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Effect of Infilled Walls on RC Frame Due to Seismic Forces

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ABSTRACT: This study investigated into the effect of infill walls on behavior of reinforced concrete (RC) frame subjected to multiple earthquakes. For this purpose, 12 storey RC frames in three cases of inclusion and exclusion of infill walls as well as inclusion of infill walls with openings are analyzed using ETABS software. The nonlinear static and dynamic analyses are carried out on the models and for dynamic analyses. Accordingly strength and stiffness of the structure are determined using nonlinear static (Response spectrum analysis) analysis and structural responses such as displacement ductility, rotational ductility and energy absorption are obtained from nonlinear static and dynamic analysis. The results indicate the inclusion of infill walls, increases stiffness and ultimate strength of the structure. Among all models the structures including infill walls produced more lateral resistance against earthquake loads. The dead, live & earthquake loads were defined as per IS 875 part I, II & IS 1893 part I. The structural element such as beams, columns, slabs, footings, were designed by limit state method as per provisions given in IS456:2000.

KEYWORDS: Infill walls, Dynamic analysis, Earthquake loads, Displacement ductility, Stiffness

I. INTRODUCTION

This work involves the effect of infill walls on RC frames due to the seismic forces of a building in Mumbai. G+12-framed RC frames with inclusion and exclusion of infill walls as well as inclusion of infill walls with openings were analyzed for this work. The purpose of the analysis is to determine which cases have more resistance to seismic forces due to earthquakes. The objectives of this work are specified as follows.

- To study the effectiveness of masonry infill to resist the seismic forces.
- To analyze the building by Response spectrum analysis and Time history analysis using ETABS software.
- To study and compare the results of various parameters such as story drift, displacement and fundamental periods.

Various IS Codes like IS 1893:2016(Part 1) and IS 456:2000 was referred for design purpose. The required architectural plan, sizes of beams and columns for analysis and design purpose is collected from a construction site of a multi- storey building.

II. LITERATURE SURVEY

Robin Davis et.al [1] provides the comparative study on summary of performance of low rise and high rise RC symmetrical and asymmetrical frame buildings with and without infill walls. The masonry infill walls are entirely replaced by equivalent diagonal strut in-order to assess their contribution in seismic resistance of normal Reinforced concrete buildings. Seismic analysis has been performed using Equivalent Lateral Force Method for different reinforced concrete (RC) frame building models that include bare frame, infilled frame and open first storey frame. The results of bare frame, infilled frame and open first storey frame are discussed and conclusions are made, Tamboli HR, et.al [2]. Khubaib Ilyas et.al[3] performed the time history analyses on masonry infilled RC frame structures and influence of variation of number of bays, number of storeys, percentage opening in the infill wall, location of the opening, type of openings, number of openings, infill strength, outer frame strength and infill thickness on the performance of masonry infilled RC frames. The results of the study will help to understand the complex behaviour of the masonry infills for different variations and will also provide useful information to improve and economize the design of masonry infilled RC frame structures. According to FEMA-273, & ATC-40 which contained the provisions of calculation of stiffness of infilled frames by modelling infill as "Equivalent diagonal strut method". This analysis was to be carried out on the models such as bare frame, strut frame, strut frame with 15% centre & corner opening, which is performed by using computer software STAAD-Pro from which different parameters were computed. In

which it shows that infill panels increase the stiffness of the structure, Nikhil Agrawal et. al [4]. Girum Mindaye et. al [5] analysed the seismic response of a residential G+10 RC frame building by the linear analysis approaches of Equivalent Static Lateral Force and Response Spectrum methods using ETABS Ultimate 2015 software as per the IS-1893-2002-Part-1. These analysis were carried out by considering different seismic zones, medium soil type for all zones and for zone II & III using OMRF frame type and for those of the rest zones using OMRF & SMRF frame types. Different response like lateral force, overturning moment, story drift, displacements, base shear were plotted in order to compare the results of the static and dynamic analysis. Krishna G Nair et.al [6] focused on the study of the effect of masonry infill wall on RC frame building. Response Spectrum Method was used for analysis purpose and analysis was done on ETABS software. N.A. Khan et.al [7] studied and confirmed that the structural performance of full masonry infill walls frame model (FIF) was better than the other two. The study also revealed that the single strut model was unable to capture the real behaviour of the infill wall in RC structures, favouring the use of multi diagonal struts macro modelling techniques. In the modal analysis as the modal mass participation of the highest mode was more than 90% thus it indicates the stiffness is more Sujit Suryawanshi et.al [8].

