as compared to the bare frame structure .

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BIOGRAPHY



Mohammed Nauman received his B.Tech. degree in Civil Engineering from Jamia Millia Islamia, New Delhi, India, in 2008 and the M.Tech degree in Earthquake Engineering from Jamia Millia Islamia, New Delhi, India, in 2013. Currently, he is a practicing structural engineer. His areas of designing are design of multistorey RCC and steel structures. His main area of interest is the retrofitting of the existing RCC and steel structures.



Dr. Nazrul Islam received has published more than 55 research papers in International journals and conferences along with the degrees like obtained his Bachelor's Degree in Civil Engineering from AMU Aligarh, India in the year 1984, Master's degree in Structures from IIT Roorkee, India (then known as University of Roorkee) in the year 1990. He has obtained his Ph.D. degree in Structures from IIT Delhi, India in the year 1998. He served as teaching faculty in Jamia Millia Islamia for more than 28 years presently working as Professor and Head of the Civil Engineering Department in Islamic university, Medinah Munawwarah, Kingdom of Saudi Arabia.