STUDY AND COMPARISON OF STRUCTURE HAVING DIFFERENT INFILL MATERIALS USING ETABS

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ABSTRACT

Reinforcement concrete structure frame system widely used around the world. In building structure, structure element is generally taken as Beam, column, foundation. The dead & live load is transferred from beam to column, column to footing then ultimately load distributed into the soil. The wall load is taken by beam. In building design, we mentioned the whole wall on the beam is possible, if it is not possible, we taken concealed beam into the slab below the wall. During the analysis of frame structure, we consider wall as non-structural element. But including walls in the structure analysis is play important role. This study deals with the examination of the impact of infill in structure and their behaviour in structure. In present situation high rise building constructed with the various type of infill wall materials. Some of them generally use for example red brick, AAC wall, Hollow concrete block, lightweight Aluminium & Steel panels. So three types of models are created on ETABS software. In this study 9 storey high rise building is designed in ETABS with taking 3 infill materials like Fly Ash brick, AAC block and Hollow concrete block taken for study which on the most critical earthquake zone IV analysis (Dynamic) is done using ETABS, soil properties assumed medium and importance factor is taken 1.2 . The all three infill wall models compare with the basic design parameter like moment, shear force, displacement. The all three models that I passed under seismic loading helped me to reach the conclusion on how all three models perform in the case of seismic loading. And by comparing the percentage growth in the displacement and storey drift we can decide the most efficient building. Because the AAC block has the lowest density hence it should have the least moment generated compared to other bricks almost 20-30 percent difference is expected. And the model with Strut member should have least deflection compared to other models. The difference of 15-20 percent is expected atleast.

Keywords: ETABS, Structural Analysis, masonry infill, RC frame, earthquake, displacement, drift, base shear, AAC blocks, Hollow concrete block, Bending moment, Diagonal Strut

CHAPTER-1 INTRODUCTION

1.1 : OVERVIEW:

A tall structure is a multi-story structure in which most tenants rely upon lifts [lifts] to arrive at their goals. Now a days due to growth of the population Housing has developed into an economy generating industry. Because of this high rise buildings have become a solution in large cities. The increasing frequency of the earthquakes in the world and building of tall structures, over the last few 10-20 years forces for the development of tremor safe structures. A considerable lot of the tall structures had fell in ongoing tremors and the reasons credited were poor plan and development rehearses. The goal of this work is to talk about the potential outcomes of demonstrating support itemizing of strengthened solid models in common sense use considering different type of infill walls. To carry out the analytical investigations, the structure is modelled and analysis is done in ETABS software.

1.2 : INFILL WALL:

The infill wall is the supported wall that works as separator in buildings used to define shape of a room or outer boundary of a building constructed with a three-dimensional framework structure generally made of steel or reinforced concrete. Therefore, the basic edge guarantees the bearing capacity, though the infill divider serves to isolate inward and space, topping off the crates of the external casings. The walls has one of a kind static capacity to shoulder its very own load. Infill walls are outside vertical misty kind of conclusion. As for different types of separators, the infill- walls contrasts from the parcel that divides two inside spaces. The last plays out similar elements of the infill-wall, hydro-thermally and acoustically, however performs static capacities as well.. The use of masonry infill walls, and to some extent veneer walls, especially in reinforced concrete frame structures, is regular in numerous nations. Indeed, the utilization of stone work infill dividers offers a prudent and tough arrangement. They are anything but difficult to fabricate, appealing for engineering and has a productive cost-execution.

Infill walling is the conventional name of a board that is worked in the middle of the floors of the essential auxiliary casing of a working as such Infill board dividers are a type of cladding worked between the basic individuals from a building.

The auxiliary edge offers help for the cladding framework, and the cladding gives division of the inner and outside environments. Infill dividers are viewed as non-load bearing, yet they oppose wind loads. Useful prerequisites for infill board dividers include: They are self-supporting between basic surrounding individuals. They give climate obstruction.

They give warm and sound protection. The give imperviousness to fire. They give adequate openings to common ventilation and coating.

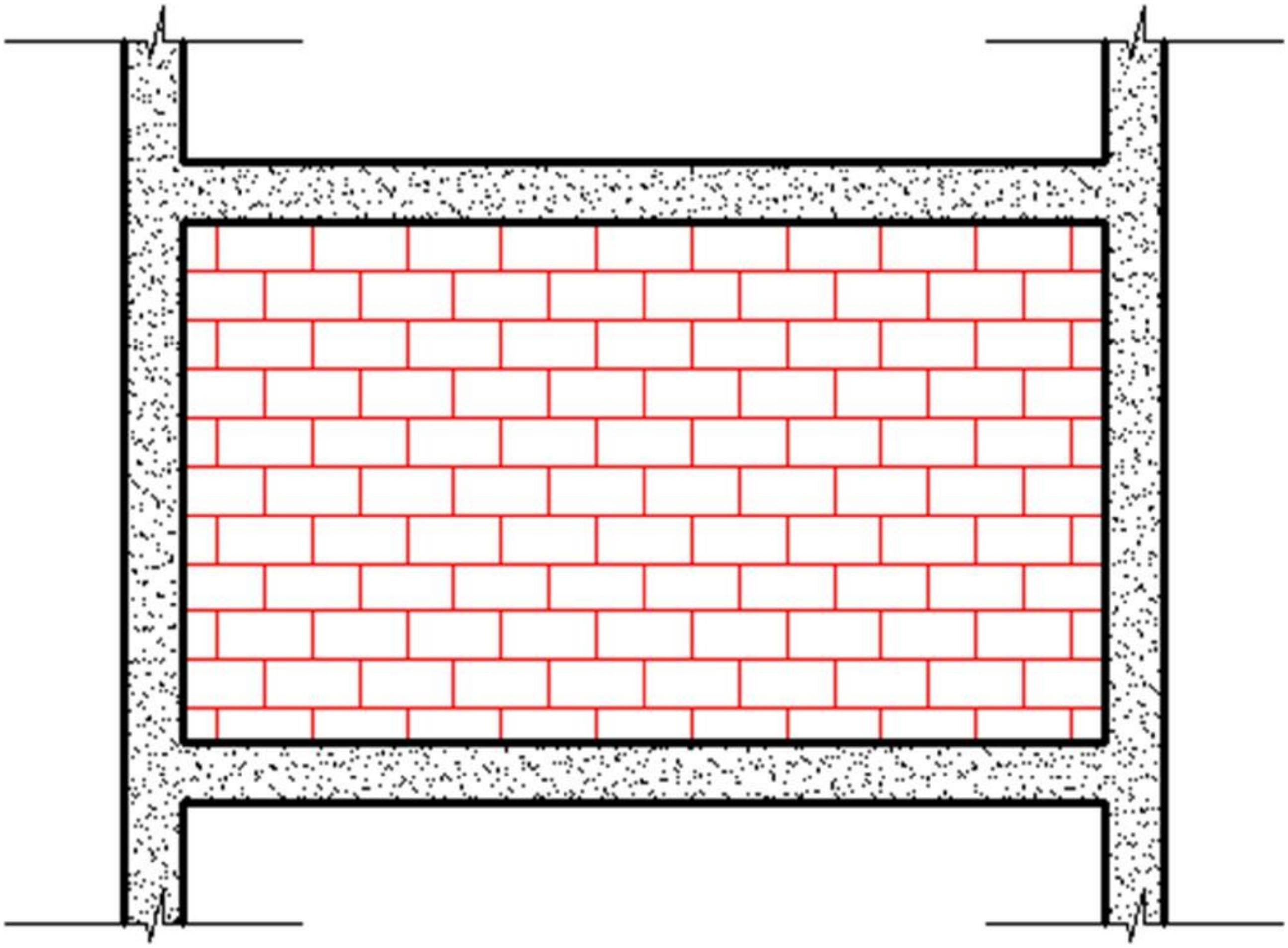

Fig. 1.1: Infill Wall

Above figure shows a section of Infill wall built between supporting columns and beams.

1.3 : DIAGONAL STRUT MEMBER METHOD:

For the presence of infill in our building frame modal, we can create a diagonal (strut) member in frame structure, the width of strut depends on the length of contact between the wall & the columns (αh) and between the wall & the beams (αL). Stafford Smith formulated method of calculating αh and αL by assuming beam on an elastic foundation in the year 1966. Hendry in the year 1998 gave the given equation to calculate the strut width w which can replace structural properties of an infill- wall, where the strut is under uniform compressive stress.

$$\alpha_h = \frac{\pi}{2} \sqrt[4]{\frac{4E_f I_c h}{E_m t \sin 2\theta}}$$

$$\alpha_L = \pi \sqrt[4]{\frac{4E_f I_b L}{E_m t \sin 2\theta}}$$

$$w = \frac{1}{2}\sqrt{\alpha_h^{\;2} + \alpha_L^{\;2}}$$

Where, 'Em' is elastic modulus of wall, 'Ef' is elastic modulus of what the frame is made of, t is thickness of wall(infill), 'h' is height of wall(infill) and L is length of infill, 'Ic' is moment of inertia of the column, 'Ib' is moment of inertia of the beam and θ = tan-1 (h/L).

1.4 : DESIGN CRITERIA OF HIGH-RISE BUILDING:

In this section, the points of importance to be considered for the design of any high-rise building structure are described. The points which may cause particular consequence in any high rise building and are based on above-mentioned literature are mentioned below.

1.4.1 : Design Philosophy: General Design Philosophy

The Limit State method of designing is accepted worldwide and based on semi-probabilistic for load and geometric conditions. One of the two fundamental types of limit state designing is ultimate limit state and it is usually taken under consideration in the design of high-rise structure. Due to tendency of instantly getting ultimate limit state it is a critical issue in high rise buildings and is given special consideration. An appropriate safety factor should be considered for the safe designing. The Limit State design mainly deals with the limit of collapse and limit of flexure. Limit State of serviceability deals with the appearance, efficiency and durability of the building throughout its design life. This can be accomplished by controlling unnecessary avoidance and break width. As it is notable, the above plan standards apply additionally to low-ascent structures.

1.4.2 : Lateral Load Design Philosophy

As opposed to vertical burden that might be accepted to increment directly with stature, parallel burdens are very factor and increment quickly with tallness. For example, under a regular wind load the moment (overturning) at the base differs in proportion with respect to the square of building height, while the lateral deflection differs as the fourth power.

As for their lower brethren, there are four factors to consider in the design of the tall buildings: strength, rigidity, stability and now-a-days legality. The quality necessity is the prevailing role, and often control the design. There are two ways to fulfil rigidity and stability requirements.

[1]. Increase the size of members above and beyond the strength requirements. However, this methodology has its very own points of confinement, past which it turns out to be either unreasonable or uneconomical.

[2]. The second and the more elegant approach is to change the configuration of the structure into something that is inherently more rigid and stable. It is of significant to note that there are no reports of completed tall buildings having collapsed because of wind loads.

Analytically, , it very well may be demonstrated that a tall working under the activity of wind will achieve a condition of breakdown by the purported p-d impact, in which the unconventionality of the gravity load increments to such a size, that it realizes pounding of sections because of substantial hub loads. In this manner, a vital security paradigm is to guarantee that anticipated breeze burdens will be underneath the heap comparing to stability limit. The second thought is to restrict the parallel redirection to a dimension that will guarantee that the compositional completes and parcels are not harmed. albeit less serious than the breakdown of the fundamental structure, the floor to floor avoidance typically alluded to as the inter-story drift nevertheless has to be limited because of the cost of relaxing the windows and the hazard to pedestrians of falling glass.

Large deflections and accelerations of the building's top floor should be considered from the standpoint of service-ability and occupant comfort. Peak acceleration at the top floors of the building resulting from frequent windstorm should be limited to minimize possible perception of motion by the occupants. In earthquake resisting plan it is important to avoid out and out breakdown of working under serious quakes while restricting the non-auxiliary harm to a base amid incessant earth tremors. The building should be designed to have a reserve of ductility to sustain gravity loads under large inelastic deformations during severe seismic activity.