III. METHODOLOGY

Modeling

First the grid line plan is prepared in ETABS.

- The materials like concrete, rebars are defined.
- Frame sections as beams, columns, slab, infill walls, opening are defined.
- Properties of slab, beams, columns and infill walls are assigned.
- Define the static load cases and load patterns.
- Assign the loading as Dead load, Live load, Seismic loads.
- Assign the support conditions as fixed and analyze the model.

Design Modeling Data

Following data is used for modelling of RC framed building:

- Number of storeys: Twelve
- Seismic Zone: III
- Floor Height: 3m
- Depth of Slab: 150mm
- Size of Beam: 450x450mm
- Size of Column: 600x600mm
- Size of opening: 1300x1300mm
- Live Load on floor: 4KN/m
- Floor finish: 1 KN/m
- Thickness of infill wall: 230mm
- Materials: M25, HYSD 415
- Density of concrete: 25 KN/m³
- Density of infill: 20 KN/m³

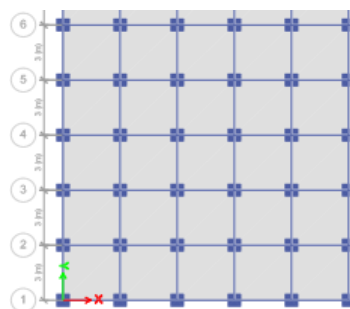


Figure 1: Plan of the 12 storey model in ETABS

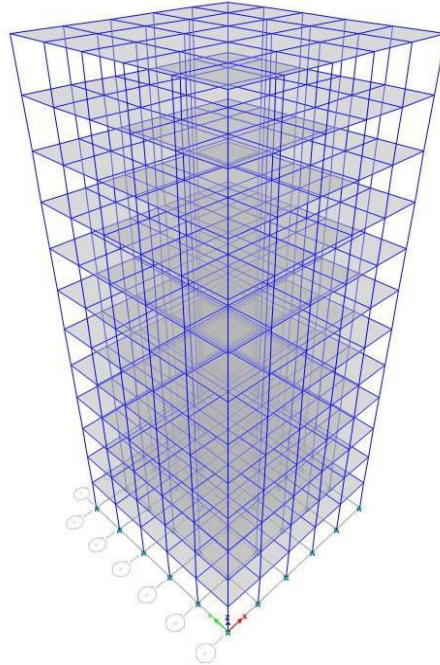


Figure 2: 3D view of the exclusion of infill wall model done in ETABS.

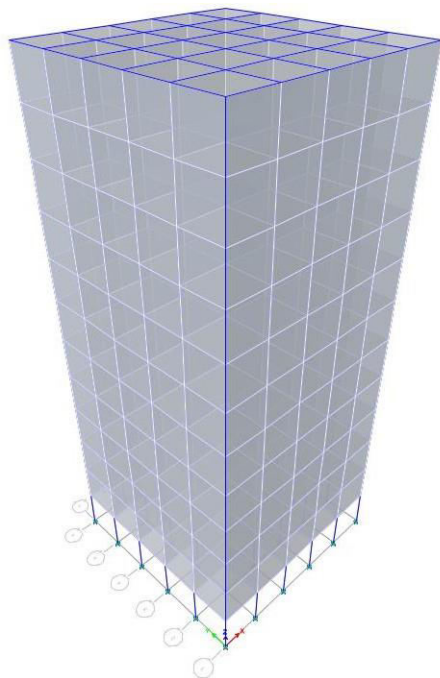


Figure 3: 3D view of the inclusion of infill wall model done in ETABS.

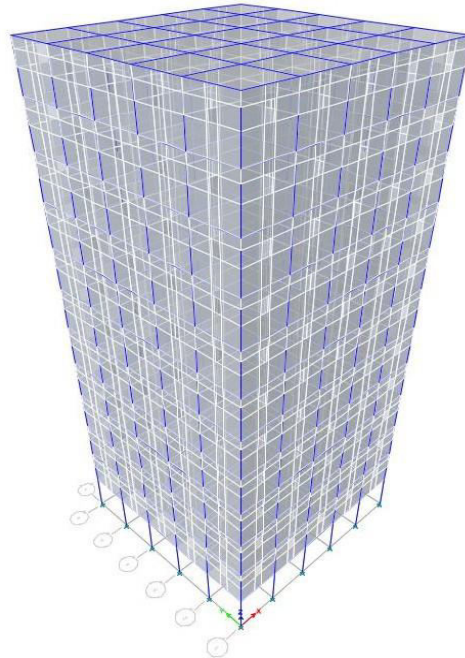


Figure 4: 3D view of the inclusion of infill wall with openings model done in ETABS

