THE BEHAVIOR OF R.C.C HIGH-RISE BUILDING UNDER EARTHQUAKE LOAD BY ADOPTING LINEAR DYNAMIC ANALYSIS

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Abstract: In this thesis, "THE BEHAVIOR OF R.C.C HIGH-RISE BUILDING UNDER EARTHQUAKE LOAD BY ADOPTING LINEAR DYNAMIC ANALYSIS" is being done and the behaviour of building with and without infilled wall under seismic load actions is explored. Infill behaves like compression strut between column and beam and compression forces transfers from one node to another. As the infill act as a compression strut member between column and beam and transfers compression forces from one node to another. The influence of masonry infill wall on the high rise building is studied under Dynamic analysis i.e., response spectrum analysis on high rise building with and without infill walls is perform for the analysis G+25 Story RCC framed is modelled and analysed Earthquake lateral loading is applied to the models. Many cases of analysis in zone II is taken. Base shear, storey displacement and storey drift for the both the case of infill and without fill walls are analysed by software ETABS and compare with the models. After observing the values obtained for the models, it is shows that the decrease of displacements drifts and time period and increase base shear. Hence, it is necessary to observe the effect of masonry infill wall for the seismic calculation of RCC frame

Keyword's: Hise-rise Building, Dynamic, displacement

1. INTRODUCTION

As the population is increasing day by day, it is the requirement of the people to build the structure in vertically as long as possible such as High Rise Building. In most urbanized areas of the India, their much need of accommodation, so it is need to have High Rise Building.

In many developing countries and India the development of moment resisting with infilled brick masonry walls are commonly constructed. Around the world, the basic construction material is the masonry, due to its availability, its usage and their cost. The basic use of masonry structure or reinforced concrete is to protect the structures from the environment effect or to partition of spaces inside the building.

While constructing any building structures, engineers usually neglect the importance of infill walls and it is treated as non-structural elements or members. As it is difficult to analysis the interaction of infill walls with the structural frames and it creates problem for analgising the structure in the addition of infill walls. So it is removed in the analysis of building structures. As the lateral loading system of the building structure will be more if masonry infills walls are connected with the other structural frames such as beams, columns and slabs. The use of such consideration creates an inappropriate or incorrect behaviour of the structures when the structure is loaded for the lateral loading systems.

The researchers are establishing the importance of moment resisting frames and their function in the transfer of load to the structures. As the incident of building collapse under seismic or lateral loading shows the importance of this aspects of masonry infills. The usage of infilled walls creates more stiffness and strength to the structure under the action of lateral loadings. It is not appropriate or incorrect to say the results of the design procedure without considering the effect of masonry infill or infill walls as lateral loading. Though the infill is a non-structural member, as it is seen in the past damages due to the seismic action or earthquakes leads to the concern of infill wall frames with the ongoing bare frame method.

1.1 Objective

Objective of this project is to demonstrate or study the response of masonry infill panels on the earthquake effect of RCC High Rise Building by considering the linear dynamic method i.e. equivalent or spectrum analysis. The observation obtained by comparison of G+20 High Rise Building for infilled frame and without infilled frames. The observation should be study in terms of i) Joint Displacement ii) Storey drift iii) Base shear.

The aim of this work is to study or find the strength and stiffness of the building with and without infill walls under lateral loading conditions. A 3-D model is created by using computer programming software such as ETABS, a comparison study should be made between the structures with infill and without infill walls. Their tensile capacities, which were negligible, were disregarded. In order to compare and understand the effect of masonry infill walls, analyses were also carried out for bare frames, i.e. without any infill wall.

1.2 Infill Walls

Infilled panels are the wall between the beams, columns or between floors which can be position and construction are subjected to induce applied loadings. Increase in the horizontal strength, stiffness and seismic energy loss by the use of infill walls with RCC frame structures it is known mostly.

Whenever any lateral load acts on the building structures, the infill walls are the most effected element and its behaviour effects lateral deflection due to seismic action. The basic four types of failures generally occurs in the infill walls are breaking at centre and corner ends of walls, shear fail and diagonal strut damage.