1.5 : SEISMIC ANALYSIS:

It has been seen in past seismic tremors that the structures on inclined plane give more overlay. Shivers make substantial damage to structures, for case, loss of people in the building and if the intensity of vibration is high then it can cause collapse of the structure. In past years people has been produced irrefutably and as a result of which cities and towns started expanding out. In light of this reason distinctive structures are being inalienable inclined zones. India sports a wide shoreline forefront which is anchored with mountains and plateau. The structures in these zones are made on inclining grounds. A tremendous piece of the unforgiving ranges in India go under the seismic zone II, III and IV zones in such case working in context of slanting grounds are exceedingly slight against seismic tremor. This is a possible result of the way that the bits in the ground floor differentiate in their statures as showed up by the tendency of the ground. Segments toward one side are short and on flip side are long, by righteousness of which they are exceedingly delicate. Seismic forces acts more separate in inclining zones due to the assistant inconsistency. Moreover it has been examined that the seismic tremor exercises are slanted in inclining ranges. In India, for example, the north-east states. The deficiency of plain ground in inclining ranges powers advancement development on inclining ground realizing diverse imperative structures, for instance, reinforced concrete encompassed specialist's offices, colleges, motels and work environments laying on uneven inclinations. The lead of structures in the midst of tremor depends on the dispersal of mass and immovability in both even and vertical planes of the structures. In slanting district both these properties varies with irregularity and asymmetry. Such improvements in seismically slanted regions make them exhibited to more unmistakable shears and torsion.

Poor conduct of short portions is a consequence of how short area is stiffer when showed up distinctively in connection to the long piece, and it draws in more noteworthy earthquake control. Solidness of a zone is the invulnerability to natural disasters – the more prominent is the steadfastness, more noteworthy is the power required to turn it. On the off chance that a short region isn't attractively proposed for such a liberal oblige, it can endure through essential insidiousness amidst a seismic tremor. The immediate static arrangement of building is appeared with their straightly versatile strength of the building. Course of regular shake demands for the straight static framework related to static sidelong powers whose aggregate is corresponding to the parallel weight. When it is joined with the straightly adaptable model of the building it will accomplish graph development amplitudes approximating most vital relocations that are normal amidst the course of action shiver. To mastermind the earth tremor weights to figure the internal forces will be sensible evaluated of predicted that amidst would design earth shudder.

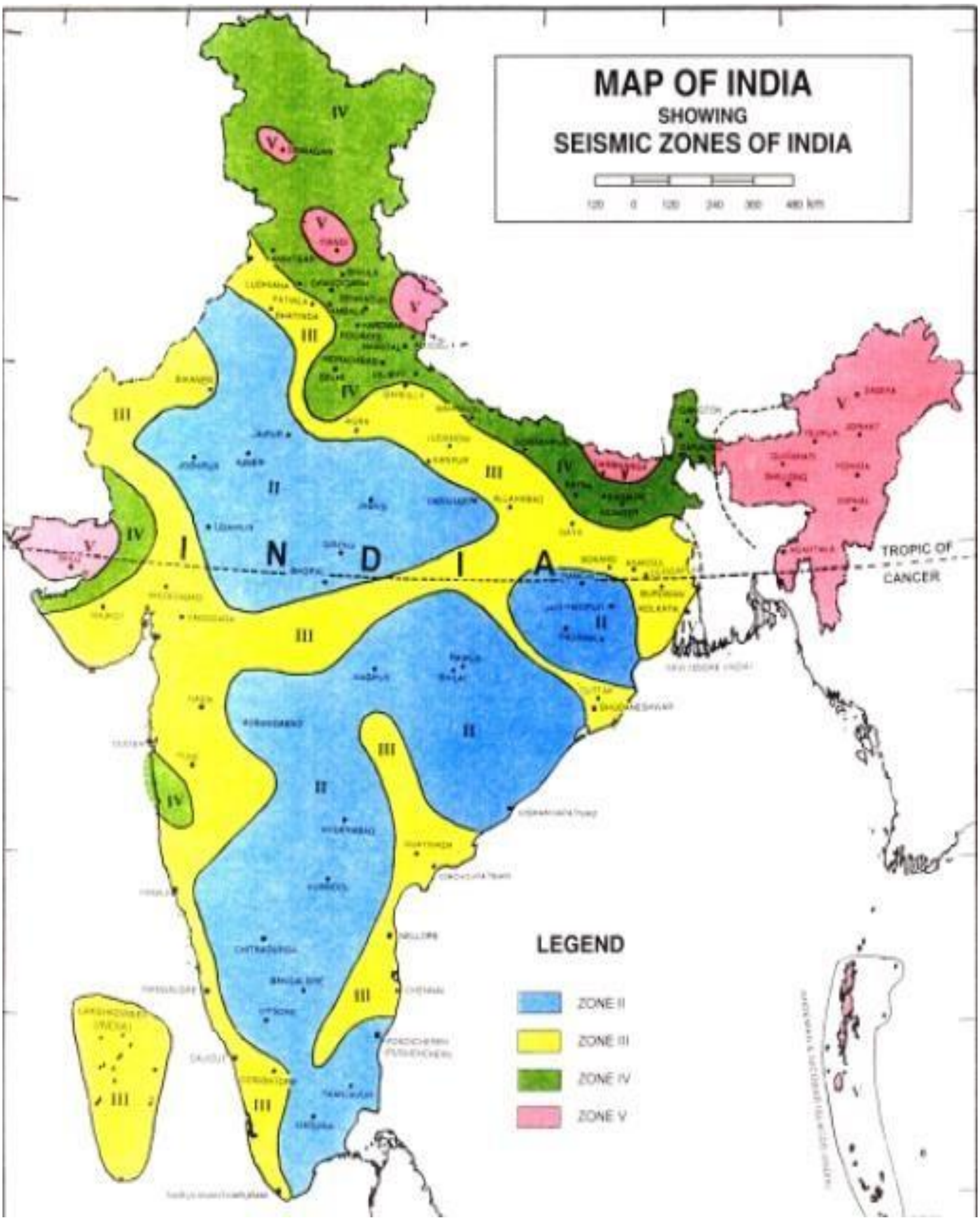

Fig. 1.2: Seismic Zone Distribution Map

This Map shows the different Seismic zones into which India is divided. Each zone is displayed in different color and the legend is given at the bottom of the Map.

The force and vibration because of seismic waves are ascertained according to IS 1893:2016 where the configuration seismic level coefficient A_h can be figured by the expression: -

$$\mathbf{V_b = Ah \times W}$$

V_b = Seismic base shear (Design) **Ah** = Horizontal seismic coefficient **W** = Weight of the building

(Seismic)

2. $$\mathbf{Ah} = \frac{Z\,.I}{R} \times Sa/g$$

Where Z = zone factor given in table 2 in IS 1893:2016.

Table No. 1.1: Seismic Zones and Their Intensity

SEISMIC ZONE	II	III	IV	V
INTENSITY	Low	Moderate	Severe	Very Severe
Z	0.10	0.16	0.24	0.36

This table gives the average Intensity of Earthquake in different Seismic Zones. In our study we are focusing on the structure situated in the Zone IV Seismic Zone which has severe intensity

Table No. 1.2: Importance Factor for Different Structures

S. No.	Structure	Importance Factor
1	Important service and community buildings, such as hospitals; schools; monumental structures; telephone exchange, power grid, court, etc.	1.5
2	All other buildings	1

Different types of buildings have different Importance factor based upon there usage it is defined as per I.S. code. The Importance factor is the governing factor which helps deciding the precautionary measures taken while designing a building in a certain earthquake zone. I = Importance factor as given in the table no. 6 of I.S. code 1893:2016 (Part-1)

Table No.1.3: Response Reduction Factor for different R.C.C. building systems

Building Frame System	Response Reduction Factor	Remark
O.M.R.F. (Ordinary moment resisting frame)	3	Ordinary detailing
S.M.R.F. (Special moment resisting frame)	5	Ductile detailing

Response reduction factor is the factor by which the actual base shear force should be reduced, to obtain the design lateral force during design basic earthquake (DBE) shaking.

R = Response reduction factor as given in the table no. 7 of I.S. code 1893: 2016 (part-1)

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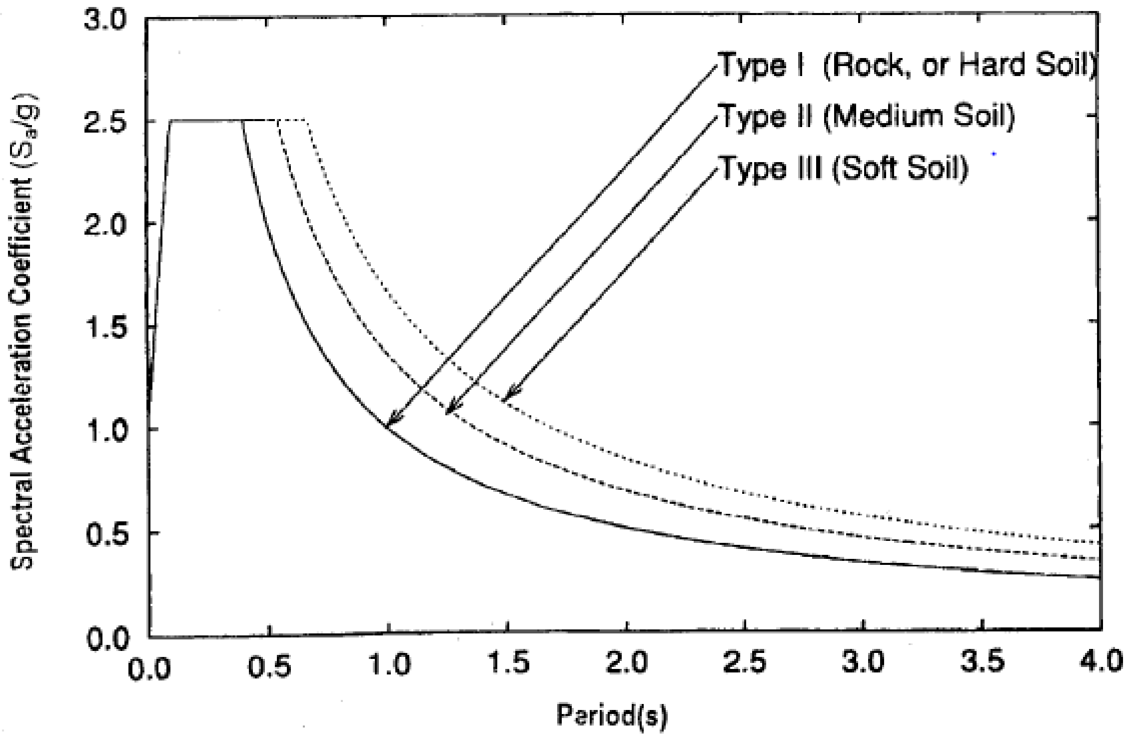

Fig: 1.3: Response spectra for 5% damping condition

Here Sa/g is the Average response acceleration coefficient.

This table shows the spectrum of change in the Average Response Acceleration coefficient with the periods.

1.6 : APPLICATION OF RESPONSE SPECTRUM:

After defining the seismic parameters, dynamic analysis is performed using ETABS'17 software by applying response spectrum method in accordance with IS-1893:2016. It is done by providing acceleration in X-direction using SRSS (Square root sum of the squares) for different types of soil condition.

Acceleration in X-direction is calculated using formula = Z/2 x I/R x Sa/g, Where Z = 0.24 (For Zone IV),

The design base shear VB (calculated from the Response Spectrum method) is contrasted and the base shear Vb (determined by observational recipe for the major time period).

On the off chance that VB is not exactly Vb, the majority of the reaction amounts are increased by Vb/VB according to Condition 7.8.2. The ratio Vb / VB is known as multiplication factor (MF) and this process is repeated until MF≤ 1. The same process is applied to other load cases.

1.7 : OBJECTIVES:

The goals of this study are as follows:-

- To Determine the Analysis of a Building structure with various types of infill walls
- To determine performance of building structure with infill walls in zones IV.
- To analyze the implementation of SRSS Method in tall structure using ETABS.
- To compare normal conventional building with building with different infill wall building with behavior in loading and other structure parameter.

1.8 : SCOPE & NEED OF THE STUDY:

The analysis is done on the seismic behaviour of a symmetrical/regular shaped building having Fly Ash, AAC Block & Red Brick:

a. In future studies will can analyze the different infill walls effect in the irregular building under the seismic loading dynamic analysis.

b. We can also analyze infill wall effect in large span building (like Flat or PT Slab).

The present study attempts to provide a study of the behaviour of a regular structure with under seismic dynamic loading considering different infill materials.

1.9 : LAYOUT OF THE STUDY:

Chapter 1: Introduction

This chapter presents details study of behaviour of reinforced cement concrete structure under lateral loads on the basis of different infill materials used. It defines the research problem adopted and the scope, states the aims and objectives adopted for the project work.

Chapter 2: Literature review

This chapter presents the review of previously published literature in the field of reinforced concrete framed structures with different infill materials and loading considerations. It also reviews the behaviour of buildings under lateral forces and infill walls during earthquake/lateral loading, methods of modelling of infill walls.

