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Earthquake analysis of High Rise Building with and without Infilled walls

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Abstract - *Masonry is commonly used construction material for buildings. In building masonry walls are used as a partition walls. Most of the time it is not considered as a structural member, due to complexity behavior it is ignored in analysis. Masonry is strong in compression and weak in tension. For the analysis of building the interaction between masonry infill and R.C.C members should considered. When masonry infill's are considered to interact with their surrounding frames, the lateral load capacity of the structure largely increase. The infill walls have large stiffness in plane of loading so that joint displacement is reduced as compared to without infill walls or bared infill panels.*

The same approach is applied to the R.C.C high-rise building having G+ 37 floors. Total length of building is 76.76m and width of building is 32.12m. Typical story height of building is 3m. Building is symmetrical in plan for y axis. Analysis is carried out for two models one is with infill walls and another is without infill walls. Infill wall behaves as a diagonal strut approach. Infill wall modeling is carried out by equivalent strut approach given by FEMA-356 code. Linear dynamic analysis is carried for two earthquakes such as Loma and Northridge. Various types of loading condition and various load cases set. Also the effect of soft story, podium is considered. Only linear properties of materials is considered as per IS codes

Modeling and analysis is carried out in finite element based software SAP-2000-12. Two types of time history applied to models. From the analysis it is shown that masonry walls are necessary in R.C.C framed building. For infilled model base shear is increased, top displacement and natural time period of building is reduced.

Key Words: **Infilled walls, high-rise building, equivalent strut, linear dynamics analysis, displacement**

1. INTRODUCTION

In metro cities now a day's RCC High Rise building is well establishing. For construction of high rise building infill walls are constructed for partition purpose. Brick is easily available material so it is widely used. In earthquake analysis of building role of infill walls are neglected due to complexity behavior. Masonry infill's are strong in compression. Infill walls have to consider interacting with their surrounding frames due to this lateral load capacity of structure is largely increases. When infill walls are placed in RCC frame it masonry behaves as diagonal compression strut and transmits compression force to the another joint. Variations in the column stiffness can influence the mode of failure and lateral stiffness of the infill.[1]

1.1 Structural modeling

For the analysis of work two models of R.C.C. High Rise building G+37 floors with podium are made to know the realistic behavior of building during earthquake. The length of the building is 76.76m and width is 32.12m. Height of typical story is 3m while podium is 4m. Sizes of column changes at each 12 story. Building is symmetrical about y axis. Building is designed as per IS 456-2000[2]. Material concrete grade M20, M30, M40 is used. Steel Fe 415 and Fe 500 is used. Masonry brick having density 19 KN/m3 is used. An only linear property of material is considered. Modal damping 5% is considered. Diaphragm is assigned at each floor. Analytical modeling that include all components which influence the mass, strength and stiffness. The non-structural element and components that do not significantly influence the building behavior were not modeled. Beams and columns are modeled as frame element and joined node to nodes. The effect of soil structure interaction is ignored in analysis. The columns are assumed to be fixed at the ground level.

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. The high rise building response spectrum results are not applicable. Linear dynamic analysis i.e. time history analysis is used. As per guideline given in IS-1893 Part1 [3]. Two types of earthquake time histories are used Loma and Northridge Earthquake. Max acceleration is applied at the base of building.

1.2 Modeling 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. Modeling of infill wall can be done by finite element method or static equivalent strut approach in this study later type modeling is done. In this type of modeling 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 modeling the infill as an equivalent strut approach given by FEMA 356[4].

Width of strut is given by

$$a = 0.175\,(\lambda_l h_{col})^{-0.4}\, r_{inf}$$

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

Where

hcol = Column height between centerlines 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

2. STUDIED STRUCTURAL CONFIGURATION

Following structural configuration studied for two time histories i.e. Loma and Northridge earthquake

in software SAP2000-12.

