EARTHQUAKE ANALYSIS OF A G+12 STOREY BUILDING WITH AND WITHOUT INFILL FOR BHUJ AND KOYNA EARTHQUAKE FUNCTIONS

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Abstract - *The improper design and construction of the structures may cause great destruction to the structures. This has been proved by the earthquakes occurred in the recent past. Hence we will have to confirm safety against the earthquake forces that are affecting the structures and determine seismic responses of such buildings by carrying out the seismic analysis and then construct the structures to be earthquake resistant. In the present work G+12 storey building model with and without infill is considered and the time history analysis considering for bhuj and koyna earthquake functions is carried out in ETABS 2013 software. The seismic responses of story displacements, storey drifts and time history plots of base force v/s time and roof displacement v/s time for both time history functions are compared and studied.*

Key Words: *Time history analysis, Storey displacements, Storey drifts, Time history plots.*

1. INTRODUCTION

The impact of urbanization is very common in the recent past. The building and development of higher buildings is much needed in today's generation. But those structures can be damaged to a very large extent when the earthquakes occur. Therefore such structures need to be analyzed and designed properly before constructing.

Every year nearly one lakh earthquakes of approximate magnitude more than three strike the earth and results in the loss of nearly 15 million humans. And the reinforced concrete buildings also get damaged to a very large extent during earthquakes because of contradictory seismic response, irregularity in plan and mass of the building etc. Different earthquakes have different magnitudes and intensities at different regions and the destruction caused in these regions is also different. Therefore it is very important to study the seismic behavior of RC structures for different earthquake functions in terms of responses such as storey displacements, base shear etc. and it is also very important to figure out the actual seismic performance of the building that is inflicted to earthquake forces.

The blank space in reinforced concrete frames that is formed by the arrangement of columns and beams are commonly filled in by brick masonry or any other type of masonry which is referred as infill wall or infill panel. During the construction of any structure, the burnt bricks in cement mortar are used to build the infill walls in brick masonry type of infill. Infill acts as a compression strut between beam and column thus compression forces get transferred from one node to other node.

1.1 OBJECTIVES

Following are the objectives of this study.

1. To analyze the G+12 structure with and without infill walls for Bhuj and Koyna earthquake functions using Time History Analysis.
2. To study various responses such as storey displacements, storey drifts, time history plots of Roof displacement v/s time and plot of Base force v/s time for the considered model with and without infill for Bhuj and Koyna earthquake functions.

3. To compare the effect of Time history analysis on performance of RCC multistory structure for both with and without infill cases considering for Bhuj and Koyna earthquake functions.

1.2 STRUCTURAL MODELLING AND SEISMIC ANALYSIS

During the earthquakes, shaking of the surface of the earth occurs due to the built-up stress within the rocks in the Earth's crust. The severity of the earthquake ground motions can be strong, moderate or minor. The strong earthquakes occur rarely while moderate earthquakes occur occasionally and minor earthquakes occur frequently. When the ground vibrates at times of earthquakes, this earthquake ground motion effects the structures supported on the ground to move. This movement of supports causes the dynamic loading on the structure.

2. METHODOLOGY

The methodology adopted for this study is, first modeling the considered structure in ETABS 2013 software and analyzing the same by Time History Method of analysis for two earthquake functions Bhuj and Koyna. The type of model considered here is a G+12 storey building of both bare and infill type. The base fixation for both types of model is taken to be fixed. The seismic analysis in India is done as according to the IS 1893 (Part 1).

In this work the plan dimension has a symmetric arrangement of 6 bays of 3.5m width in both X and Y directions.

2.1 PRELIMINARY DATA TAKEN FOR THE RCC FRAME AND INFILL

Type of the structure: RC special moment resisting frame
Seismic zone: V
Zone factor: 0.36
Storey height: 3m
Base floor height: 3m
Live load on floors: 4KN/m^2 for all storey floors except terrace floor where 1.5KN/m^2 is used.
Floor finish: 0.75KN/m^2
Materials used: Brick infill, M20 concrete and Fe415 steel
Column size: 0.23m x 0.5m
Beam size: 0.23m x 0.7m
Slab thickness: 0.125m
Weight density of RCC= 25KN/m^3
Modulus of elasticity of M20 concrete: 22360.68MPa
Modulus of elasticity of masonry infill: 13800MPa
Type of soil: hard
Modal damping of structure: 5%
Importance factor: 1
Infill wall thickness: 0.23m
Weight density of masonry infill: 20KN/m^3

2.2 LOADS CONSIDERED

The loadings applied on the structures considered in this study include dead load, live load and earthquake load.