IV. ANALYSIS RESULTS

Modal Analysis

No of modes: 40

First mode: Translation

Time period difference = $0.748 - 0.714 = 0.034 < 0.1$ (without infill wall) Time period difference = $0.773 - 0.712 = 0.061 < 0.1$ (with infill wall)

Time period difference = $0.502 - 0.437 = 0.065 < 0.1$ (infill wall with opening)

Table 1: Time period of inclusion and exclusion of infill wall as well as inclusion of infill wall with opening

Mode	Period sec	Mode	Period sec	Mode	Period sec
1	0.748	1	0.773	1	0.502
2	0.748	2	0.712	2	0.502
3	0.714	3	0.693	3	0.437
4	0.241	4	0.249	4	0.084
5	0.241	5	0.231	5	0.084
6	0.231	6	0.225	6	0.017
7	0.136	7	0.14	7	0.016
8	0.136	8	0.131	8	0.011
9	0.131	9	0.128	9	0.011
10	0.091	10	0.094	10	0.008
11	0.091	11	0.088	11	0.007
12	0.088	12	0.086	12	0.006

Table-2 : Displacement of inclusion and exclusion of infill wall as well as inclusion of infill wall with opening

UX	UY	UZ	UX	UY	UZ	UX	UY	UZ
0.745	0.0519	0	0.4026	0.3945	0	0.0003	0.9956	0
0.0519	0.745	0	0.1788	0.1833	0	0.9956	0.0003	0
0	0	0	0.2173	0.221	0	0	0	0
0.0932	0.0066	0	0.0504	0.0494	0	0.0003	0.0039	0
0.0066	0.0932	0	0.0224	0.023	0	0.0039	0.0003	0
0	0	0	0.0272	0.0276	0	0	0	0
0.0356	0.0024	0	0.0192	0.0188	0	0	0	0
0.0024	0.0356	0	0.0073	0.0075	0	0	0	0
0	0	0	0.0111	0.0113	0	0	0	0
0.0035	0.0179	0	0.0108	0.0106	0	0	0	0
0.0179	0.0035	0	0.0052	0.0054	0	0	0	0
0	0	0	0.005	0.005	0	0	0	0

Inter storey drift ratio

Inter story drift ratio should be less than 0.004 To be checked for EQ X,
 Drift ratio for EQ X = 0.000667 (without infill wall) Drift ratio for EQ X = 0.000482 (with infill wall)
 Drift ratio for EQ X = 0.00169 (infill wall with opening) Hence passed.