In recent studies, the researcher has found the economic loss due to the failure of a non-structural component such as infill walls, increases the cost of structures due to non-innovation of new techniques to overcome losses. However it is necessary to innovate research work to reduce the damage of the structures with infill walls The scientific or concept wise ideas to be implemented to tackle the behaviour of infill walls due to lateral load or seismic actions. Moreover the loss due to infill walls at normal seismic influence will be reduced/eliminate and the loss of energy with seismic action can be reducing by other means.

A graph represents the base shear verses the lateral drift for infilled and bare frame shown in figure 1.1

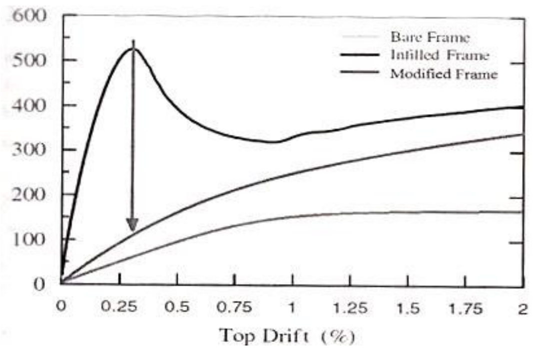

Figure 1. The above graph shows the base shear vs lateral drift curves

A RC infilled frame is the most concern structural frames for many budding researchers. However, most of these studies have been carried out in order to increase the lateral load capacity of pre-70s buildings. In the early and on pre-70's buildings the main cause to reduce the damage of structural frame is the use of infill walls as lateral support to the structures and increases the strength of the structures to some extents. Only some of the researchers concern or focussed on the prevention of damage to infill walls.

Therefore, considering the effects of infill walls in the structural behaviour, several state-of-the-art technological solutions and design methods have been investigated in order to both. However to reduce the effect of infill walls in the frames structure response many developing innovation technologies to develop various methods to be investigated, so as to

1.3 USAGE OF MASONRY INFILLS

Many under developed or developing countries is normally using the masonry infill walls which may be unreinforced clay bricks or hollow masonry blocks is available around the world at a very cheaper cost because of the availability of the materials with low cost labour availability make this material the preferred choice.

- In many parts of the world, the people are worried about increasing labour expenditure, non-availability of trained labour and more time consuming construction method they preferred pre cast brick work.
- Solid walls are mostly constructed around the world because of their culture. Outer walls are constructed with solid walls.
- The cavities on the masonry brick skins can be effectively use as protection under weather condition, if it is properly constructed. The face brick outer skin of cavity walls provides a hardwearing maintenance free façade finish provided proper articulation is adopted and cracking of brick walls is avoided. The construction of cavity brick is costly and expensive for many under develop and poor countries. As the single masonry brick is constructed with the mixture of ordinary cement/ gypsum content and water retarding paints on the infill masonry wall.
- To reduce the damage effect of infill walls and
- As by using limiting design method the reduction of the damage of the structures can be minimized for the structural response.

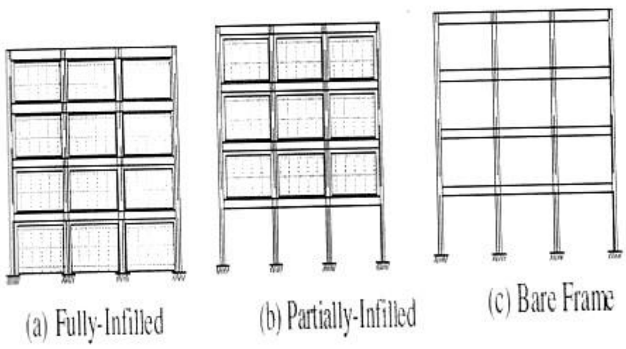

Figure 2.Frames with infills.

TYPES OF INFILL WALLING

- Masonry infill walls
- Concrete infill walls
- Timber framed infill walls
- Light steel framed infill walls
- Stone walls

2. LATERAL FORCES ON INFILLED WALLS

Typical considered to be those which act parallel to the ground plane may occur at many angles other than perfectly horizontal generally utilized as the vertical load to the normal building systems

