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Earthquake Analysis of High Rise Building with and Without In filled Walls

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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. In analytically analysis 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.

Key words - **In Filled Walls, High-Rise Building, and Equivalent Strut, Linear Dynamics Analysis, Displacement.**

I. INTRODUCTION

It has always been a human aspiration to create taller and taller structures. Development of metro cities in India there is increasing demand in High Rise Building. The reinforced cement concrete moment resisting frames in filled with unreinforced brick masonry walls are very common in India and in other developing countries. Masonry is a commonly used construction material in the world for reason that includes accessibility, functionality, and cost. The primary function of masonry is either to protect inside of the structure from the environment or to divide inside spaces. Normally considered as architectural elements. Engineer's often neglect their presence. Because of complexity of the problem, their interaction with the bounding frame is often neglected in the analysis of building structures. When masonry in fills are considered to interact with their surrounding frames, the lateral load capacity of the structure largely increases. This assumption may lead to an important inaccuracy in predicting the response of the structure. This occurs especially when subjected to lateral loading. Role of infill's in altering the behavior of moment resisting frames and their participation in the transfer of loads has been established by decades of research. The survey of buildings damaged in earthquakes further reinforces this understanding. The positive aspects of the presence of infills are higher strength and higher stiffness of the infilled frames. Never the less, it may not be appropriate to neglect their presence and declare the resulting design as conservative. Observed infill induced damage in buildings in the past earthquakes exposes the shortcomings of the current bare frame approach. In high rise buildings, the ordinarily occurring vertical loads, dead or live, do not pose much of a problem, but the lateral loads due to wind or earthquake tremors are a matter of great concern and need special consideration in the design of buildings. These lateral forces can produce the critical stress in a structure, set up undesirable vibrations and in addition, cause lateral sway of the structure which can reach a stage of discomfort to the occupants. In many countries situated in seismic regions, reinforced concrete frames are in filled fully or partially by brick masonry panels with or without openings. Although the infill panels significantly enhance both the stiffness and strength of the frame, their contribution is often not taken into account because of the lack of knowledge of the composite behavior of the frame and the infill. Infill wall can be modelled in several forms such as, equivalent diagonal strut approach and finite element method etc. For new buildings, infill wall is modelled and designed to provide high rigidity. Also older buildings are rehabilitated with infills that are compatible with the original frame work. Studies found that infill fails in two main ways; Shear failure and Corner crushing. The variability of the mechanical properties of infill panels, depending on both the mechanical properties of their materials and the construction details, introduces difficulty in predicting the behavior of infill panels. Additionally, the overall geometry of the structure i.e. number of bays and stories, aspect ratio of infill panels, and the detailing of the reinforced concrete members are aspects that should be considered. The location and the dimensions of openings play also an important role in the evaluation of the strength and stiffness of the infill panels. Despite the aforementioned cases of undesired structural behavior, field experience, analytical and experimental research have demonstrated that the beneficial contribution of the infill walls to the overall seismic performance of the building, especially when the latter exhibits limited engineering seismic resistance. In fact, infill panels through their in-plane horizontal stiffness and strength decrease the storey drift demands and increase the storey lateral force resistance respectively, while their contribution to the global energy dissipation capacity is significant, always under the assumption that they are effectively confined by the surrounding frame.

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II. OBJECTIVE

The main objective of this work is To carry out the effect of masonry infill walls on the seismic behavior of R.C.C. High-Rise building with linear dynamic analysis method i.e. time history analysis. and To study the single strut approach. Following results would be compared for G+9 storey building for bared frame and infilled frames. The analysis results would be compared in terms of i) Joint Displacement ii) Base shear iii) Storey drift

A. Problem Formulation and Validation

1 .Problem Formulation:

In the analysis work two models of R.C.C. High Rise building G+9 floors are made to know the realistic behavior of building during earthquake. The length of the building is 17.01m and width is 11.96m. Height of typical story is 3m. Building is located in third zone. Shear wall is provided at the end of the building to resist the earthquake as well as wind forces. Building is designed as per IS 456-2000[17]. Material concrete grade M20, M25 is used, while steel Fe 415 and Fe 500 are used. Masonry brick having density 19 KN/m3 is used. Linear properties of material are considered. Modal damping 5% is considered. For the analysis work ETABS software is used. The columns are assumed to be fixed at the ground level.