Chapter 3: Methodology

This chapter presents the proper procedure and step wise process for completion of research with proper flow chart. In this chapter modelling of all cases in ETABS has also been described.

Chapter 4: Analysis & Results

In this chapter results in terms of Shear Force, Maximum Storey Drift and Deflection in all stories has been shown. This chapter includes detailed description regarding analysis procedure and outcome behaviour is provided using tool ETABS.

Chapter 5: Conclusion & Future scope

In the last chapter conclusion as per results observed in chapter 5 is explained with possible future scope of the study.

CHAPTER-2 LITERATURE REVIEW

2.1 : GENERAL:

As seismic analysis is very important in regions prone to earthquake, up-gradation in seismic provisions may lead to more stability in structure for present conditions. Writing survey goes past the quest for data and incorporates the recognizable proof and explanation of connection between the writing and field of research. While the form of literature review might be varying with various types of studies. Different literature review from papers, journals, websites and dissertation related to our research area has been taken. Infill masonry work, bracings effect, software analysis and dynamic analysis have been included.

- **Omprakash, Netula et al (2017),** investigated the effect of infill in building and their behavior in structure for this the have considered different types of infill materials like brick infill, AAC block infill and Hollow concrete blocks infill. four different types of model used: RCC frame taking infill masonry weight, neglecting effect of stiffness, Effect of stiffness is considered in addition to taking weight of infill, Effect of stiffness is considered in addition to weight of infill excluding soft ground storey and Effect of stiffness is considered in addition to weight of infill including soft ground storey effect. For each infill four cases studied. Overall 12 models have been prepared in ETABS 15 storey building is considered for analysis which is located in zone 4 earth quake region. Static analysis is done using ETABS software, soil conditions is to be medium and importance factor is to be taken as 1.2. various parameter studied like lateral displacement of building, axial load in column, storey drift, storey shear, base shear, moments diagrams for a particular beam for all three types of material and for all four cases. Results are represented in graphical as well as in tabular form.. They concluded that AAC blocks masonry and hollow concrete masonry perform superior to that of brick masonry therefore AAC blocks and hollow concrete masonry can be used to replace the conventional brick masonry which is usually used in India in seismic prone area. It also concluded that seismic analysis should be performed by considering the infill walls in analysis. Due to presence of infill wall, stiffness of the reinforced concrete frame increases and decrease in displacement, storey drift will occur.

- **Irfanullah and B. Patil (2013),** studied the behaviour of RC frames with various arrangement of infill when subjected to earthquake loading. To observe the effect of masonry infill panel, it is modelled as an equivalent diagonal strut. In order to study these six RC framed buildings with brick masonry infill were designed. The results of bare frame, frame with infill, soft ground floor, soft basement and infill in swastika pattern in ground floor are compared and conclusions are made. It is observed that, providing infill below plinth and in swastika pattern in the ground floor improves earthquake resistant behaviour of the structure when compared to soft basement.
- **Pujol and Fick (2010),** conducted tests on a three-story full-scale flat plate structure which was designed to resist gravity loads only. The purpose of the study was to investigate the possible positive and negative effects of the partition walls. Therefore, the study was concentrated on the response of full-scale RC frame with and without partition walls. In this report response was assessed by strength, stiffness and displacement capacity of the system. It was concluded that partition walls can be expected to help control inter-story drift, provided that measures are taken to prevent out-of-plane failure of the infill and the shear failure of the columns.

- **Neves and Cavaco et al (2018),** studied one full scale RC frame designed according to Eurocode is statically tested to investigate the behaviour of the frame with and without masonry infill wall.

The obtained results show that infill wall can significantly increase the load carrying capacity of RC frame and thus serve as an important robustness reserve in the case of unpredictable extreme events (i.e. local impact, blast or earthquake). They concluded that When the failure is governed by formation of plastic hinges at the beams the high percentage of reinforcement of column does not have effect on the load carrying capacity of the frame, while high percent of longitudinal reinforcement of beams can significantly increase of the load carrying capacity of the frame, The frame reinforcement details have a pronounced effect on the frame performance.

- **Patil1 and Kulkarni,** Many urban multistory buildings in India today have open first storey as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first stories. Also for offices or for any other purpose such as communication hall etc. The construction of reinforced concrete structures with infill wall is a common method of providing shelter to the ever increasing population, where there is seismic activity. In the present work, the effect of different infill materials on the seismic behaviour of high rise building with soft stories is studied. For that, G+11 RCC model is selected. To study the effect of different infill material on high rise structure, linear dynamic analysis (Response spectrum analysis) in software ETABs is carried out. Seismic parameters like time period, base shear, storey displacement and storey drift are checked out.

- **Ioana and Olteanu et al (2014),** studied influence of the infill material on the overall behavior of the structure. Numerical simulation in two different computer software i.e. Axis VM and SAP2000. The different infill bricks made of clay tile, aerated light weight concrete (A.A.C) and Flexy Brick. They that the behavior of reinforced concrete frame structures can be improved by changing the material characteristics of the infill. The proposed polyurethane brick has a flexible behavior, with good properties for thermal insulation and mechanical ones. The main advantage is the low unit weight, respectively the low load that is transmitted to the structural system.

- **Das and Murty,** Five reinforced concrete (RC) framed buildings with brick masonry infill were designed for the same seismic hazard in accordance with the applicable provisions given in Eurocode 8 , Nepal Building Code 201 and Indian seismic code (with and without ductile detailing), and the equivalent braced frame method given in the literature. The buildings designed by the Nepal Building Code 201 and the equivalent braced frame method were found to be more economical.

- **Patel and B. Patel,** Earthquakes are natural hazards under which disasters are mainly caused by damage or collapse of buildings and other man-made structures. Due to accommodation of vehicles and their movements at ground levels infill walls are generally avoided, which creates soft storey effect. It should be noted that 70 to 80 % of buildings of urban areas in India fall under the classification of soft storey according to IS 1893 (2002) Part-I. In analysis and design of the high rise building generally we do not consider the effect of the brick masonry infill panel and design it by considering bare frame. Here to observe the effect of brick masonry infill panel and without infill panel in analysis of plane frame. Brick infill panel is modelled as diagonal strut and they are placed at all above the ground plus level. also check out stiffness of building.

- **Baghi, Oliveira et al,** The effectiveness of masonry infill wall on behavior of a Reinforced Concrete (RC) frame subjected to a column failure is studied experimentally. For this reason, one full scale RC frame designed according to Eurocode is statically tested to investigate the behavior of the frame with and without masonry infill wall. The obtained results show that infill wall can significantly increase the load carrying capacity of RC frame and thus serve as an important robustness reserve in the case of unpredictable extreme events (i.e. local impact, blast or earthquake). A photogrammetry analysis is carried out to study the behavior of the structure. Results give valuable information about the alternative load path, transfer of the applied load to the column and beams, and interaction forces between RC frame and infill wall. At the end, the experimental program is simulated by the OpenSees software to study the behavior of the frame. After having demonstrated that this model can predict the load deflection with good accuracy, a parametric study is conducted to evaluate the effect of the percentage of longitudinal reinforcement ratio of beams and columns on the load carrying capacity of the infilled RC frame.

- **Kumbhar and Rajguru**, In India, masonry infilled reinforced concrete frame is one of the most common structural system. The simplicity of construction and highly developed expertise have made the infilled frame one of the most rapid and economical structural form for reinforced concrete buildings. Masonry infills are functioning mostly as partitions and exterior walls. There are two different approaches for designing masonry infilled concrete frames depending on local construction site. In the first approach, masonry infill is taken as a part of structural system and they are assumed to brace the frame against horizontal loading. In the second approach, the frame is designed to carry the total vertical and horizontal loading. Moreover, masonry infill is uncoupled to avoid load being transferred to them. In earthquake prone regions like India, masonry infill walls are counted as non-structural elements. They are not taken into account at design stage.

- **Tamboli and Karadi**, Masonry infills are normally considered as non-structural elements and their stiffness contributions are generally ignored in practice, such an approach can lead to an unsafe design. The masonry infill walls though constructed as secondary elements behaves as a constituent part of the structural system and determine the overall behaviour of the structure especially when it is subjected to seismic loads. In this paper 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. In modelling the masonry infill panels the Equivalent diagonal Strut method is used and the software ETABS is used for the analysis of all the frame models.

- **Jadhao and Pajgade,** The construction of reinforced concrete buildings with unreinforced infill is common practice in India. Infill panels have traditionally been made of heavy rigid materials, such as clay bricks or concrete blocks. However, more lightweight and flexible infill options Such as AAC (aerated light weight concrete) blocks are now available in India to be used as masonry infill (MI) material in reinforced concrete (RC) framed buildings. The behavior of in-filled reinforced concrete (R/C) frames has been studied experimentally and analytically by a number of researchers. It has been recognized that infill materials give significant effect to the performance of the resulting in-filled frame structures. Most of the researches carried out in this area are focused on parameters such as the distribution of MI, variation of geometry, the strength of infill materials and the relative stiffness of infill to frame elements. The study of the effect of types of infill materials used (lightweight versus conventional brick masonry) on the behavior of in- filled R/C frames is however still limited. Previous experimental study has concluded that the R/C frame in-filled with AAC blocks exhibited better performance under lateral loads than that in-filled with conventional clay bricks. In the present paper an investigation has been made to study the behavior of RC frames with both AAC block and conventional clay bricks infill when subjected to seismic loads.

- **Agrawal1, Kulkarni et. al,** Infilled frame structures are commonly used in buildings. Masonry infilled RC frames are the most common type of structures used for multi- storeyed constructions in the developing countries, even in those which are located in seismically active regions also. Masonry infill walls are mainly used to increase initial stiffness and strength of reinforced concrete (RC) frame buildings. In the present study, it is attempt to highlights the performance of masonry infilled reinforced concrete (RC) frames including open first storey of with and without opening. This opening is express in terms of various percentages here, in this paper, symmetrical frame of college building (G+5) located in seismic zone-III is considered by modelling of initial frame.

According to FEMA-273, & ATC-40 which contain the provisions of calculation of stiffness of infilled frames by modelling infill as “Equivalent diagonal strut method”. This analysis is to be carried out on the models such as bare frame, strut frame, strut frame with 15% center & corner opening, which is performed by using computer software STAAD-Pro from which different parameters are computed. In which it shows that infill panels increase the stiffness of the structure.

- **Devipriya and Hariprasad,** The paper deals with a seismic study on an irregular G+9 building with and without infill walls and its effect on overall seismic response of this building. The presence infill wall has a significant impact on the seismic response of a reinforced concrete frame building, increasing structural strength and stiffness. An irregular E-shaped building is considered for the analysis. This study is to compare various parameters such as storey drift, storey shear, storey displacement, and time period of the building under seismic loads. Different infill materials like brick, AAC block and GFRG panels are used for the analysis. The results obtained were compared to find the suitable infill material for the RC frames. Analysis is done by response spectrum analysis using ETABS.

- **Bhargavi**, RC frames with brick masonry infill walls are commonly used in many parts of the country, including high seismic zones in India. Door and window openings are unavoidable components in in-fills because of functional and ventilation requirements. Various studies (experimental, analytical and numerical studies) have been carried out to understand the behavior of in-filled frames but the effect of openings (i.e., Door(s) and window(s)) and presence of lintel or lintel bands above the openings are not much studied and are rather neglected in the analysis and design procedures. Though experimental studies are more realistic, they cost too much for varying parameters and time taking. Therefore, in this study, a numerical model has been considered which analyzed keeping mechanical properties constant are and varying opening size and position, which helps in understanding the failure mechanism of in-fills in RC frames under seismic loading. This study is on the seismic behavior of brick masonry in-fill walls without openings, with openings and openings strengthened with lintel and lintel band. A building can be analyzed under all types of loading, such as monotonic, cyclic and earthquake loading. This numerical model is capable of showing crack initiation in the building when loaded till total collapse of the building, as Modelled and analyzed using Applied Element Method (AEM). This study focuses on understanding behavior of RC framed brick infill building under monotonic-static loading. A parametric study has been done in order to understand the effect of various parameters such as openings in walls, opening sizes, opening position and effect of lintel and lintel bands. Later damage estimation has been made based on the strength, stiffness and ductility of infill in RC frame structure. It was observed that performance of lintel band with opening is better than lintel with opening based on type of opening, opening location and material properties considered.