- Dead Loads are as according to IS 875 Part I
- Live Loads are as according to IS 875 Part II
- Earthquake Loads are as according to IS 1893(Part I): 2002

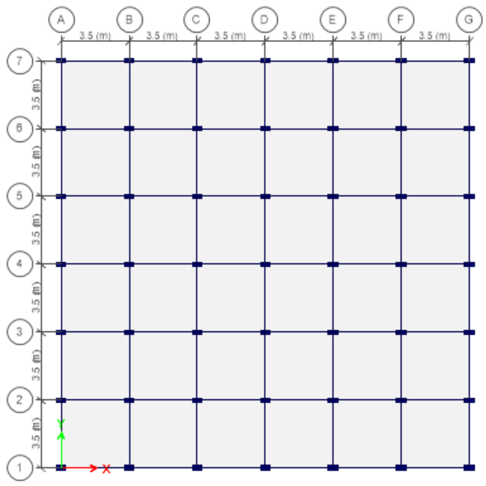

Fig.2.1 Plan of G+12 multistory Building with and without infill

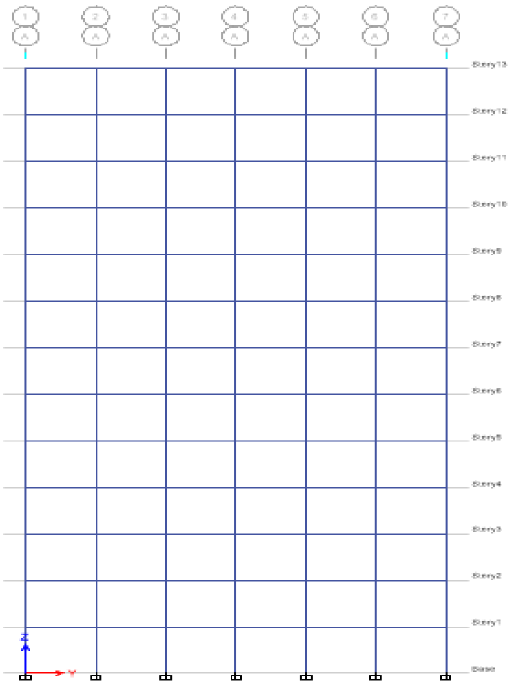

Fig.2.2 Elevation of G+12 multistory building without infill

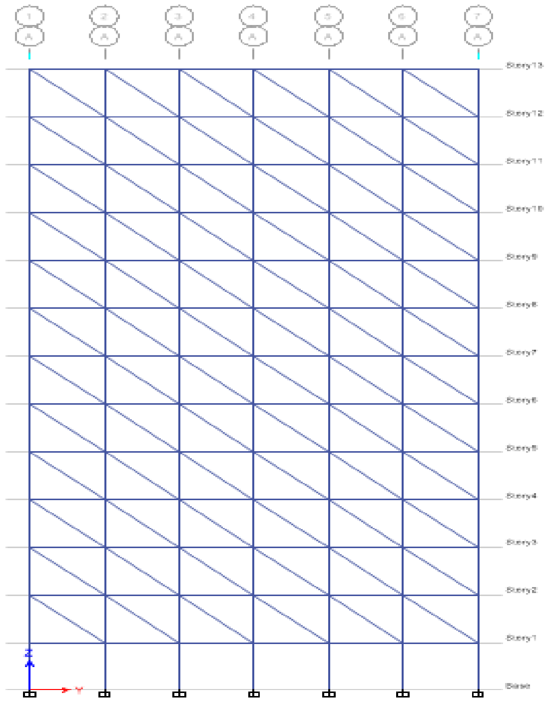

Fig.2.3 Elevation of G+12 multistory building with infill

3. RESULTS AND DISCUSSIONS

The above structural model is modeled and then the time history analysis was done using ETABS 2013 software. The responses of storey displacement, drift and time history plots of Base force v/s time and Roof displacement v/s time were gained and compared for all the model with and without infill for koyna and bhuj seismic functions and studied.