2. Schedules of R.C.C.Structural members:

Sizes of Beams 0.23x0.45 M ,

Sizes of Columns 0.23x0.6 M

Table No 2.1 Sizes of Slab and Shear wall

3. Modelling of infill walls:

Use of masonry infill walls located in between the columns of reinforced concrete framed structures plays a major role in the damage and collapse of buildings during strong earthquakes. Modelling of infill wall can be done by finite element method or static equivalent strut approach in this study later type modeling is done.

4 .FEMA Approach:

In this type of modelling stiffness of wall is considered in plane of loading. For 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 strut approach given by FEMA- 356[18] as below

Width of strut is given by -0.4

a=0.175 λ1hcol rinf

$$\lambda_1 = \left[\frac{E_m t \sin(2\theta)}{4 E_{fe} I_{col} h_{inf}} \right]^{1/4}$$

Where

hcol = Column height between centre lines of beams

hinf = Height of infill panel

Efe = Expected modulus of elasticity of frame material

Em = Expected modulus of elasticity of infill material

Icol = Moment of inertia of column

r inf = Diagonal length of infill panel

t = Thickness of infill panel and equivalent strut

θ= diagonal angle

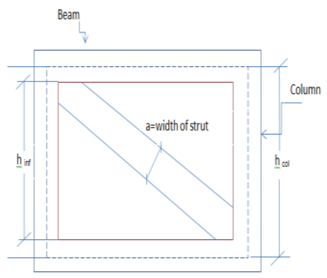

Fig 1 Equivalent Width of Strut

5 .Width of strut for R.C.C. High Rise Building

Table 1. Thickness Table

Slab and Wall Thickness	
One Way Slab	0.10 m
Terrace Slab	0.125 m
Shear Wall	0.15 m

Table 2: Strut Widths

Sr.No	Strut Width (M)
1	1.62
2	1.73
3	1.20
4	1.23
5	1.32
6	1.54
7	1.56
8	1.80

6. Time History Analysis

Static procedures are appropriate when higher mode effects are not significant. This is generally true for short, regular building. Therefore, for tall Buildings, building with torsional irregularities, or non-orthogonal systems, a dynamic procedure is required. There are two types of dynamic analysis; response spectrum analysis and linear dynamic analysis i.e. time history analysis. In this work

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killare Earthquake time history is used for the analysis.1. Killare earthquake - Centered near the village of Killari, Latur district, Maharashtra State, Central India (18.2N; 76.4E) September 30, 1993, 00:03:53 local time, Ma = 6.4; Mb= 6.3; Mw= 6.1; centroid depth = 5km; moment tensor solution yields an almost pure thrust with quasi-horizontal P axis striking N31° E.

Table.3 Comparison of Displacement given by ETABS and Staad Pro-07

Displacement at top floor	
EATABS	STAAD PRO 07
0.0055m	0.0054m

III. RESULTS AND DISCUSSION

1 Base Shear

Table. 4 Base Shear and B.M. Of G+9 Model with Infill Wall

Sr.No	Storey	Base Shear (KN)	Time Period	B.M. (KN-M)
1	11	0.00	0.00	0.00
2	10	67.92	0.065	203.77
3	9	132.45	0.13	601.11
4	8	183.43	0.17	1151.39
5	7	222.46	0.21	1818.77
6	6	251.14	0.24	2572.18
7	5	271.05	0.26	3385.33
8	4	283.8	0.27	4236.72
9	3	290.96	0.28	5109.61
10	2	294.15	0.28	5992.06
11	1	294.69	0.28	6876.14