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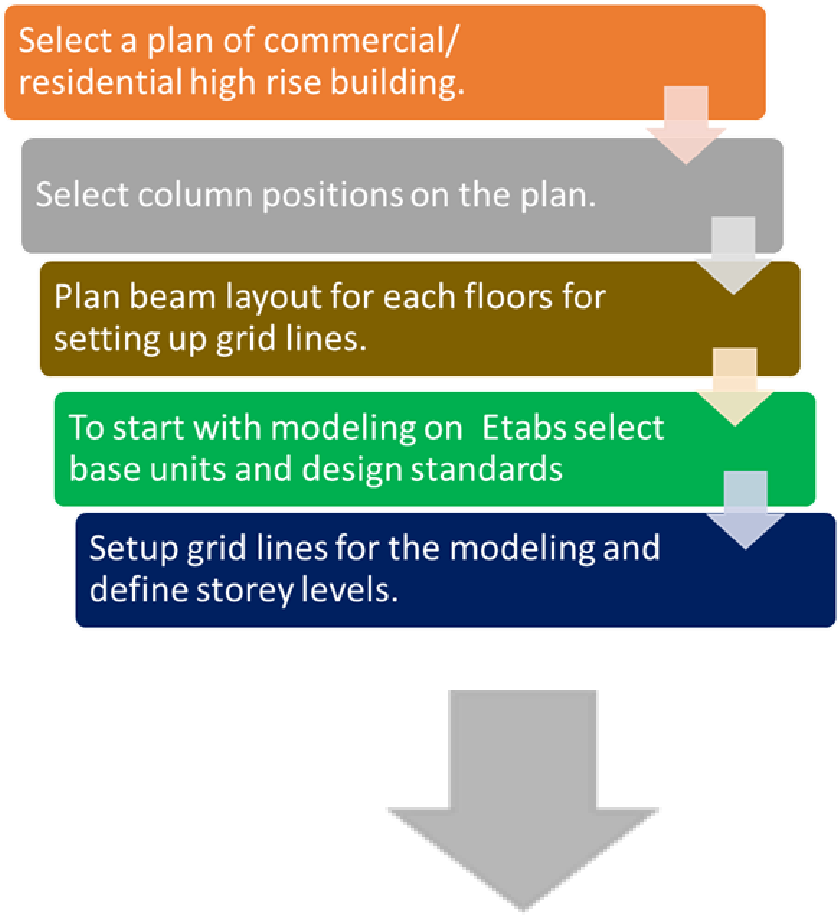
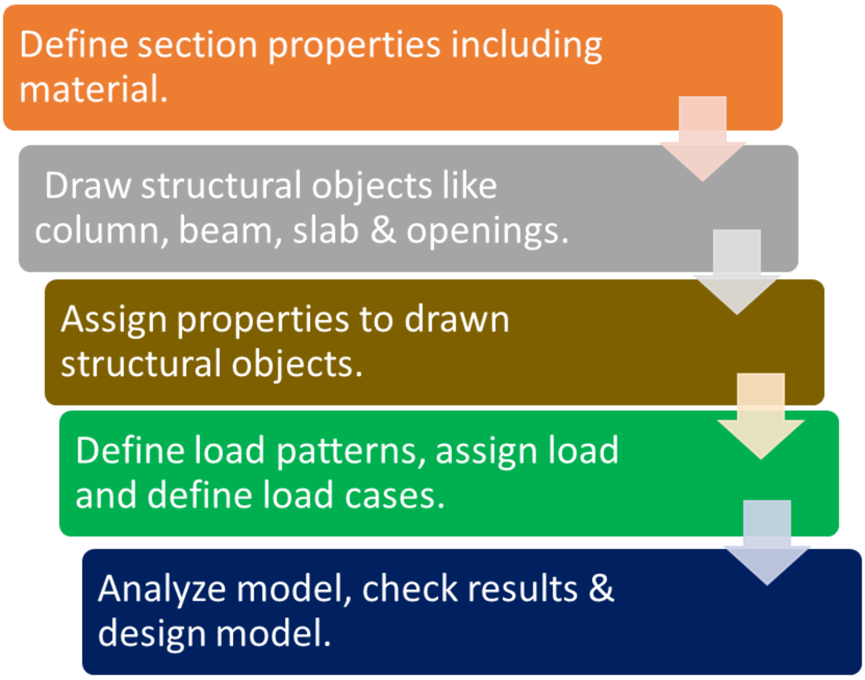
CHAPTER-3 METHODOLOGY

3.1 : INTRODUCTION:

In this work, the analysis based on Square-Root-of-Sum-of-Squares (SRSS) method in seismic analysis is used to investigate "ANALYSIS AND COMPARISON OF STRUTURE HAVING DIFFERENT INFILL MATERIAL (RED BRICK, AAC BLOCK, HOLLOW CONCRETE BLOCK) USING ETABS SOFTWARE" as per IS-standards.

3.2 : FLOW CHART:





3.3 : GENERAL DESCRIPTION:

Table No.3.1: Material Description

S.NO	Description	Density	Compressive strength
1.	FLY ASH BRICK	Y = 19 KN/m3	10-12 N/mm2
2.	AAC BLOCKS	Y = 8 KN/m3	3-4.5 N/mm2
3.	HOLLOW CONCRETE BLOCK	Y = 14 KN/m3	5.6 N/mm2

Table 3.1 displays the densities and compressive strength of different Infill Materials used in this study.

Table No.3.2: Material Properties

S.NO	PROPERTIES	VALUES
4.	YOUNG’S MODULAS OF ELASTICITY OF STEEL , Es	2.17 × 105 N/mm2
5.	ULTIMATE TENSILE STRENGTH OF STEEL	500N/mm2
6.	GRADE OF CONCRETE	M25
7.	POISION RATIO	0.17

This table shows some additional material properties of steel, concrete which are being used in the analysis.

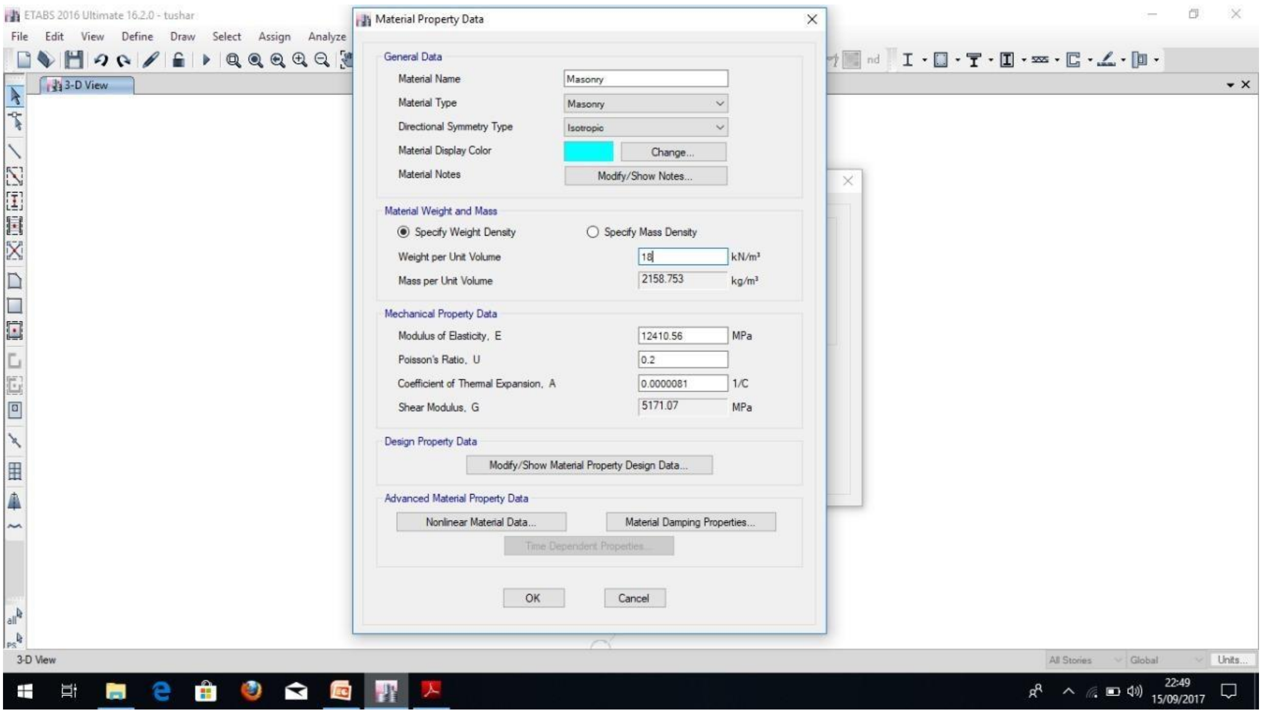


Fig. 3.1: Material Property Data

Figure shows the procedure of selecting material properties while analysis.

Table No.3.3: Building Geometry

S.NO	Description	Value
1	Area	20 X 25 m
2	Number of bays in X direction	4
3	Number of bays in Z direction	5
4	Height of Floors	3.0 m
5	Overall height	27 m

This table shows geometrical extents of the building model considered under this study. The area, height of the floor etc.

Table No.3.4: Load assignment as per I.S. Code

S. No.	Load Type	As per I.S. Code
1	Dead Load	I.S. 875-PART-1
2	Superimposed Load	I.S. 875-PART-2
3	Seismic Load	I.S. 1893-PART-1
4	Load Combinations	I.S. 875-PART-5

Different types of loads which will be applied on the building in this study in ETABS.

Table No.3.5: TYPES OF MODEL FORMATION IN ETABS

S.NO	TYPES OF MODEL FORMULATION IN ETABS
1.	RCC Frame Taking with Infill Wall loading. (Calculated Value)
2.	RCC Frame with Assigning Infill-Wall Properties in ETABS
3.	RCC Frame with Diagonal Strut Member Method

In this present study we have created 3 types of model: -

In these three types of modal formulation, we modelled three types of infill wall in ETABS software, totally we modelled 9 types of modals.

Table No.3.6: Earthquake Parameters

S.NO	PARAMETER	VALUE
1.	Zone IV	0.24
2.	Damping Ratio	0.05
3.	Importance Factor	1.2
4.	Response Reduction Factor	5
5	Soil Site Factor	Medium

The Earthquake Parameters which are used in this Study for building different models are shown in this above table.as per the codal provision. The code considered for earthquake parameters is I.S. code 1893-2016.

3.4 : LOAD CALCULATION: -

3.4.1 : DEAD LOAD-

a) Wall Load

1. FLY ASH BRICK = 0.2X 18X (3-0.5) = 9 KN / m^2
2. AAC BLOCK = 0.2 X 8 X (3-0.5) = 4 KN / m^2
3. HOLLOW CONCRETE = 0.2 X 14 X (3-0.5) = 7 KN / m^2

b) Slab Load

1. 0.125 X 25 X 1 +1 = 4.2 KN / m^2 (Including floor finish)

3.4.2 : LIVE LOAD –

Assessable Area – 2 KN / m^2

Live Load (Seismic calculation) 25% of Live load: - 0.5 kN/m^2

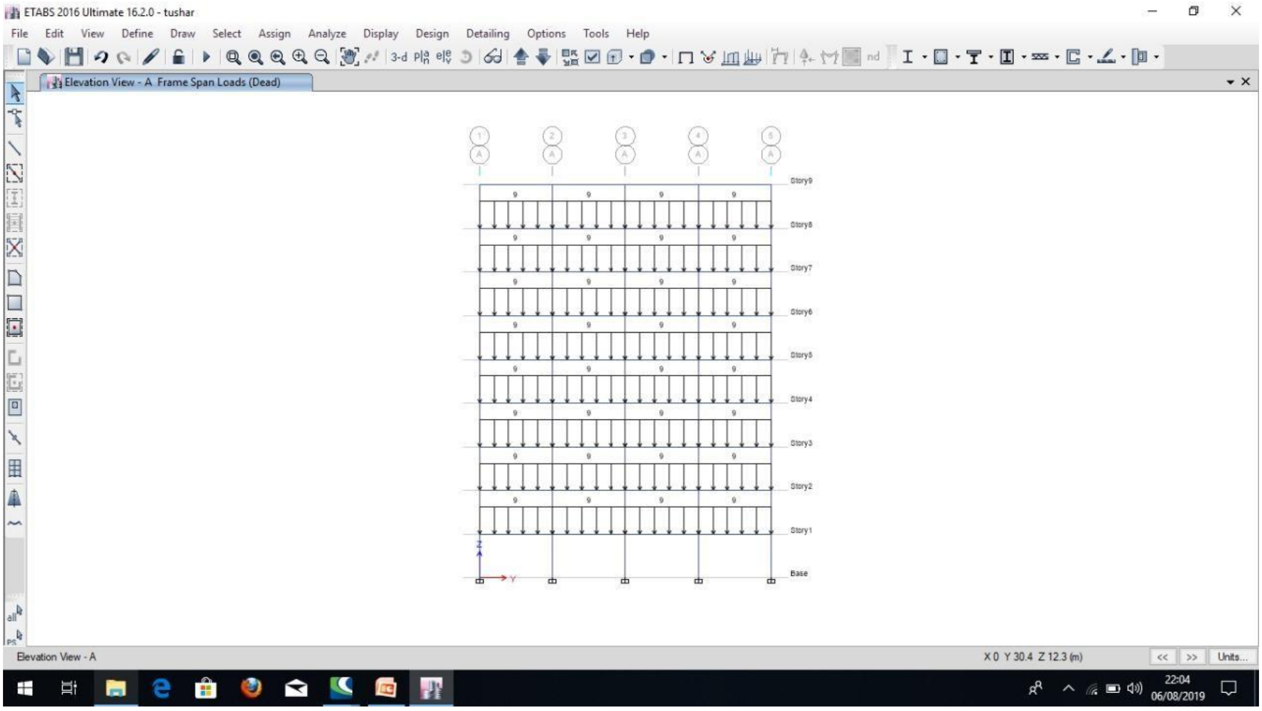


Fig. 3.2: Wall Loading

Fig 3.2 is displaying the way the wall loads are applied on the structure. This figure is the Elevation view from the side A