2.1 Earthquake Loads

An earthquake occurs due to the sudden release of large amount of energy from the earth crust along the faulty plane of earth crust that would develop over a long time. Seismic waves are generated due sudden shaking during earthquake. These earthquake waves are formed when the rock slips under the earth crust lead to large amount of energy. The release energy moves in the form of radiate waves or ripples formed like when a stone thrown in a lake. The plates near the tectonic region of the earth crust tend to bend, slides and expand due to the inside forces develop under the earth leads to earthquakes. Due to movement of tectonic plates, most of the physical changes on the earth surface such as faults, volcanoes and earthquakes Displacement and separation of planes along the fractures on the earth crust leads to the geologic fault. As the rock is a brittle material it breaks under the action of large stresses on the earth surfaces. Deep under the surface of the earth, the rock flows as ductile material. The change in the volume of rock to the original volume is known as strain. Because rocks can “flow” when they are deep within the earth, they considered ductile. When the rock shows brittle properties it leads to the ductility over the surface. The rocks when moves from ductile state to brittle state, it may cause breaking of structures leads to the instant release of more amount of energy causes earthquakes. As when the dry brake of the tree, is applied by some amount of load over it, it bend up to permissible limit or its elasticity limit after that it breaks as the brittle materials.

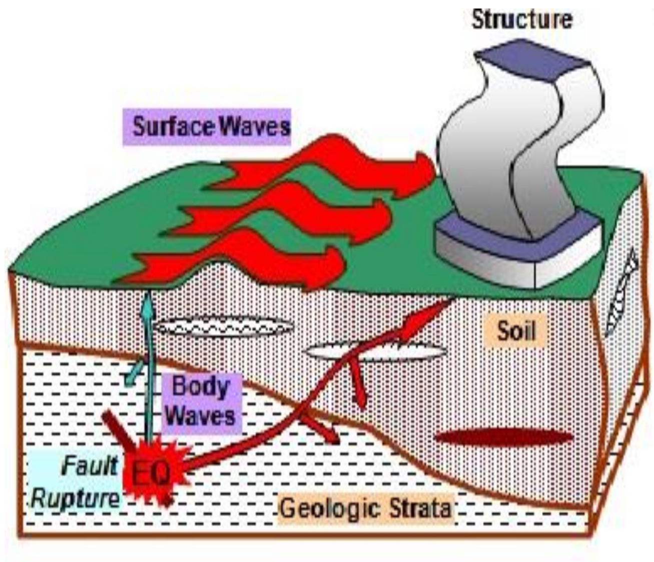

Figure 3. Movement of seismic or earthquake waves from the origin to the earth surfaces

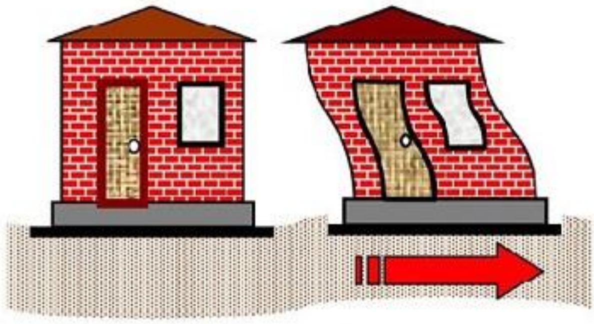

Figure 2.4 Influence of seismic propagation under the surface of the building

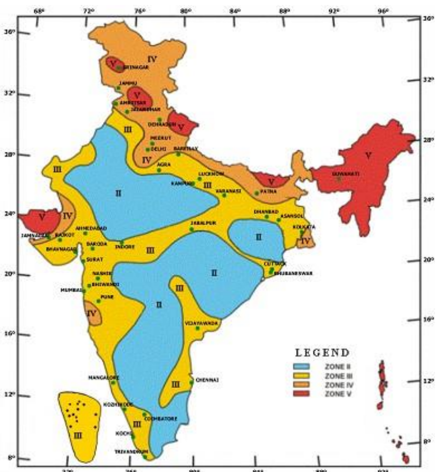

Figure 4. Indian seismic zone map as per I.S: 1893(PART 1)-2002

2.3 Effects of Earthquakes on High Rise Buildings

When a building experiences earthquake vibrations, its foundation will move back and forth with the ground. These waves or shaking can be great intense, making stress and deflection along the structures moving the upper edges of the buildings deflect from few mm to many cm depends on heights, size and mass of structures. Earthquake zones are uniform whether the building is single storey or multi storey in the regions. The building should be design in such a way that it will allow certain amount of lateral movement of the building components to withstand earthquakes shakings. It has been showed that different building at sizes and height are vibrates with varying frequencies.