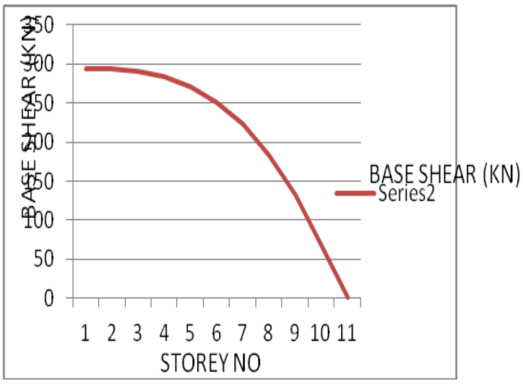

Fig 2. Base Shears for Infill Walls

Table 5 Base shear and B.M. of G+9 Model with Out Infill Wall

Sr.No	Storey	Base Shear (KN)	Time Period (SEC)	B.M. (KN-M)
1	11	0.00	0.00	0.00
2	10	168.17	0.16	504.51
3	9	350.89	0.33	1557.19
4	8	493.37	0.47	3037.31
5	7	600.39	0.57	4838.49
6	6	677.02	0.65	6869.54
7	5	728.31	0.70	9054.48
8	4	759.34	0.72	11332.5
9	3	775.17	0.74	13658
10	2	780.87	0.75	16000
11	1	781.27	0.75	17172.5

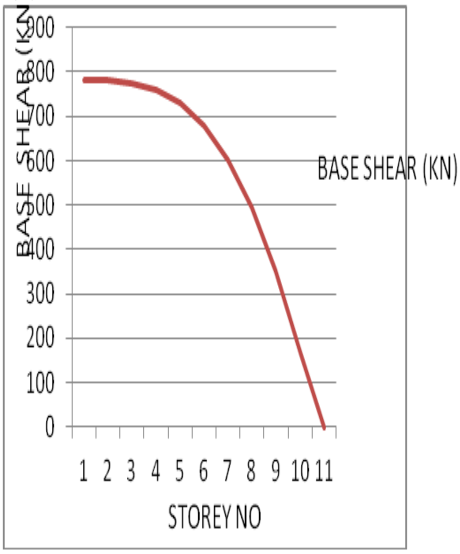

Fig 3. Base Shear For Without Infill Wall

Table 6 Base Shear for Various Cases

Sr.No	Case	Base Shear (KN)	% Diff.
1	With Infill	294.69	
2	Without Infill Single Strut Earthquake Ux	781.27	4.86

2. Displacements

Joint displacement of the building is compared for. Various cases Table No 3.5. Displacement comparison between with and without infill wall in ux direction

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Table 7 Displacement Vs Storey No. For With and Without Infill Wall in Uy Direction

Earthquake Direction Uy- Joint Displacement (M)					
Sr.No	Storey	Point	Without Infill	With Infill	% Diff
1	11	47	0.00555	0.0132	0.77
2	10	9	0.0052	0.0151	0.99
3	9	16	0.0048	0.0141	0.93
4	8	30	0.0044	0.0129	0.85
5	7	43	0.0039	0.0114	0.75
6	6	30	0.0033	0.0097	0.64
7	5	41	0.0027	0.0079	0.52
8	4	41	0.0021	0.006	0.39
9	3	41	0.0015	0.0041	0.26
10	2	41	0.001	0.0024	0.14
11	1	41	0.0006	0.0009	0.03

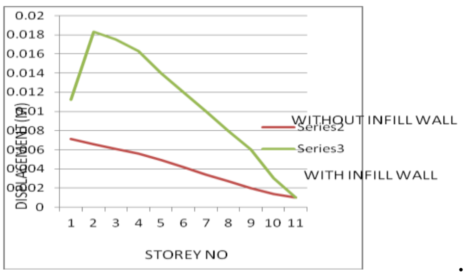

Fig 4. Displacement Vs Storey No. For With and Without Infill Wall Ux Direction

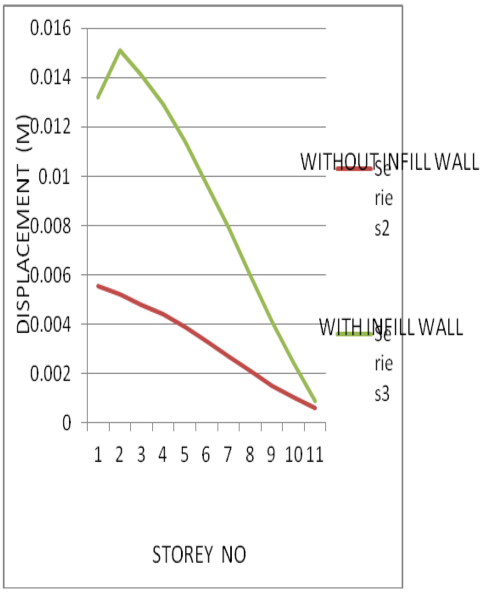

Fig 5. Displacement Vs Storey No. For With and Without Infill Wall in Uy Direction