3.4.3 : SESMIC LOAD-

When a building experiences the ground motion or ground vibration it reacts by shaking. This random shaking of structure occurs in all directions i.e. in (X) and (Y) and also in (Z) direction i.e. horizontal and vertical both way shaking is possible and it causes the building to vibrate in all three directions horizontally, laterally and vertically and this seismic forces can be calculated as per given in IS: 1893:2016.

3.5 : DIFFERENT VIEWS OF THE STRUCTURE:

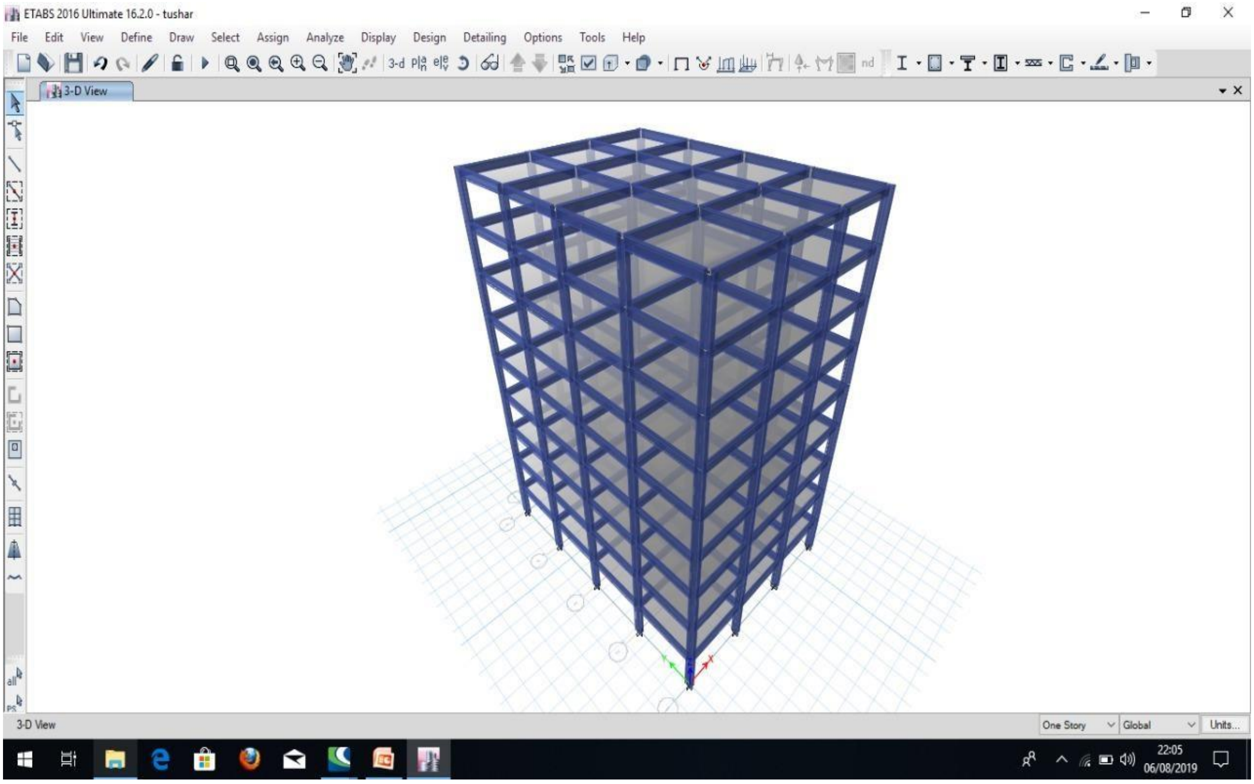


Fig. 3.3: 3d View of Building

The above Figure shows a 3D View of the building with Manually calculated load of the Infill Walls added to the total applied load and properties of infill walls are not taken into consideration (Model 1), i.e. walls are treated like non-structural element in this model.

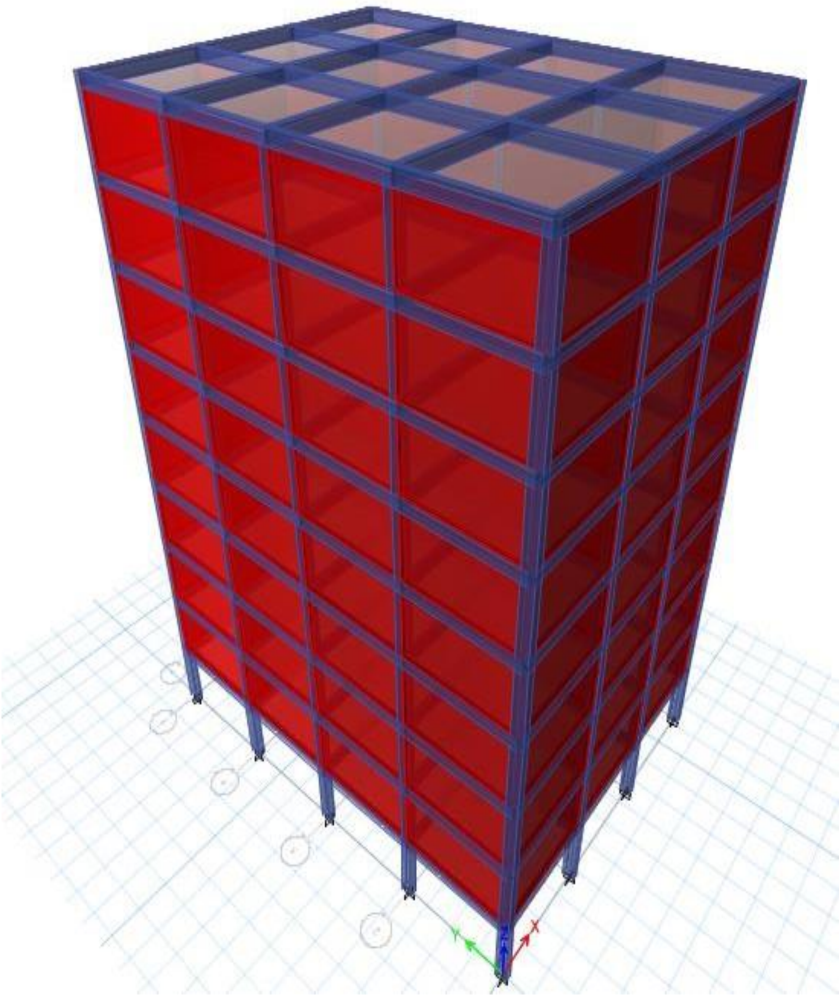


Fig. 3.4: 3d View of Building With Infill Wall Property

3D View of the building with considering properties of infill wall while analysis. This is second type of model (Model 2) which is analysed in this study. Here wall properties are also added with wall loads to see the effect of wall while applying loads to the structure.

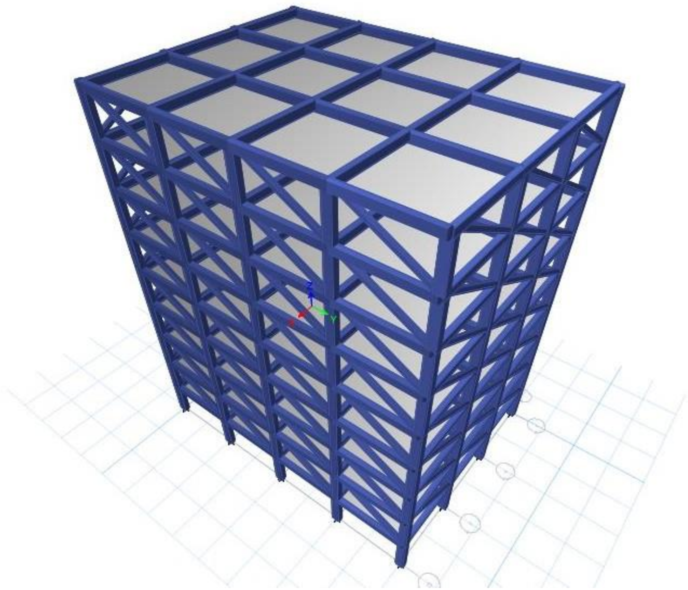


Fig 3.5: Etabs Modal with Strut Member

This above figure shows a 3D View of the building where the infill walls are replaced by Diagonal struts which Behave exactly like Infill walls in the case of lateral loading (Model 3).

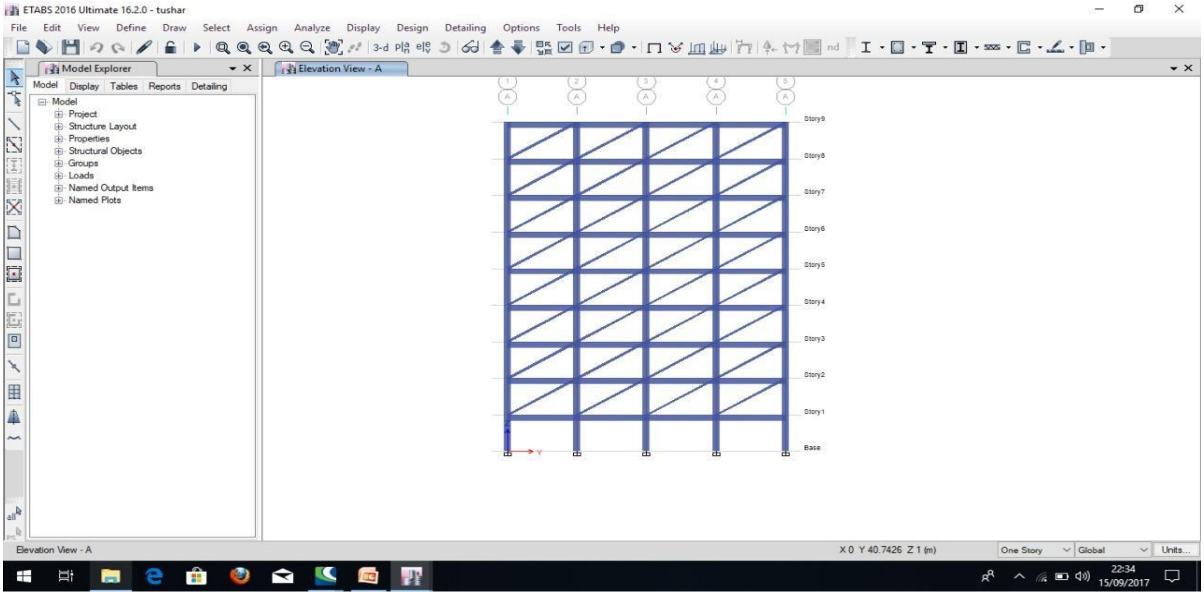


Fig 3.6: Side View of Strut Member

This figure shows the side view of the Model 3 here we can see Diagonal struts used in the place of walls.