Where these were made next to each other, they created stresses in both the structures, thus weakened each other, and in many cases caused the failure of both the structures. Bureau of Indian Standards makes clear instruction, in its code IS 4326 that a separation section is to be provided between building. The space left between the adjacent parts of the building or different parts is defined as the separation Permit movement to prevent the shaking or movement during earthquakes". Further it declares that the height of the building exceeding the 40m should carry dynamic analysis of the structures to calculate the drift at story and the separation between the different parts of structures.

However it has to provided sufficient space between adjoining of the building higher than the summation of assumed flexural of both the buildings at their top, it may have sufficient space to shake. When the neighbouring slab comes into contact with the middle of the walls and the column of the adjacent building, as the building elements such as walls and columns are not designed to take additional lateral force caused by the lateral forces coming from the adjacent building slabs.

2.4 Wind Forces

The application of wind forces to a closed building in the form of pressure applied normal to the exterior surfaces of the building. As the building is covered by cladding when lateral wind force act on the building structures. Wall surface element on the windward side or assumed to take the total wind pressure and are typically designed to span vertically between the roof and floor structures. Roof and floor slabs, considered as rigid planes (called diaphragms), receive the edge loading from the windward wall and distribute the load to the vertical bracing system. Vertical frames or shear walls, acting as vertical cantilevers, receive the loads from the horizontal diaphragms and transfer them to the building foundations. The footing must be providing with vertical connecting elements for transferring the loads on the ground.

Table 1. Zone wise basic wind speeds in m/s

Zone	Basic wind speed (m/sec)
I	33
II	39
III	44
IV	47
V	50
VI	55

3. LITERATURE REVIEW

Sucuoglu & erberik studied seismic performance of a three-storey unreinforced masonry building which survived in 1992 erzincan earthquake without damage. A certain number of experiments have been performed to know the material or mechanical properties of the masonry walls. A computer program used for the development of model of masonry infill structure for the analysis of the structures. Results of performed dynamic analysis showed that if it satisfies the requirement of seismic code have considerable lateral load resistance both in elastic and ultimate limit state.

However the performance of dynamic analysis of masonry building shown a satisfactory result by the use of standard codes such as elastic limit states. Masonry wall due to the internal friction shows the closing of energy. However, these entire conclusions were based on the mechanical properties that were obtained by laboratory tests. In other words, validity of these conclusions is dependent on achievement of the same material properties.

Paulay & priestley propose a theory about the seismic behaviour of masonry infilled frame and a design method for infilled frames. Although the masonry infill walls increases the over all lateral stability of the structures under the lateral loading such seismic and wind forces for various parts of the building. Infilled frames behaviour is different with respect to seismic load and masonry infill shows structural failures.

Smith & coull presented a design method for infilled frame based on diagonally braced frame criteria. As they shows 3 ways of failure of infill walls, one is the shear, second is the diagonal breaking and the third is the breaking of corner infill. Effective width of diagonal compression is equal to the 1/10 of structural diagonal length. Initially the design should be based on gravity loadings itself.

Sucuoglu & mcniven studied seismic response of reinforced masonry piers that reveal a shear mode of failure. They have presented two parts after conducting the number of experiment under simultaneous lateral loads. Based on the experimental result certain have been used for the seismic design of masonry and specified codes. They focused on the seismic shear response of reinforced masonry piers. As the gravity load and aspect ratios increases the structural piers fails due to the shear. Their more concern about shear design property of masonry piers based on analytical and invention of masonry behaviour at ultimate failure. Their design method was based on diagonal cracking strength of masonry piers. In addition, web reinforcement was used in design method to provide post-cracking capacity. They concluded that vertical loads have strong effect on both cracking and ultimate strength level. Moreover, the results of the proposed method, which determined the design shear and the amount of web reinforcement essential for ductile resistance, matched with the experimental results.

Smith & carter examined multi-storey 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. Their prior necessity is to know behaviour of composite infilled frames under damage modes. Compression strut's width is greatly effect and it is determined. After determining the design curves and crushing strength the behaviour of the masonry structures is known. For the rehabilitation and retrofitting of the masonry infill walls can be analysed by using the guide lines of the federal management guideline. Since this is not a code but by using this we can effective built the structures and it is document analysis procedures.