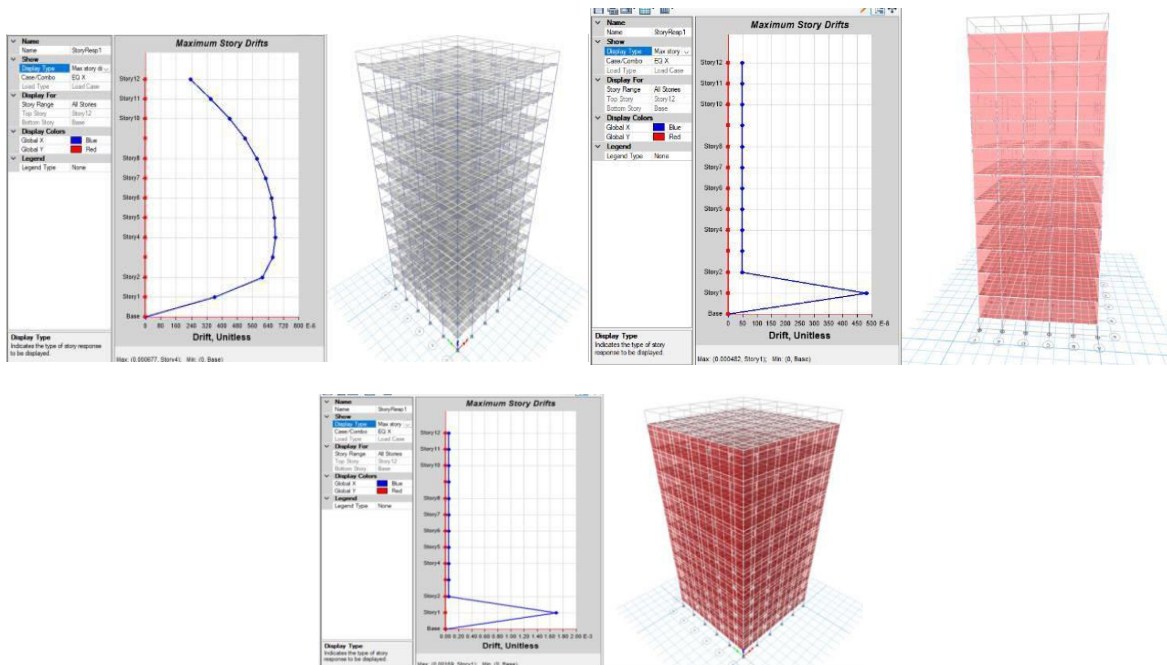


Figure-5: Inter storey drift ratio of inclusion and exclusion of infill wall as well as inclusion of infill wall with opening.

Maximum storey displacement

Maximum displacement against earthquake should be less than = H/250mm H = 36000mm

To be checked for RS X for with and without infill wall H/250=36000/250=144mm

Maximum displacement against earthquake RS x = 19.14mm (without infill wall)

Maximum displacement against earthquake RS x = 3.06mm (with infill wall) Maximum displacement against

earthquake RS x = 6.74mm (infill wall with opening)
Hence passed.