3.1 STOREY DISPLACEMENTS

The storey displacements were figured out for the above model after analyzing and the results were tabulated as follows for with and without infill conditions and for both bhuj and koyna functions.

Table.3.1.1 Variation of maximum storey displacement for earthquake in X direction by THM for G+12 building

Story level	bhuj without infill	koyna without infill	bhuj with infill	koyna with infill
Base	0	0	0	0
Story2	7.2	3.7	14.1	8
Story3	9	5.9	14.9	8.4
Story4	10.9	8	15.6	8.8
Story5	12.8	10.2	16.1	9.3
Story6	14.7	12.4	16.6	9.7
Story7	16.6	14.5	17	9.9
Story8	18.3	16.3	17.5	10.1
Story9	19.9	17.2	17.7	10.3
Story10	21.4	18.1	18	10.6
Story11	22.6	18.8	18.2	10.9
Story12	23.5	19.5	18.4	11.2
Story13	24.2	19.9	18.6	11.4

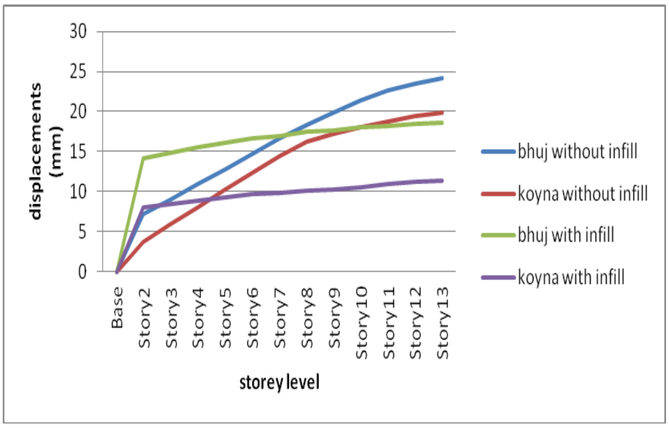

Fig.3.1.1 Variation of maximum storey displacement for earthquake in X direction by THM for G+12 building

From the above results, it is seen that for a G+12 story building, top storey displacement value for bhuj without infill is 18.02% more than that for koyna without infill and for with infill condition, the value for bhuj is 39.01% more than that for koyna. Also the value for bhuj without infill is 23.1% more than for bhuj with infill and for koyna without infill is 42.71% more than for koyna with infill. It is found from above displacement results that the displacements for bhuj were more compared to koyna and the displacements of bare frame models are more than those for infill models which suggests that as the infill stiffness increases the top story displacement reduces.

3.2 STOREY DRIFTS

The storey drifts were computed for the model with and without infill for bhuj and koyna earthquake functions and is tabulated as follows along with the graphical representation.

Table.3.2.1 Variation of maximum storey drift for earthquake in X direction by THM for G+12 building

Story level	bhuj without infill	koyna without infill	bhuj with infill	koyna with infill
Story1	0.000549	0.000425	0.000105	0.000077
Story2	0.000691	0.000611	0.000135	0.000091
Story3	0.000715	0.000627	0.000148	0.000087
Story4	0.000726	0.000634	0.000147	0.000086
Story5	0.000728	0.000636	0.000146	0.000086
Story6	0.000719	0.000628	0.000145	0.000085
Story7	0.000699	0.00061	0.000144	0.000084
Story8	0.000664	0.00058	0.000142	0.000083
Story9	0.000615	0.000537	0.000139	0.000082
Story10	0.000549	0.00048	0.000136	0.00008
Story11	0.000466	0.000407	0.000132	0.000078
Story12	0.000364	0.000318	0.000127	0.000075
Story13	0.000248	0.000217	0.000122	0.000072

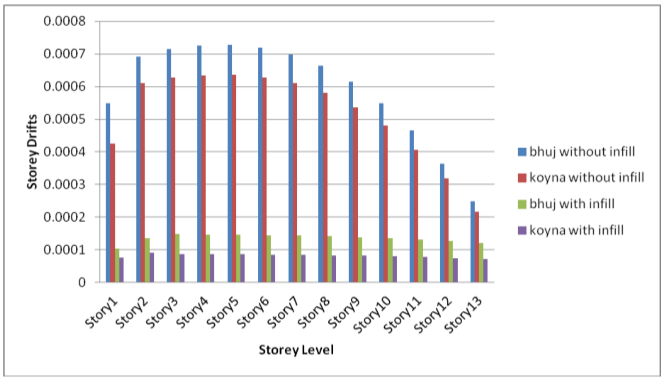

Fig.3.2.1 Variation of maximum storey drift for earthquake in X direction by THM for G+12 building

It is seen from the above results that the drift values of bhuj function were more than for koyna function for both infilled and without infilled model and it is also seen that with infill drift values are comparatively less than without infill drift values for both time history functions and drift values are below permissible value of drift that is 0.004 times of story height.