Material properties and design criteria for concrete, steel, masonry and lightweight materials are given in separate chapters. As the concrete provision shall be design for the infilled concrete frames. As per this instructions that concrete frames with infill walls will be constructed in such a manner that the infill and frame should be connected when load is acting. Young's modulus of elasticity of material and stiffness should be known prior to construct.

4. METHODOLOGY

If a structure act by lateral loading system such as earthquake due to their influences, the structure starts vibrating. Whenever the earthquake force act on the structure, it is divided into three forces and is perpendicular to each other directions. The first and the second are the horizontal forces in direction (x and y) and the third vertical force in the direction (z). due to the forces the particle or parts vibrates in all the three directions, the most important force for our consideration is the horizontal forces. Initially the gravity loads are force by the product of mass and time gravity in the vertical direction. Because of the inherent factor of safety used in the design specifications, most structures tend to be adequately protected against vertical shaking. For the structure with the larger span over all stability of the structures is effected with vertical acceleration.

4.1 Dynamic Analysis

Dynamic analysis can be used to determine the design seismic forces and their behaviour at different levels of high rise buildings and subjected with different lateral loading systems for the structural elements to the building. As the normal building constructed in the seismic region of zones IV and V, is more than when seen with normal building height in zones II and III. As per the code for the analysis of the structures for the dynamic analysis from IS CODE can be figure out the type of irregularities in the building.

5. MODELING OF STRUCTURAL

The modelling of the building structures for a multi storey buildings making the floor plan and repeating the same plan in the vertical direction.

Modelling features is the stream line analysis-model generation, and advanced stimulate seismic systems are listed as below:

- Global system and local systems templates
- Arrangement of shell and frame objects
- Geometric section and behaviour is customized and constitutive
- Manual options and automatic meshing system
- 3D views , plan and elevation assignment and editing features
- Advance seismic systems for model isolators and dampers for link assignment
- Specification for non-linear hinges