1. G+37 RCC Framed structure without infill wall

2. G+37 RCC Framed structure with infill wall

3. G+37 RCC Framed structure with infill wall with soft story at bottom

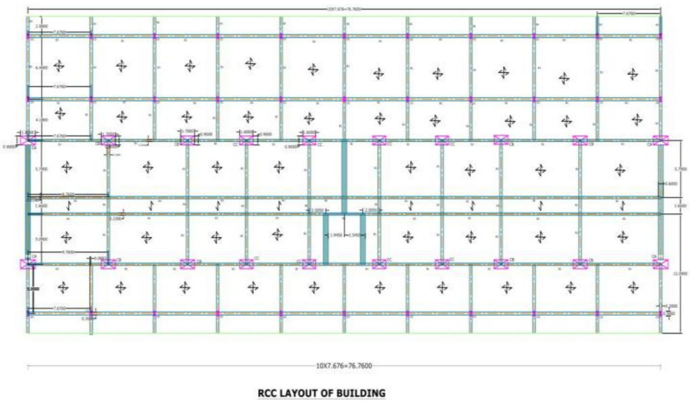

Fig -1: RCC Layout of Building: Plan view

1.2 Analysis of Model

Time history analysis method is used for the analysis of building. Two time histories used i.e.

1. Loma Prieta earthquake - Oakland outer harbour wharf

October 17, 1989, 17:04 pdt corrected accelogram, channel 1, 270 degrees, cdmg ql89a472

source: Nisee, U.S. Berkeley, California

2000 pts of acceleration data equally spaced at 0.020 sec. (Units: cm/sec/sec)

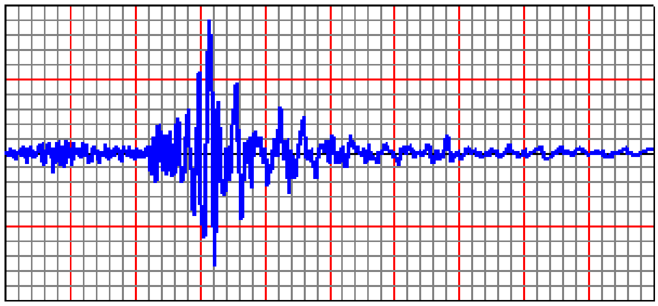

Fig -2: Acceleration Vs Time graph of Loma Prieta Earthquake

2. Northridge earthquake - Sylmar county hospital

January 17, 1994 04:31 pdt

corrected accelerogram, channel (90 deg), cdmg qn94a514

Source: Nisee, U.S. Berkeley, California

3000 points of acceleration data equally spaced at 0.020 sec. (Units: cm/sec/sec)