3.3 Time History Plots of Base force v/s Time

The time history plots of the Base force v/s Time was plotted as shown in the figures below obtained for two earthquake records of bhuj and koyna earthquake for both with infill and without infill conditions.

Table.3.3.1 Base force time histories in KN v/s sec for bhuj and koyna functions for a G+12 storey building without infill

time	bhuj without infill	koyna without infill
0	0	0
3	0.0094	0.0018
6	0.0349	-0.0062
9	0.0087	0.0092
12	0.0724	0.0017
15	0.0914	-0.0024
18	0.0829	-0.0228
21	0.0752	0.0082
24	0.0747	-0.028
27	0.0764	0.0013
30	0.0772	-0.0227

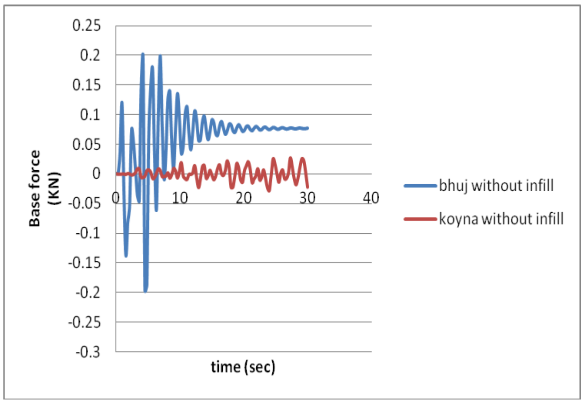

Fig.3.3.1 Base force time histories in KN v/s sec for bhuj and koyna functions for a G+12 storey building without infill

Table.3.3.2 Base force time histories in KN v/s sec for bhuj and koyna functions for a G+12 story building with infill

time	bhuj with infill	koyna with infill
0	0	0
3	-0.2859	0.0009
6	0.4282	-0.0212
9	0.5419	0.0591
12	0.4452	-0.0204
15	0.3717	-0.0444
18	0.3465	0.004
21	0.3444	0.0495
24	0.3474	-0.1671
27	0.3494	0.112
30	0.3501	-0.0803

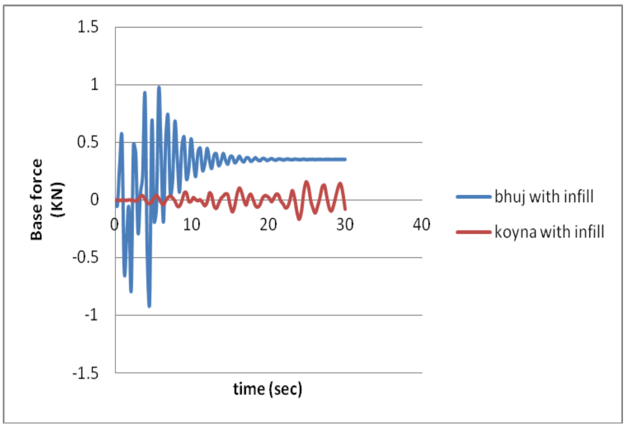

Fig.3.3.2 Base force time histories in KN v/s sec for bhuj and koyna functions for a G+12 story building with infill

It can be seen from the above graphs that the time history plots for bhuj function are more varying with higher base force values than for koyna function which shows that the bhuj earthquake function causes more force than of koyna earthquake function. And also the base force for with infill conditions is more when compared to that for without infill conditions for both functions because of the increase in stiffness in infilled buildings.

3.4 TIME HISTORY PLOTS OF ROOF DISPLACEMENT V/S TIME

The time history plots of the roof displacement v/s time was plotted as shown in the figures below obtained for two earthquake records of bhuj and koyna earthquake for both with infill and without infill conditions.