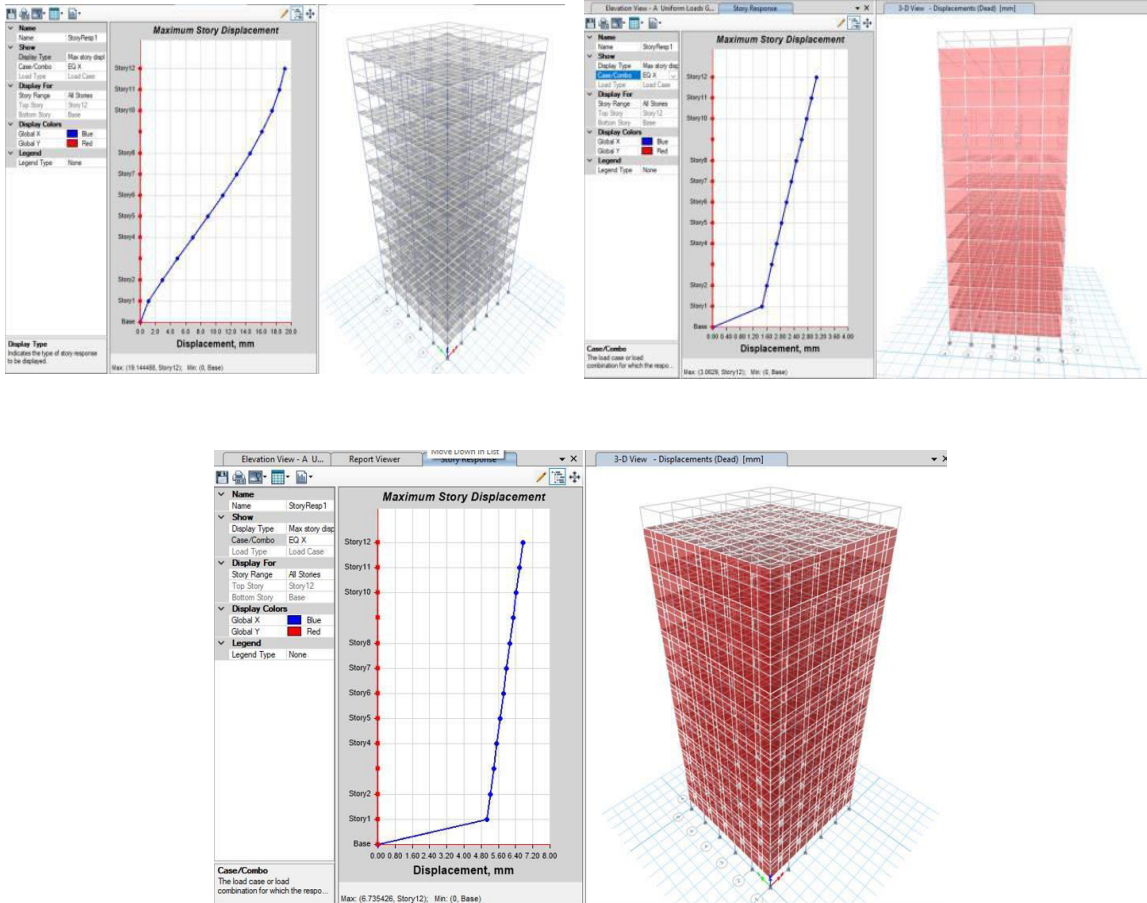


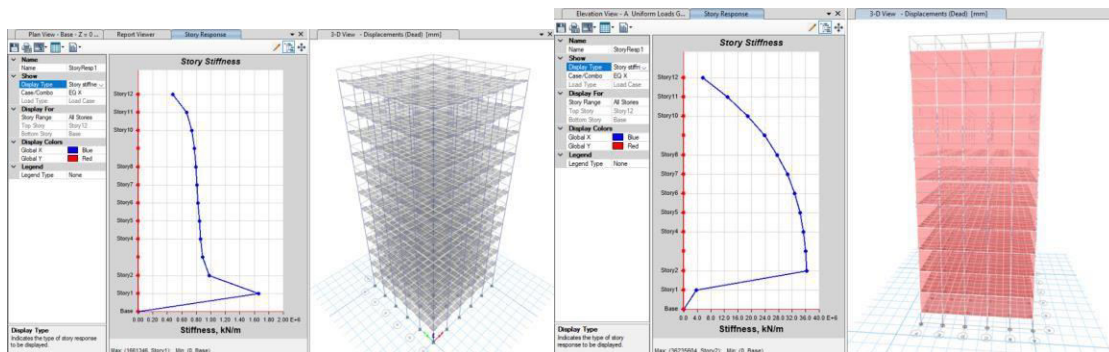
Figure-6: Maximum storey displacement of inclusion and exclusion of infill wall as well as inclusion of infill wall with opening.

Maximum storey stiffness

Maximum storey stiffness against earthquake RS x = 1661346 kN/m (without infill wall)

Maximum storey stiffness against earthquake RS x = 36235604 kN/m (with infill wall)

Maximum storey stiffness against earthquake RS x = 34143703 kN/m (infill wall with opening)



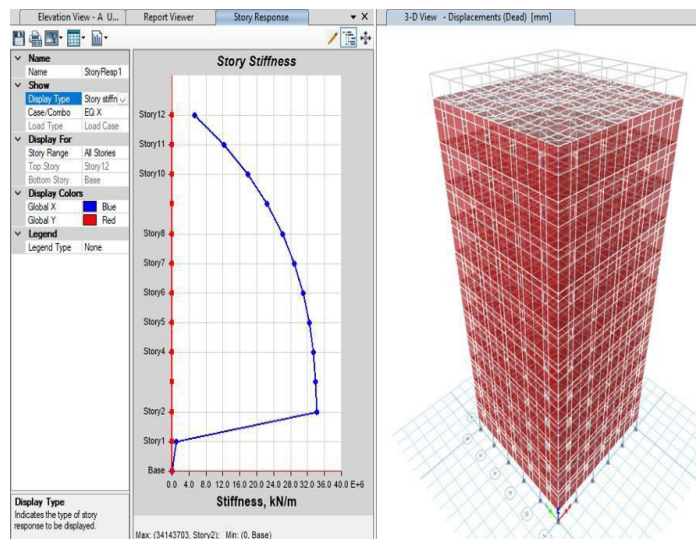


Figure-7: Maximum storey stiffness of inclusion and exclusion of infill wall as well as inclusion of infill wall with opening

Table – 3: Response spectrum analysis

Description	Without infill wall	With infill wall	Infill wall with opening
Storey stiffness	1661346 kN/m	36235604 kN/m	34143703 kN/m
Storey displacement	19.14 mm	3.06 mm	6.74 mm
Frequency	10.628 cyc/sec	170.797 cyc/sec	181.661 cyc/sec
Time period	0.824 sec	0.302 sec	0.502 sec
Storey drift	0.00067	0.000482	0.00169

Non Linear Dynamic Analysis -Time History Method

The most precise method for predicting the force and deformation demand at several components of a structure is the inelastic time-history analysis. However, its use is restricted due to the sensitive nature of the dynamic response to the modeling and ground motion characteristics. It needs actual modeling of the cyclic load-deformation characteristics. In order to perform the nonlinear dynamic time-history analysis, the analysis was performed on the three- dimensional models of pre-existing buildings. In addition, the ETABS 2021 was used in the current study with the help of sine function to clarify the load cases in both the X and Y directions.