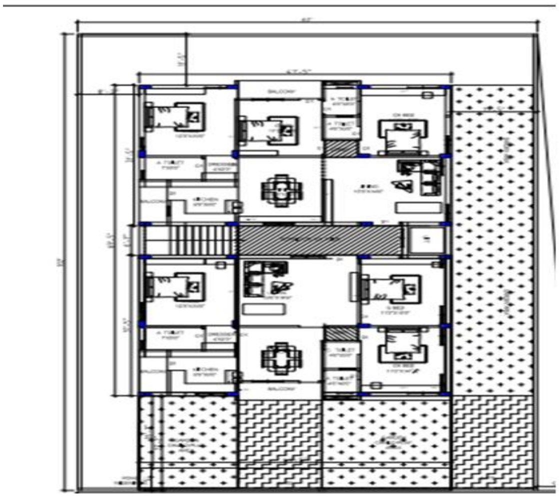

Figure 5. Typical Floor Plan

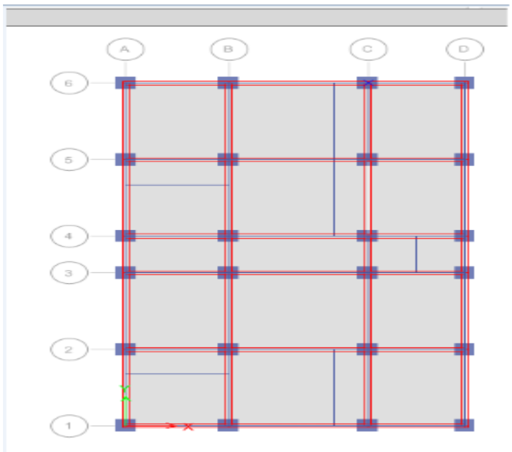

Figure 6. Showing the grid diagram and 3d model of infill wall structures

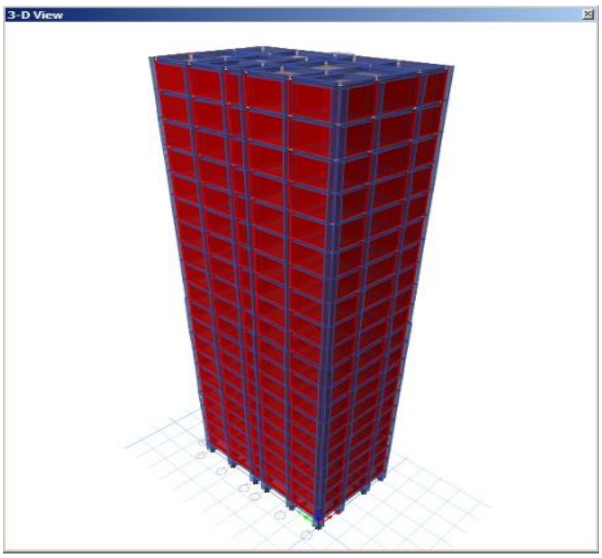

Figure 7. 3D Model View of Infill Wall Structures

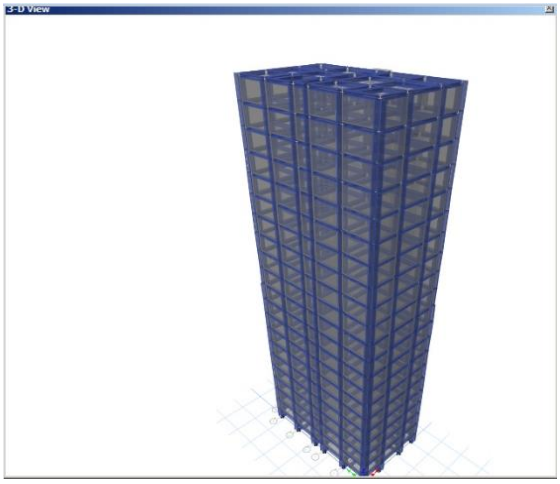

Figure 8. 3D Model View of Structures

5.1 DESCRIPTION OF BUILDING

Dead loads considered as per IS 875(part1)-1987.

- Structure: G+20-storey building rectangular in plan
- Plan dimensions: 12.39m x 20.94m.
- Column size: C750X750mm of M_{35} grade of concrete from 11th story and above, C900X900mm of M_{40} grade of concrete from 10th story and below.
- Beam size: B300X450mm of M35 grade of concrete from 11th story and above, B300X600mm of M40 grade of concrete from 10th story and below.
- Slab thickness: S200mm of M35 grade concrete for all storeys.
- Stair case: S125mm of M35 grade concrete for all storeys.
- Wall: W230mm up to 20th story, parapet wall W115mm
- Typical floor height: 3m
- Plinth level height: 1.5m
- Floor: G+20 story
- Support: fixed
- Type of soil: Medium type (IS: 1893)
- Zone: II

6. RESULTS AND DISCUSSIONS

6.1 INFILL WALL

Axial Force Diagram of Infill Wall with Elevation View 1 and Elevation View A

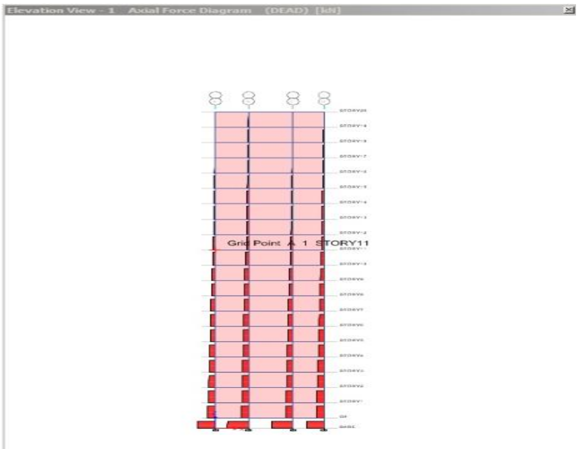

Figure 9. Axial Diagram of Infill Wall with Elevation View 1 and Elevation View A

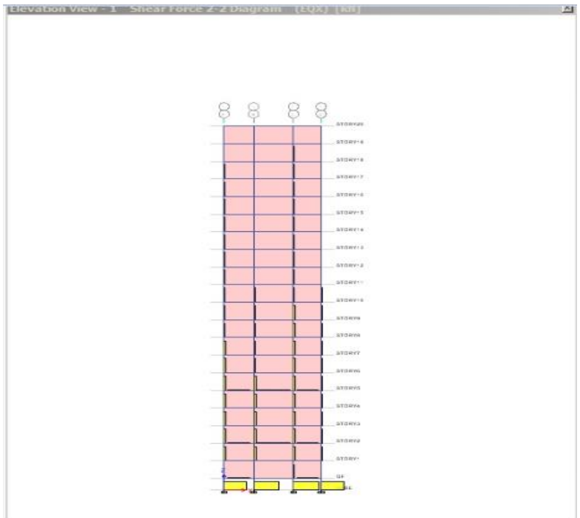

Figure 10. Shear Force Diagram of Infill Wall with Elevation View 1 And Elevation View A