Table 8 Storey Drift For With and Without Infilled Walls in Ux Direction.

Storey Drift				
Point	Storey	Without Infill	With Infill	% Diff
36	11	0.000135	0.000317	0.018
49	10	0.000128	0.000324	0.0196
9	9	0.000159	0.000415	0.0256
41	8	0.000182	0.000497	0.0315
41	7	0.000199	0.000562	0.0363
41	6	0.000207	0.000607	0.0400
41	5	0.000213	0.000628	0.0415
43	4	0.000214	0.000622	0.0408
41	3	0.000205	0.000581	0.0376
13	2	0.000219	0.000495	0.0276
41	1	0.00041	0.00031	0.00

Table 9 Storey Drift For With and Without In Filled Walls in Uy Direction

Earthquake Direction Ux- Joint Displacement (M)					
Sr.No	Storey	Point	Without Infill	With Infill	% Diff
1	11	36	0.0071	0.0112222	0.39
2	10	2	0.0066	0.0183	1.14
3	9	3	0.0061	0.0175	1.09
4	8	2	0.0056	0.0163	1.04
5	7	3	0.0049	0.014	0.91
6	6	2	0.0042	0.012	0.78
7	5	3	0.0034	0.010	0.66
8	4	2	0.0027	0.008	0.53
9	3	3	0.002	0.006	0.40
10	2	3	0.0014	0.003	0.16
11	1	11	0.001	0.001	0.00

3 Storey drift

As per clause no 7.11.1 of IS-1893 (Part-1):2002 the storey drift in any storey due to specified design lateral force with partial load factor of 1 shall not exceed 0.004 times the storey height. Maximum storey drift for building= 0.004 X h, for 3m storey height it is 0.12m.

IV. CONCLUSION

Due to infill walls in the High Rise Building top storey displacement is reduces. Base shear is increased. The presence of non-structural masonry infill walls can modify the seismic behavior of R.C.C.Framed High Rise

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building to large extent. Arrangement of infill wall also alters the displacement and base shear the top of building displacements gets reduces. In case of infill having irregularities in elevation such as soft storey that is damage was occur at level where change in infill pattern is occur. The effect of slenderness ratio emphasion displacement of frame. As the aspect ratio goes on increasing the displacement, base shear and column forces increases.

V. DISCUSSION ON RESULTS

The result of the present study show that structural infill wall have very important effect on structural behavior under earthquake effect. On structural capacity under earthquake effect displacement and relative story displacement are affected by the structural irregularities. Regarding with the result, infill walls are very important effect on structural behavior.

1. Base Shear:

From the results it is shown that due to infill walls in building the base shear is increased from 2.49 to 7.81%. and the difference is 4.86%

2. Displacement:

The displacements at top story of the building with infill's wall for single strut reduce 0.77% to 0.39% .

3. Storey Drift:

Storey drift for infilled wall model is within permissible limit. Storey drift is reduced 0.0034% to 0.018%.

Table 10.Storey Drift

Storey Drift				
Point	storey	Without Infill	With Infill	% Diff
19	11	0.000193	0.000227	0.0034
50	10	0.000185	0.000268	0.0083
41	9	0.00021	0.000412	0.0202
41	8	0.00023	0.000541	0.0311
40	7	0.000244	0.000641	0.0397
32	6	0.00025	0.000713	0.0463
76	5	0.000247	0.00076	0.0513
50	4	0.000235	0.000783	0.0548
19	3	0.000223	0.000779	0.0556
13	2	0.000332	0.000721	0.0389
8	1	0.000646	0.000483	0.00

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