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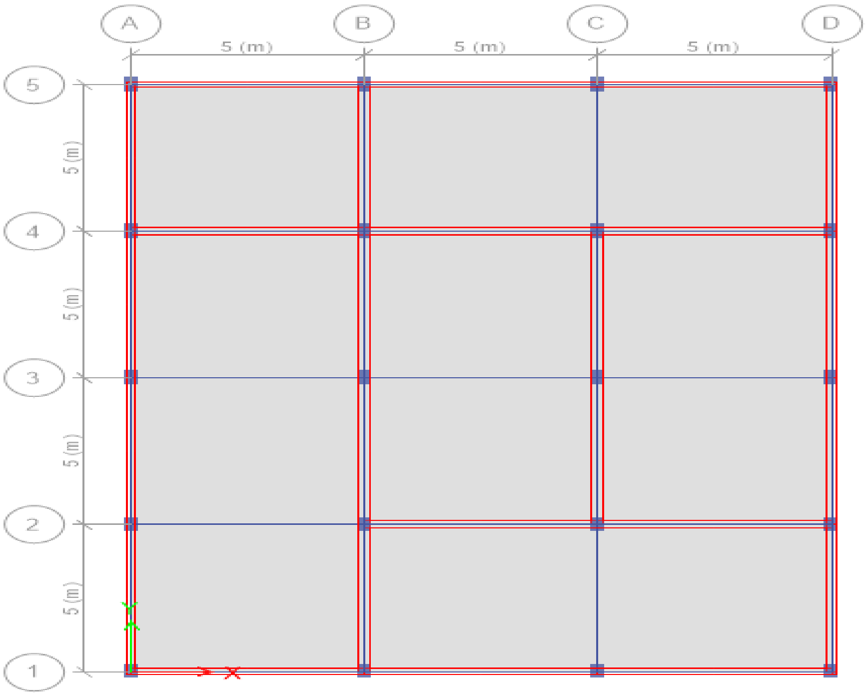

Fig 3.7: Plan & Geometry

This figure shows the top view of the structure and we can see the bays in X and Y direction and the shape of the walls provided along the structure height.

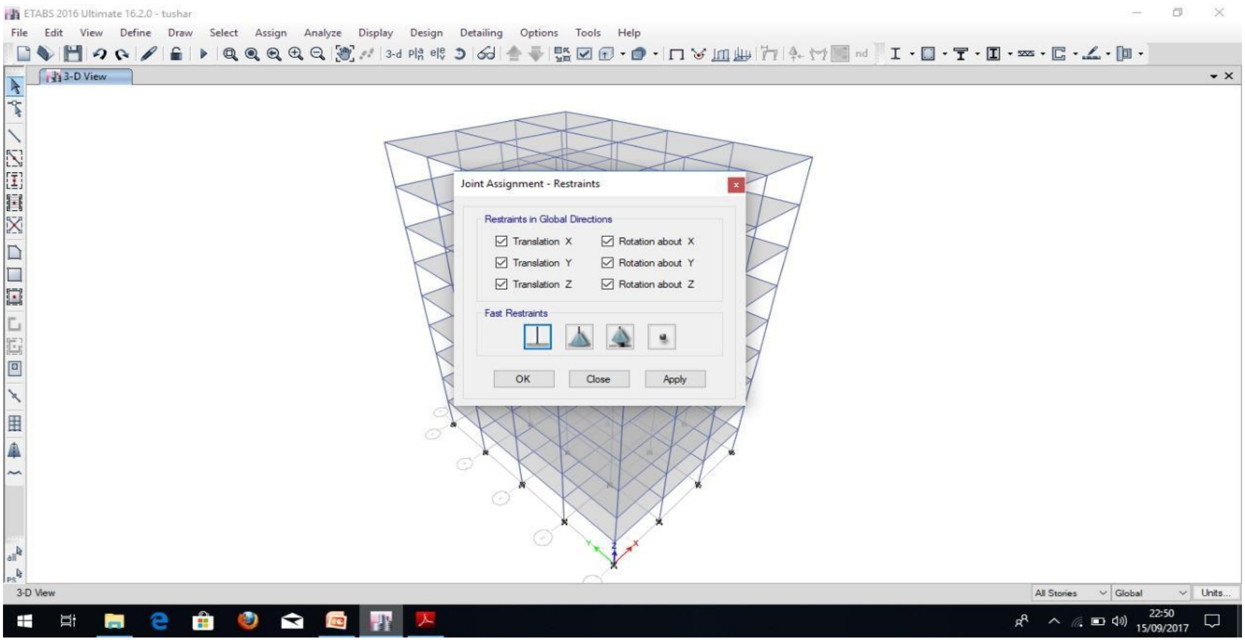

Fig. 3.8: Support Conditions: Fixed

In the above figure we can see that the structure has been provided fixed support.

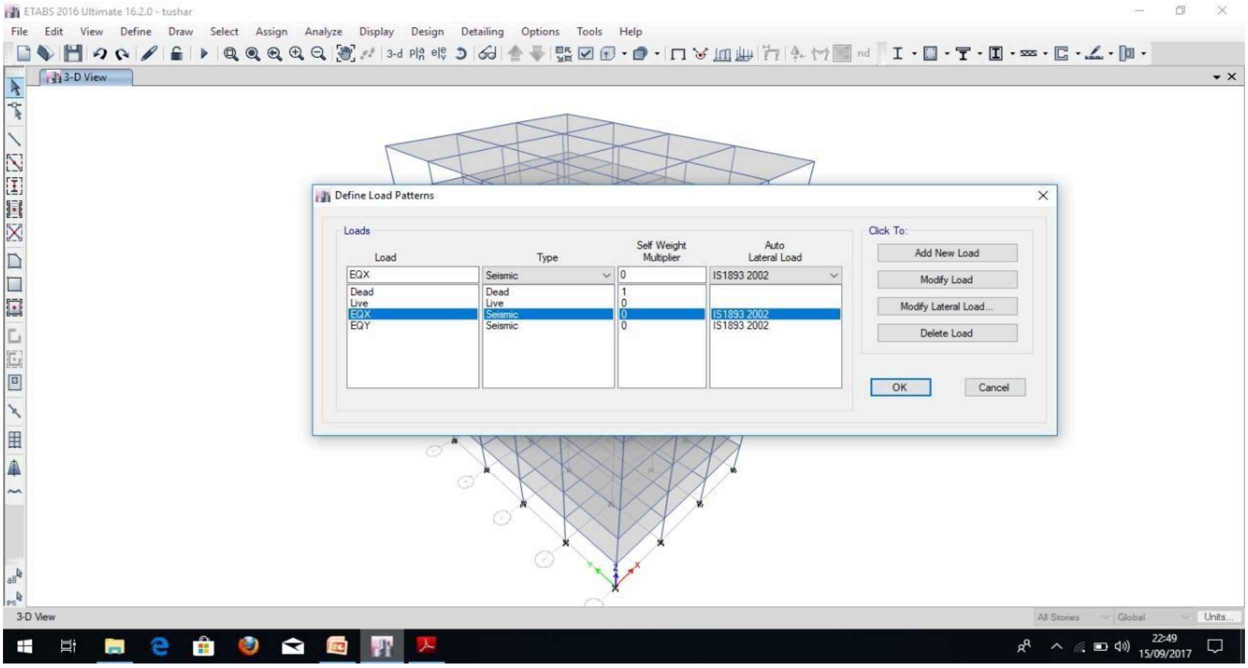

Fig. 3.9: Defining Load Patterns

In this figure Live and dead loads pattern are shown being selected and defined.

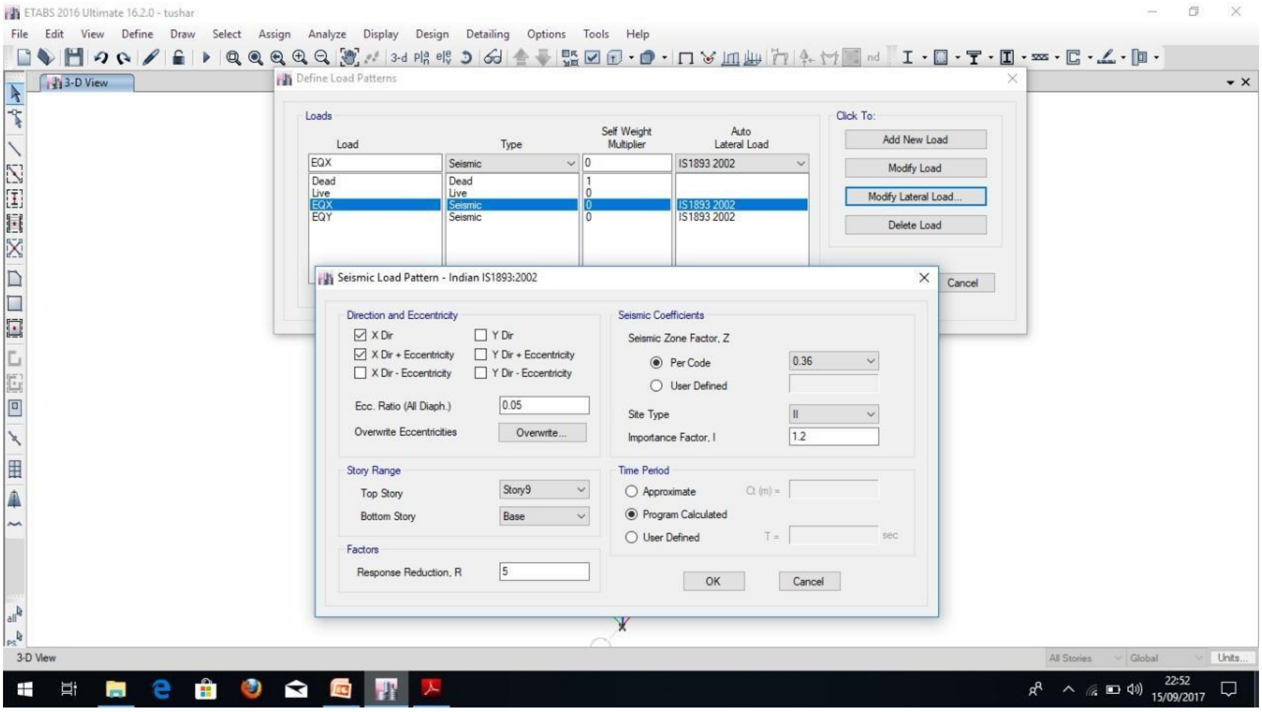

Fig. 3.10: Defining Seismic Load Patterns

In this figure the Seismic loads are being selected and the direction of the load is being defined.

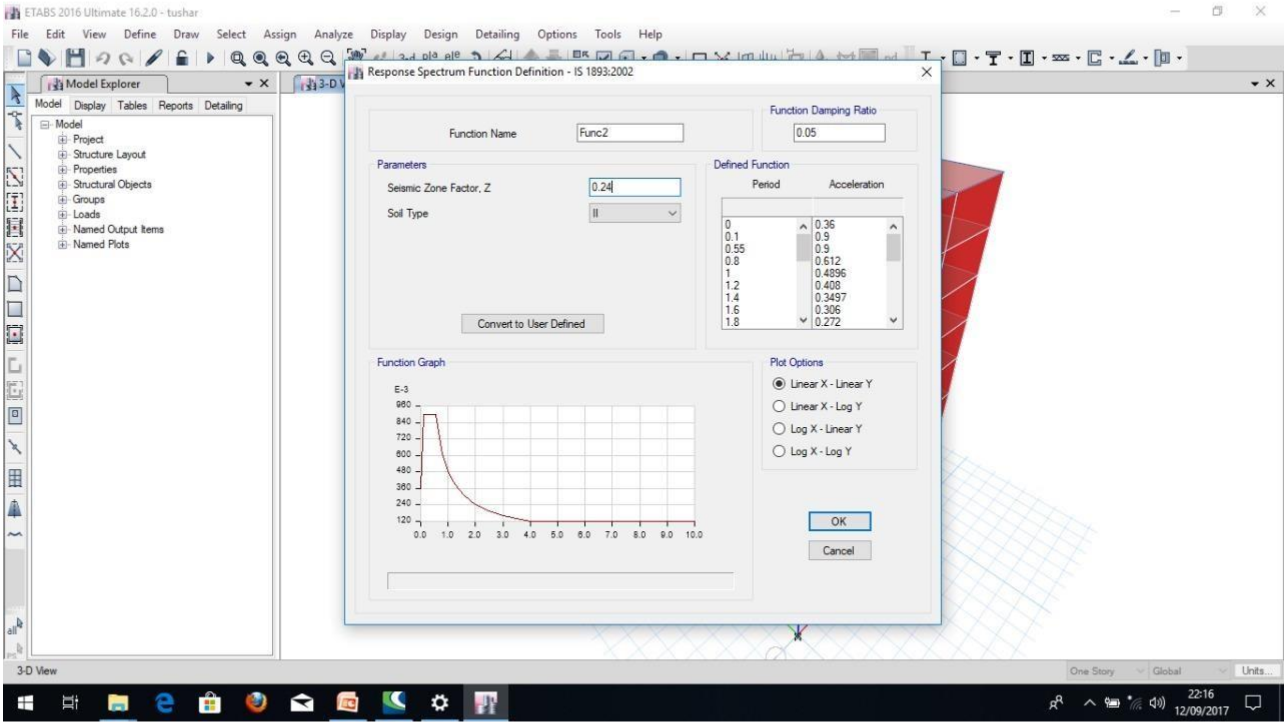

Fig. 3.11: Defining Response Spectrum

In this figure Response Spectrum parameter is being selected on the basis of Seismic Zone factor and Damping Ratio.