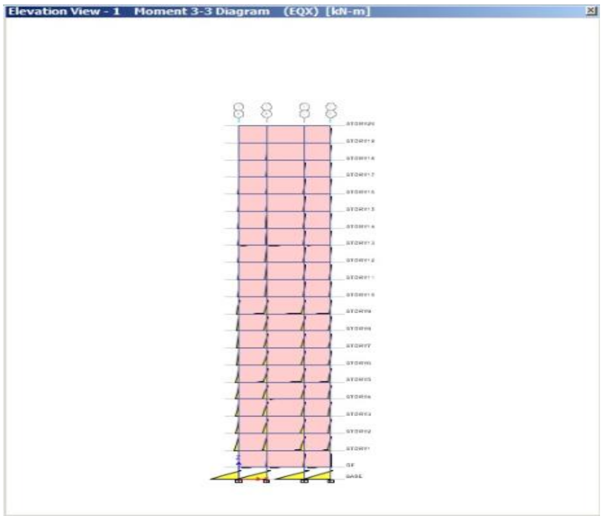

Figure 11. Bending Moment Diagram of Infill Wall With Elevation View 1 And Elevation View A

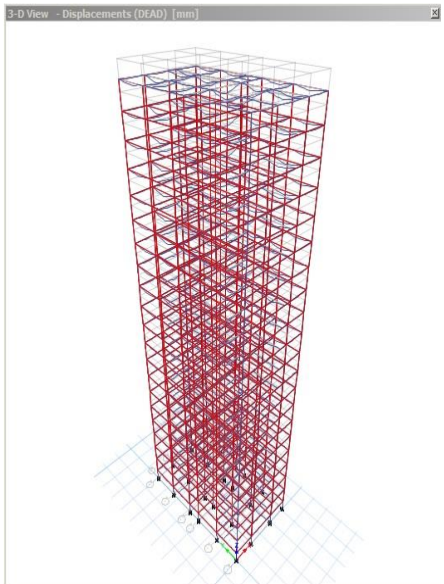

Figure 12. Displacement Diagram of Infill Wall with 3D View

6.2 WITHOUT INFILL WALL

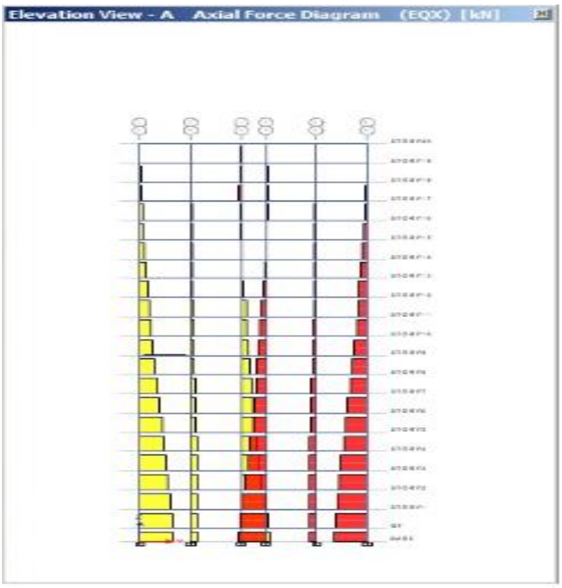

Figure 13. axial Diagram of Without Infill Wall with Elevation View A

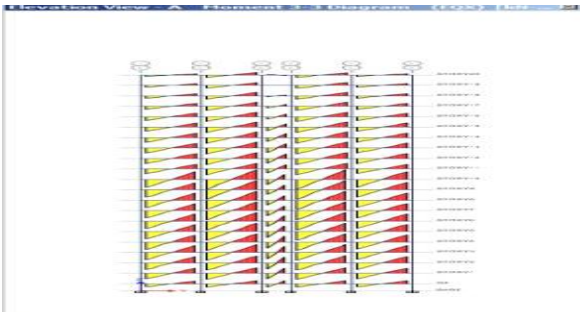

Figure 14. Bending Moment Diagram of without Infill Wall with Elevation View A

7. DISCUSSION OF RESULTS

After analysing the high rise building structure with the effect of infill shows the agreeable response on the structural performance, subjected to lateral loading systems. The use of infill walls has an influence on the structural behaviour of the structures. Knowing the values of the displacement, drift and base shear values.