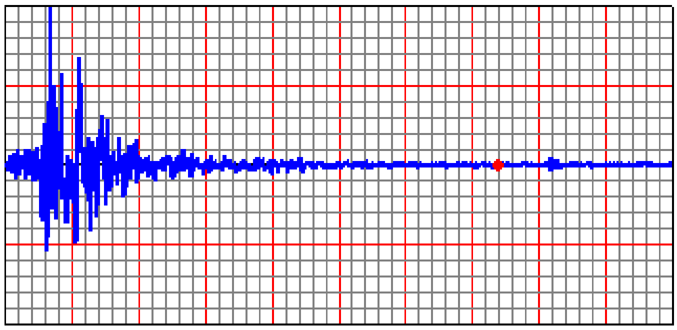

Fig -3: Acceleration Vs Time graph of Northridge Earthquake

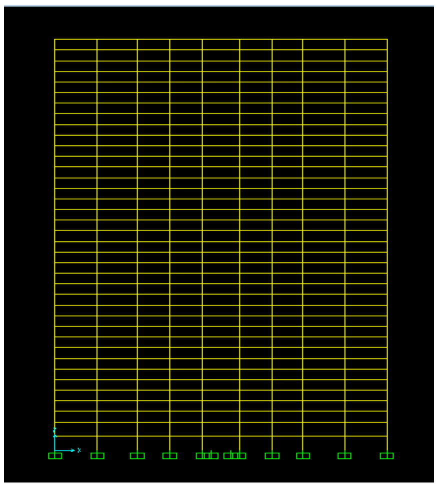

Fig -4: RCC Framed model of building without infill walls

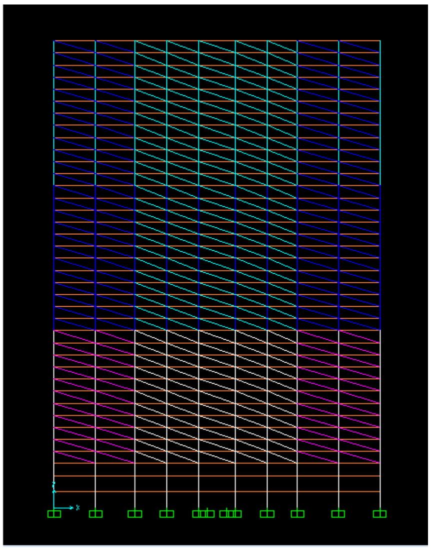

Fig -5: RCC Framed model of building with infill walls

2. RESULT

Comparison is made with two models i.e. with infilled walls and without infilled walls and two time hisories i.e. Loma Prieta & Northridge.

Base shear:

Table -1: Base shear

SR.NO	EARTHQUAKE	CASE	WITHOUT INFILL [KN]	WITH INFILL [KN]	% DIFF
1	NORTHRIDGE-X	WITH PODIUM (SOFT STORY)	21376	32166	33
2	NORTHRIDGE-Y		26374	36860	28
3	NORTHRIDGE-X	WITHOUT PODIUM	21376	31987	33
4	NORTHRIDGE-Y		26374	36534	27
5	LOMA-X	WITH PODIUM (SOFT STORY)	10462	23222	54
6	LOMA-Y		9876	22354	55
7	LOMA-X	WITHOUT PODIUM	10462	20077	47
8	LOMA-Y		10500	17895	41

Displacement:

Table -2: Story displacement for Northridge earthquake

MODAL TIME PERIOD			
MODE NO	WITHOUT INFILL	WITH INFILL	%DIFF
1	2.59	1.24	52.12
2	2.00	1.19	40.50
3	1.50	0.83	44.67
4	1.00	0.48	52.30
5	0.54	0.34	37.78
6	0.36	0.27	24.44
7	0.34	0.21	38.82
8	0.27	0.20	25.19
9	0.21	0.19	11.32
10	0.21	0.17	20.48
11	0.21	0.15	27.75
12	0.18	0.15	15.25

Table -3: Story displacement for Loma Prieta

LOMA EARTHQUAKE INFILL IN X-Y DIRECTION				
POINT	STORY	WITHOUT INFILL	WITH INFILL	%DIFF
126	38	0.36	0.20	44.44
7317	34	0.35	0.19	45.71
7157	30	0.34	0.19	43.82
6997	26	0.31	0.18	42.26
6837	22	0.29	0.16	43.79
6677	18	0.26	0.14	44.62
6517	14	0.25	0.12	51.20
6357	10	0.24	0.10	57.92
6197	6	0.23	0.08	67.39
1606	2	0.21	0.05	75.71
1566	1	0.20	0.05	75.00

Time period

Table -4: Modal time period of the building

MODAL TIME PERIOD			
MODE NO	WITHOUT INFILL	WITH INFILL	%DIFF
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3. DISCUSSION

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 of time history analysis especially, infill walls are very important effect on structural behavior. From the tables it shows that due to infill's in both direction base shear increases from 33 to 55%. The displacements at top story of the building with infill's wall for single strut in reduces from 40 to 50%. Modal time period is also reduced up to 50%.

4. SUMMARY

The results of the analyses indicate that the infill's can completely change the distribution of damage throughout the structure. The infill's can have a beneficial effect on the structural response, provided that they are placed regularly throughout the structure, and that they do not cause shear failures of columns. The based on above result and discussion, the following conclusion can be drawn.

- The presence of non-structural masonry infill walls can modify the seismic behavior of R.C.C. Framed High Rise building to large extent.

- The stability and integrity of reinforced concrete frame are enhanced in terms of base shear and displacement.

- In case of infill having irregularities in elevation such as soft story, that is damage was occur at level where change in infill pattern is occur.

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[4] FEMA-356 Federal Emergency Management Agency, Seismic Rehabilitation of building

AUTHORS PROFILE

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