4.1 INTRODUCTION:

4.2 CHAPTER-4 ANALYSIS & RESULTS

Three Types of Infill material namely Fly-ash Bricks, AAC blocks and Hollow Concrete blocks Properties where used to make 3 Models for each Infill material. Models as mentioned before were based upon three methods how the infill walls were incorporated in the study. The main motive of doing this was to observe the effect of infill-walls in withstanding the lateral loads when only loads of the walls were considered or when the wall properties also taken or when the wall was replaced by a strut giving the exact structural benefit to the analysis.

The Observations gathered from the analysis is Displayed below. The table shows the comparative values of Deflection, Shear in all three Models and the conclusion is derived from analysing which model has the least storey drift and shear.

4.2.1 DEFLECTION OF ALL THE MODELS IN MM:

Table No.4.1: Deflection in Fly-Ash Walls Models

S. No.	**MODEL NO.1**	**MODEL NO .2**	**MODEL NO. 3**
Storey 9	12.646	8.25	5.55
Storey 8	10.55	7.5	4.8
Storey 7	10.22	6.5	3.7
Storey 6	8.23	5.5	2.8
Storey 5	7.52	4.2	1.9
Storey 4	5.2	3.2	1.58
Storey 3	4.8	2.8	1.23
Storey 2	4.5	2.5	1.2
Storey 1	3.2	2.2	1.08

This table shows the deflection caused in the Fly-Ash wall model due to lateral loading in mm. With highest deflection in 9th storey in model 1.

Table No.4.2: Deflection in AAC Block Walls Models

S. No.	MODEL NO.1	MODEL NO .2	MODEL NO. 3
Storey 9	5.44	3.44	2.55
Storey 8	4.44	3.20	2.10
Storey 7	3.25	2.7	2.05
Storey 6	3.10	2.4	1.95
Storey 5	3.05	1.8	1.85
Storey 4	2.9	1.56	1.58
Storey 3	2.5	1.44	1.23
Storey 2	2.1	1.05	0.8
Storey 1	1.8	0.785	0.65

This table shows the deflection caused in the AAC block wall model due to lateral loading in mm. Here too the displacement is maximum in model no 1 but the magnitude is less than Fly-ash bricks.

Table No. 4.3: Deflection in Hollow Concrete Block Wall Models

S. No.	MODEL NO.1	MODEL NO .2	MODEL NO. 3
Storey 9	8.52	5.25	3.55
Storey 8	7.8	5.02	3.42
Storey 7	6.7	4.8	3.2
Storey 6	6.0	4.3	3.01
Storey 5	3.05	4.0	2.8
Storey 4	2.5	3.8	2.5
Storey 3	2.3	3.5	2.2
Storey 2	1.95	3.15	2
Storey 1	1.9	3.10	1.85

This table shows the deflection caused in the Hollow Concrete block wall model due to lateral loading in mm. We can see that here too deflection is max in model 1 but the magnitude of deflection is less than in Fly-Ash brick wall model but Greater than in AAC block wall model.

Model 3 has the lowest deflection in all three models in all three infill materials and among them AAC block has the lowest deflection.

4.2.2 : SHEAR FORCE OF ALL THE MODELS IN KN:

Table No. 4.4: Shear in Fly-Ash Brick Wall Models

S. No.	MODAL NO.1	MODAL NO .2	MODAL NO. 3
Storey 9	131	303	415
Storey 8	334	351	500
Storey 7	489	418	580
Storey 6	604	725	655
Storey 5	683	900	822
Storey 4	734	1120	867
Storey 3	762	200	950
Storey 2	775	1350	1050
Storey 1	778	1400	1250

This table shows the Shear Force generated in the Fly-Ash wall model due to lateral loading in KN. Here we can see that the max Shear is in Model 2 and the Lowest is in Model 1. Model 1 has lowest Shear force because in Model 1 Stiffness of wall in not taken into consideration.

Table No. 4.5: Shear in AAC Brick Wall Models

S. No.	**MODAL NO.1**	**MODAL NO .2**	**MODAL NO. 3**
Storey 9	150	425	300
Storey 8	222	500	380
Storey 7	275	570	418
Storey 6	300	548	488
Storey 5	352	592	512
Storey 4	400	618	580
Storey 3	462	700	629
Storey 2	555	822	750
Storey 1	625	1020	892

This table shows the Shear Force generated in the AAC Block wall model due to lateral loading in KN. Here we can see that AAC block wall models has very less Shear force generated in all models as compared to Fly-ash Brick wall model.

Table No. 4.6: Shear in Hollow Concrete Block Wall Models

S. No.	MODAL NO.1	MODAL NO .2	MODAL NO. 3
Storey 9	200	360	250
Storey 8	260	419	288
Storey 7	325	522	322
Storey 6	360	582	342
Storey 5	412	600	380
Storey 4	465	622	416
Storey 3	550	800	522
Storey 2	600	950	625
Storey 1	750	1050	780

This table shows the Shear Force generated in the Hollow Concrete block wall model due to lateral loading in KN. Here also we can see the AAC Block wall are coming out as the models with lowest Shear Force generated in them. And the shear force is highest in the Model 2 because the stiffness is considered in the model, which shows that the wall stiffness plays an important role in shear force generation.

4.2.3 : BENDING MOMENT OF ALL THE MODELS IN KN-M:

Table No. 4.7: Bending Moment in Fly-Ash Brick Wall Models

S. NO.	MODEL NO.1	MODEL NO.2	MODEL NO.3
Storey 9	15305	16607	14808
Storey 8	34585	38801	32681
Storey 7	52761	54223	50555
Storey 6	70367	72945	68428
Storey 5	91348	94567	86302
Storey 4	109800	116247	104175
Storey 3	124987	135795	122049
Storey 2	143673	146834	139923
Storey 1	161856	169260	157796

Here we can see that Model 2 has the maximum bending moment because it has used Wall properties with the wall loads while making the model. And on the second number we have Model 1 in which we used manually calculated load of wall only. Model 3 has the lowest bending moment because in it the wall was replaced by a strut.

Table No. 4.8: Bending Moment in AAC Block Wall Models

S.NO.	MODEL NO. 1	MODEL NO. 2	MODEL NO. 3
STOREY 9	10945	11106	9854
STOREY 8	22557	24511	19793
STOREY 7	30274	37916	28542
STOREY 6	47348	51321	45699
STOREY 5	60371	64726	58411
STOREY 4	73455	78131	70432
STOREY 3	87326	91537	85360
STOREY 2	98732	104942	94765
STOREY 1	109432	118347	99723

We can see here that Model 3 has the lowest bending moment as compared with other. Model 2 is the heaviest hence it has the greatest bending moment. And one more thing we can see here is that the AAC block wall is the light in weight in general than a Fly-ash Brick wall and also lighter than Hollow Concrete Block wall hence the less bending moment.

Table No. 4.9: Bending Moment in Hollow Concrete Block Wall Models

S.NO.	MODEL NO. 1	MODEL NO. 2	MODEL NO. 3
STOREY 9	13966	17873	11643
STOREY 8	30632	32681	28422
STOREY 7	45322	50555	40631
STOREY 6	62480	68428	59731
STOREY 5	82450	86302	79838
STOREY 4	99233	107241	95770
STOREY 3	119476	125114	107839
STOREY 2	130322	142988	124567
STOREY 1	156786	160045	134790

Here we can see that the bending moment values are greater than the BM in AAC block models because these hollow blocks are much heavier. So at last we can finalise that Model 3 of AAC block had the lowest bending moment of all conditions.

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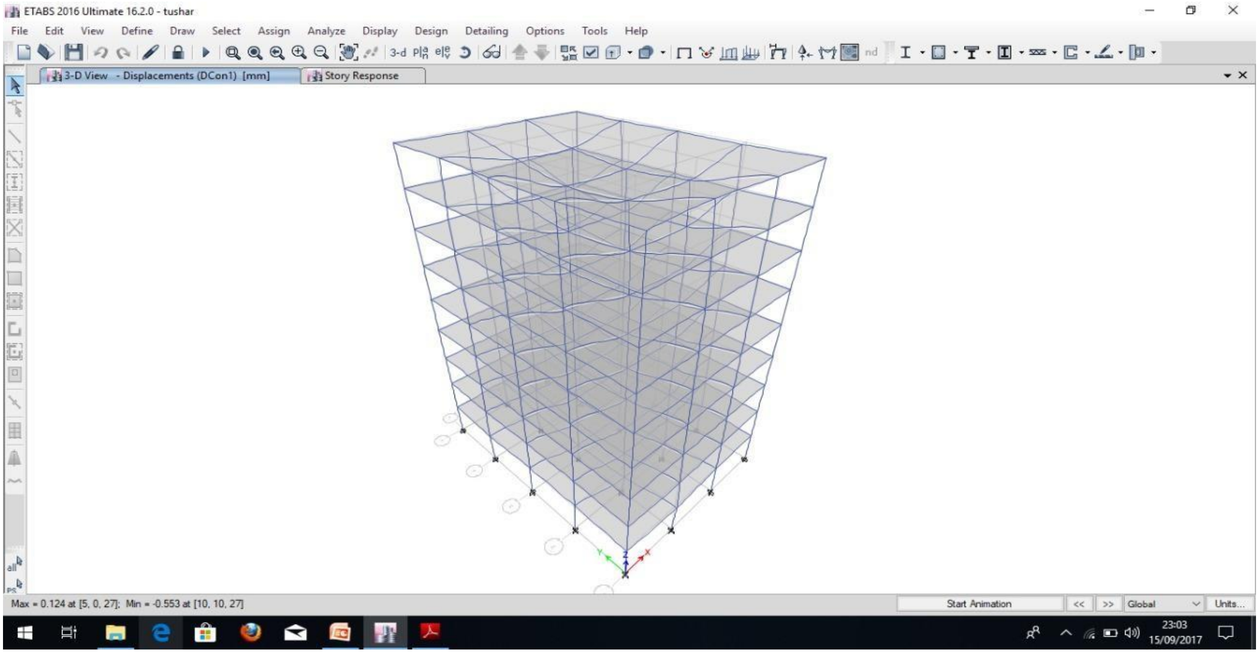

Fig. 4.1: Response of the Structure

This figure displays the Deformation caused to the structure, we can see the Displacements and Storey response.