Table.3.4.1 Roof displacement time histories in mm v/s sec for bhuj and koyna functions for a G+12 story building without infill

time	bhuj without infill	koyna without infill
0	0	0
3	-0.0001855	-0.0000227
6	0.0002483	0.0001144
9	0.0000026	-0.0001306
12	-0.0008484	-0.0000339
15	-0.001124	0.0000123
18	-0.001002	0.0003314
21	-0.0008899	-0.0000827
24	-0.0008817	0.0004057
27	-0.000907	-0.0001286
30	-0.0009179	0.0003888

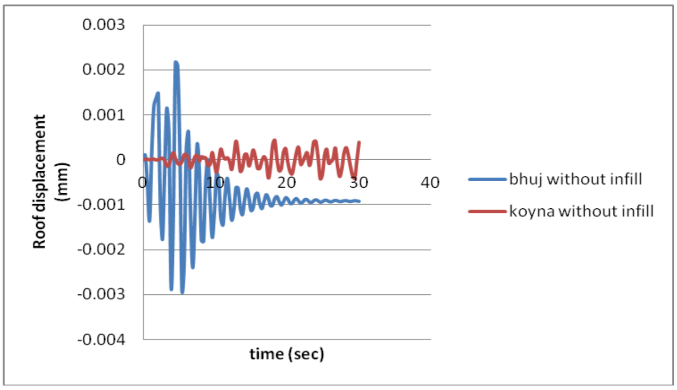

Fig.3.4.1 Roof displacement time histories in mm v/s sec for bhuj and koyna functions for a G+12 story building without infill

Table.3.4.2 Roof displacement time histories in mm v/s sec for bhuj and koyna functions for a G+12 story building with infill

time	bhuj with infill	koyna with infill
0	0	0
3	0.0002958	-0.0000028
6	-0.000587	0.0000844
9	-0.0007587	-0.0002402
12	-0.0006217	0.000083
15	-0.0005169	0.0001796
18	-0.0004811	-0.0000167
21	-0.0004781	-0.0002013
24	-0.0004824	0.0006758
27	-0.0004853	-0.0004533
30	-0.0004862	0.0003253

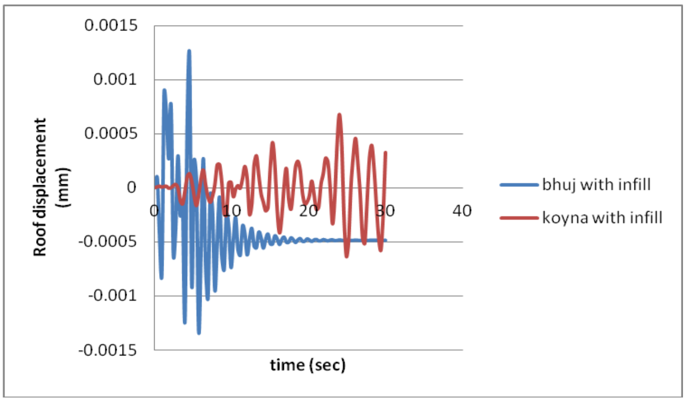

Fig.3.4.2 Roof displacement time histories in mm v/s sec for bhuj and koyna functions for a G+12 story building with infill

From the above graphical and tabulated results, we can get to know that the bhuj function displacements are more compared to koyna earthquake function displacements.

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4. CONCLUSIONS

By studying the results gained from modal time history analysis of the G+12 story building with and without infill for two time histories bhuj and koyna, the following conclusions can be drawn.

1. he displacement values for bhuj function are higher than the displacement values for koyna function and those for infilled buildings are less than for without infilled buildings which suggests that as the infill stiffness increases the top story displacement reduces.
2. he results of drifts show that the drift values because of bhuj function were more in comparison with drifts for koyna function and with infill drift values are comparatively less than without infill drift values for both time history functions. The drift values for all types are within the permissible value of drift.
3. rom the time history plots of base v/s time and roof displacement v/s time, we can conclude that the responses for bhuj are more effective with higher forces and roof displacements than for koyna.

Finally it can be recommended from above conclusions that time history analysis should be performed for buildings before construction for earthquake function with higher magnitude such as bhuj as considered in present study which gives higher responses along with taking consideration of infill walls during analysis so that buildings can perform well enough for higher magnitude earthquakes also.

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