1. DISPLACEMENT: The displacements at top story of the building with infill's wall in zone II reduces by 29.88% along X-direction and 24.98% along Y- direction.

Percentage of displacement in zone II

Story No.	% Displacement In X-Direction Without Infill Walls	% Displacement In Y-Direction Without Infill Walls
20th	29.88	24.98
10th	20.11	18.37
2th	6.13	7.85

2. STORY DRIFT: Storey drift for infilled wall model is within permissible limit as per the code provisions. The drift at top story of the building with infill walls in zone II reduces by 30.02% along X-direction and 25.63% along Y-direction.

Percentage of drift in zone II

STORY NO.	% DRIFT IN X-DIRECTION WITHOUT INFILL WALLS	% DRIFT IN Y-DIRECTION WITHOUT INFILL WALLS
20th	30.02	25.63
10th	27.38	41.84
2th	39.36	66.66

3. Base shear: From the results, it is shown that due to infill walls in building the base shear is increased to **25.10%** as compared to the model without infills

Table7.9: Comparison of Hand Calculation Values of Base Shear with Etabs

Load	Manually	Etabs	Variation In Percentage %
EQX	841.67	888	5.21
EQY	1099.07	1144	3.92

8. CONCLUSIONS

- The displacements at top story of the building with infill's wall in zone II reduces by 29.88% along X-direction and 24.98% along Y- direction.
- The percentage displacements in X-direction without infill walls at stories 20th, 10th and 2th are 29.88%, 20.11% and 6.13% respectively.

- The percentage displacements in Y-direction without infill walls at stories 20th, 10th and 2th are 24.98%, 18.37% and 7.85% respectively.

- Storey drift for infilled wall model is within permissible limit as per the code provisions. The drift at top story of the building with infill walls in zone II reduces by 30.02% along X-direction and 25.63% along Y-direction.

- The percentage drifts in X-direction without infill walls at stories 20th, 10th and 2th are 30.02%, 27.38% and 39.36% respectively.

- The percentage drifts in Y-direction without infill walls at stories 20th, 10th and 2th are 25.63%, 41.84% and 66.66% respectively.

- The base shear is increased to **25.10%** as compared to the model without infills

- The Fundamental natural time period for zone II in X-direction and Y- direction are 1.580 sec and 1.210 sec respectively

- Spectral acc. Coeff. in X-direction and Y-direction are 0.860 and 1.123 respectively

- Building top storey displacement, time-period and drift is decreases due to the presence of infill walls in the high rise buildings. And the base shear is increased. The behaviour of high rise building is change to great extent because of the use of masonry infill walls.

- After observing the drift, displacement and time-period there is decrease in their values. We can also notice that the base shear is increasing with the infill walls.

- Therefore, the inclusion of the effect of infill walls in the structural analysis of the buildings reduces the lateral load deflection and drift.

REFERENCES

1. **IS 456-2000-**Code Of Practice For Plain And Reinforced Concrete.
2. **IS 1893(Part1)-2002** Criteria For Earthquake Resistant Design Of Structures
3. **IS 875(Part1)-1987-**Code Of Practice For Design Loads(Other Than Earthquake) For Buildings And Structures-Dead Loads
4. **IS 875(Part2)-1987-** Code Of Practice For Design Loads(Other Than Earthquake) For Buildings And Structures-Imposed Loads
5. Computers & Structures, Inc., "ETABS – Integrated Building Analysis & Design User Interface Manual," January 2002.
6. **Mariopaz-** Structural Dynamics: Theory & computations (Second Edition), CBS Publishers & Distributors-New Delhi,2004
7. **Chug, R.** (2004) Studies on RC Beams
8. S.J. SHAH DESIGN OF HIGH RISE BUILDING
9. D.S. PRAKASH RAO for the analysis of structures.