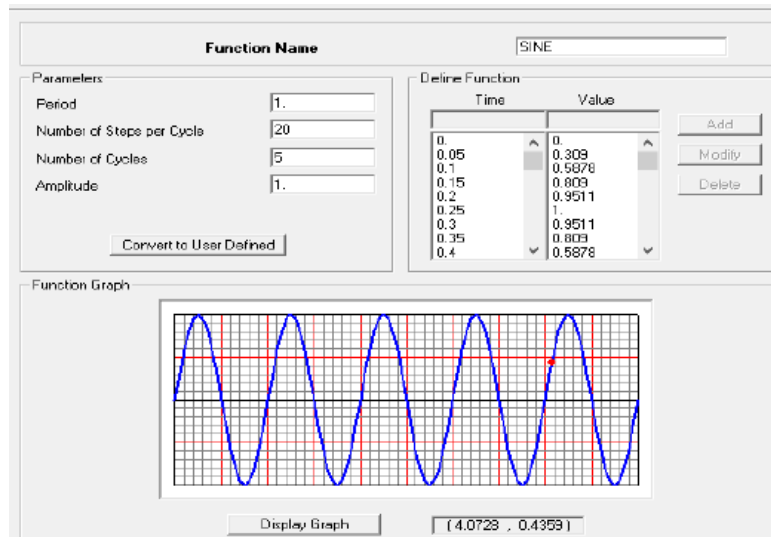


Figure - 8: Defined time history load as ELCENTRO function.

Figure 8 shows the plot of spectral acceleration and time period for the different damping ratios used in this project. It can be noted that increasing the damping ratio will reduce the spectral acceleration.

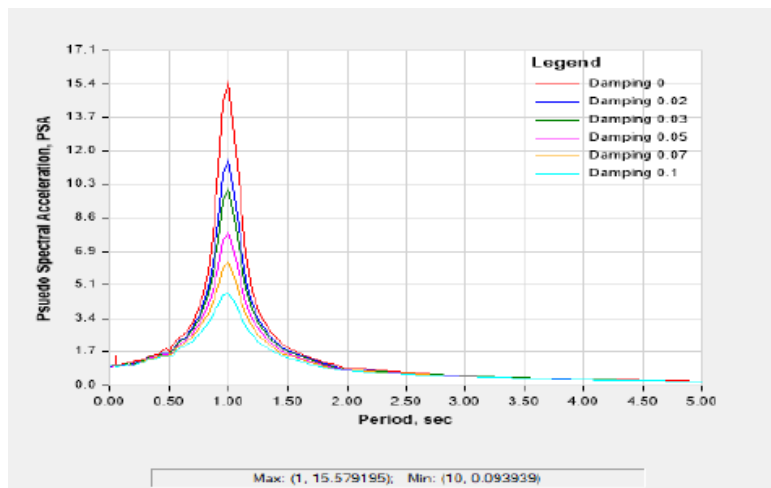


Figure - 3.9: Acceleration vs Period plot

Table – 4: Time history analysis

Description	Without infill wall	With infill wall	Infill wall with opening
Storey stiffness	914972 kN/m	36235604 kN/m	34143703 kN/m
Storey displacement	21.36 mm	3.06 mm	6.73 mm

Frequency	8.973 cyc/sec	170.797 cyc/sec	181.661 cyc/sec
Time period	0.927 sec	0.302 sec	0.502 sec
Storey drift	0.00073	0.000482	0.00169

V. CONCLUSION

In this study, the effect of infill walls on RC frames due to seismic forces has been investigated by using non-linear static (Response spectrum analysis) and non-linear dynamic (Time history analysis) analyses.

To this end, the 12 storey building under the three cases of inclusion and exclusion of infill walls as well as inclusion of infill wall with openings to account for different effective parameters such as drift ratio, storey stiffness, storey displacement, time period and fundamental frequencies were analyzed.

It is observed that the displacement value corresponding to first mode of vibration for frame with infill wall is reduced by 85% when compared with displacement value of frame without infill wall. It is also observed that the storey stiffness of the frame with infill wall is increased by 90% when compared with storey stiffness of the frame without infill wall. Hence it is concluded that the RC framed building with Infill walls has good resistance and sustain the vibration against earthquake forces.

The 12 storey modeling was analyzed and designed using ETABS software. The structural drawings were prepared using AutoCAD software for the case of inclusion of infill walls.

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