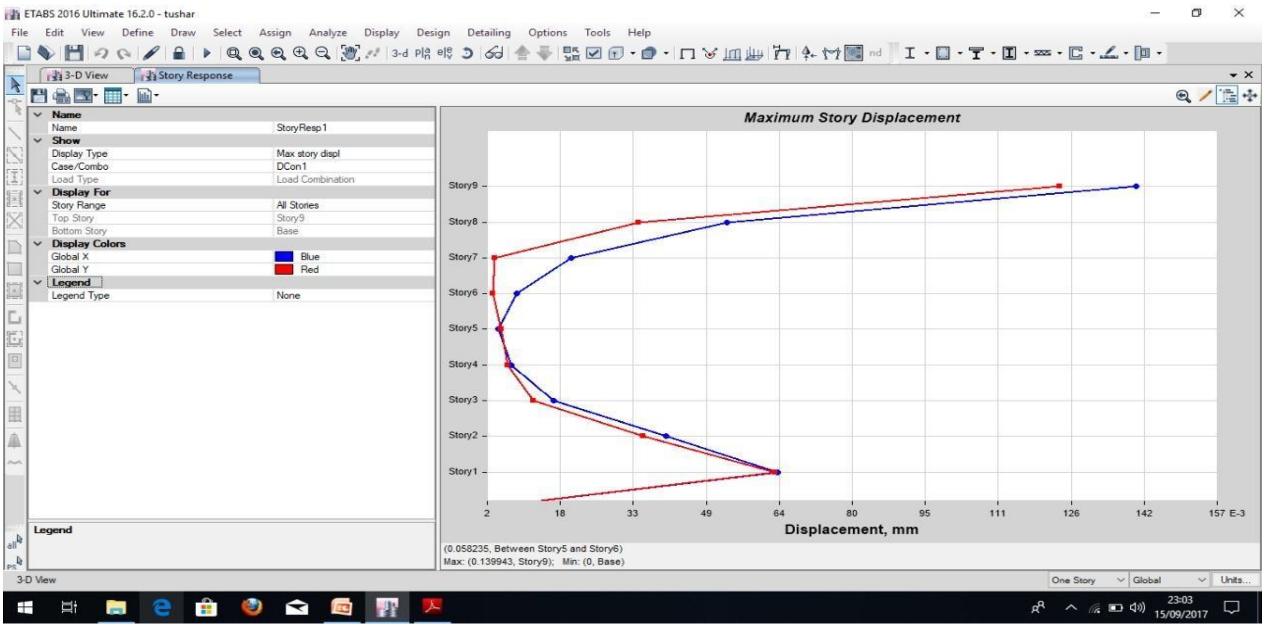

Fig. 4.2: Displacement Response of the Structure

This figure shows the graphical representation of Maximum Storey Displacement in global X and global Y direction in mm.

4.3 : MAXIMUM STORY DRIFTS IN DIFFERENT STORIES

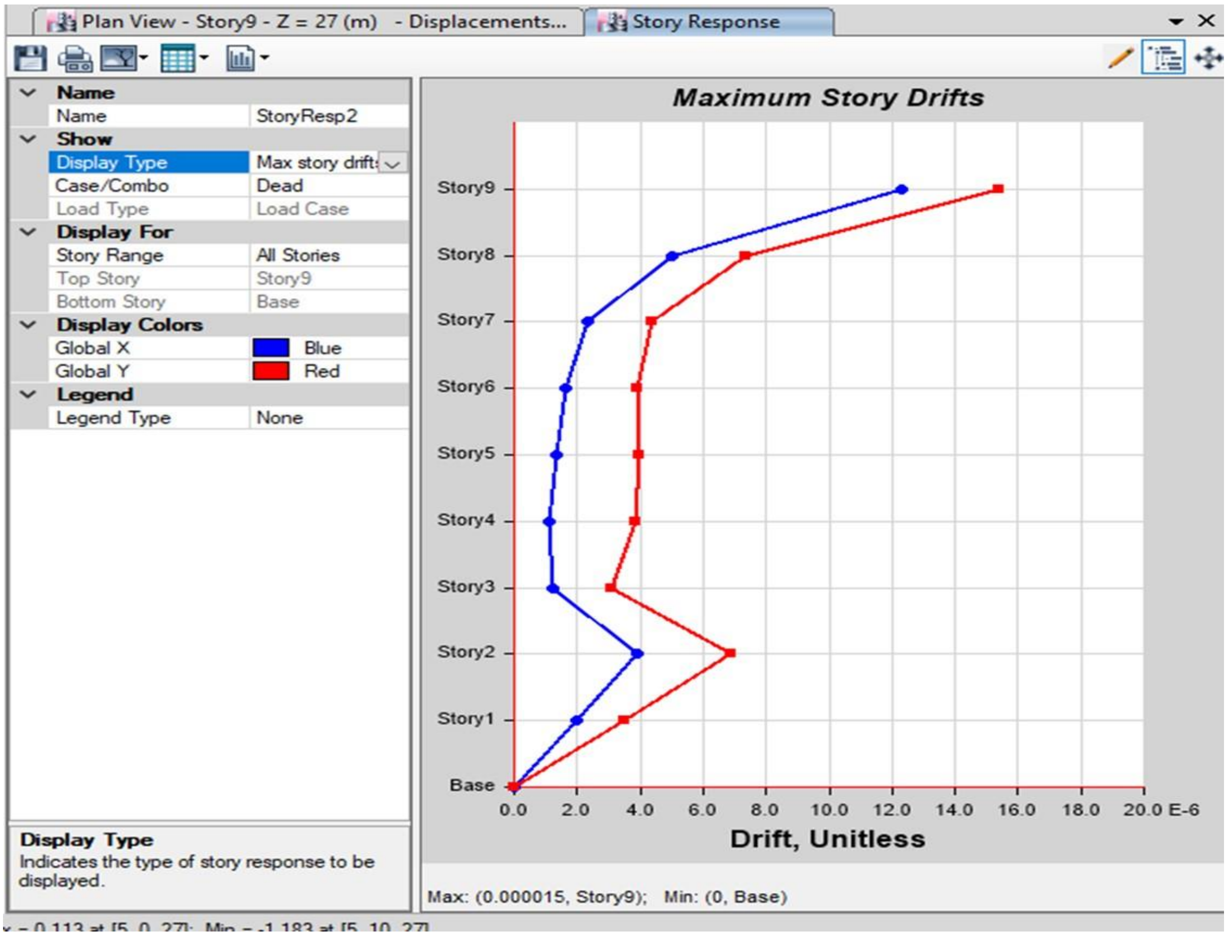

Fig. 4.3: Storey Drift Data of the Structure

Figure 4.3 displays storey drift in every storey in X and Y direction both displayed with different colour.

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4.4 : AUTO LATERAL LOAD IN DIFFERENT STORIES

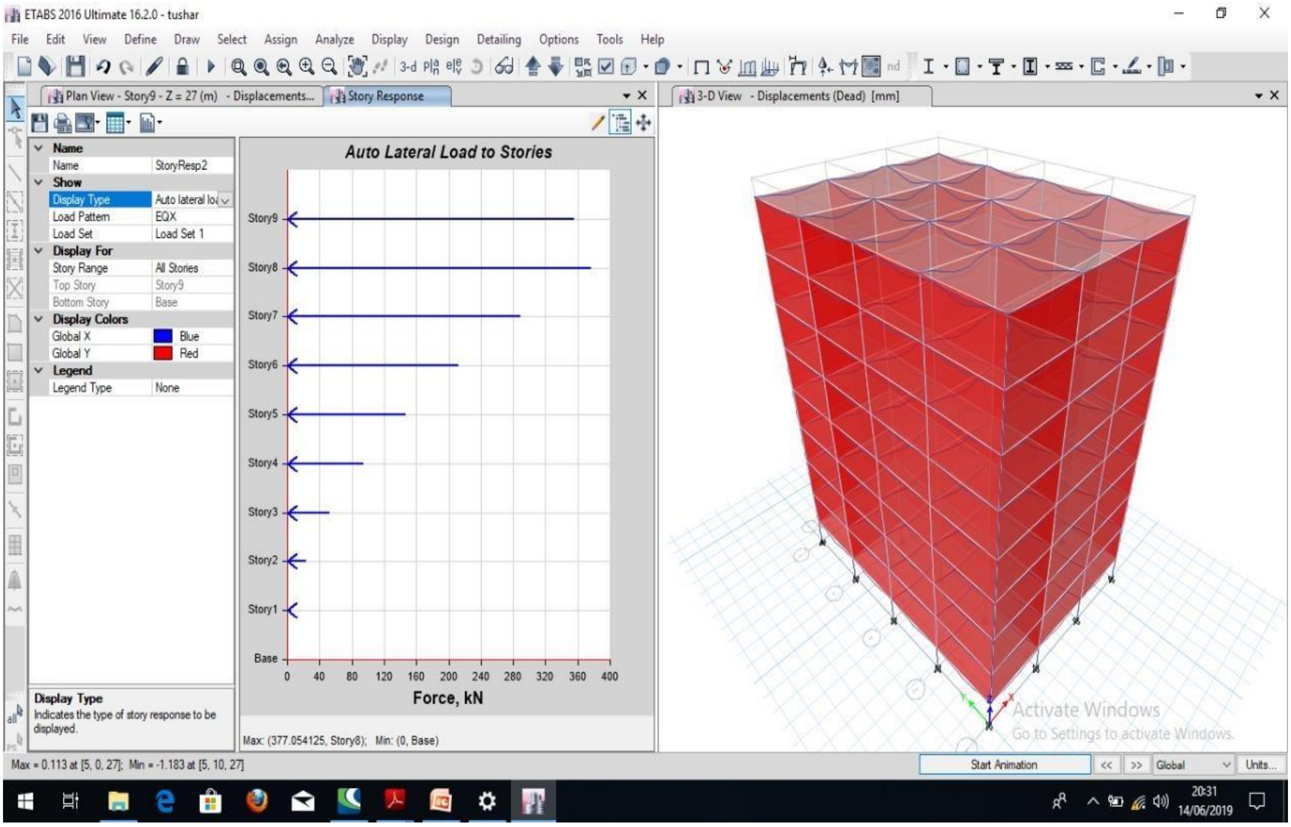

Fig. 4.4: Auto Lateral Load in the Stories

This figure displays Auto lateral load in every Storey due to Seismic Load. Lateral load are caused Due to Earthquake

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4.5 : SHEAR FORCE IN DIFFERENT STORIES:

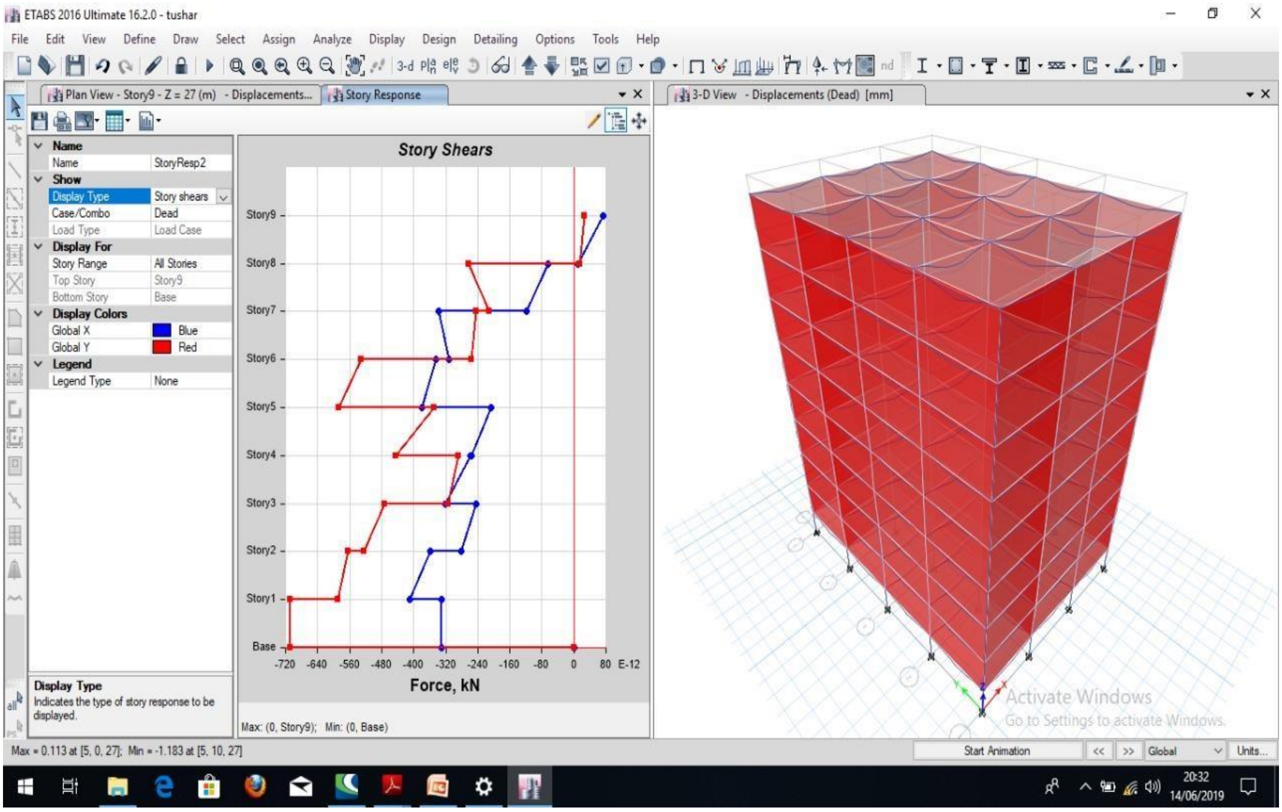

Fig. 4.5: Storey Shear Data of the Structure

This figure displays the Storey Shear Force generated in each storey in Global X and Y directions.

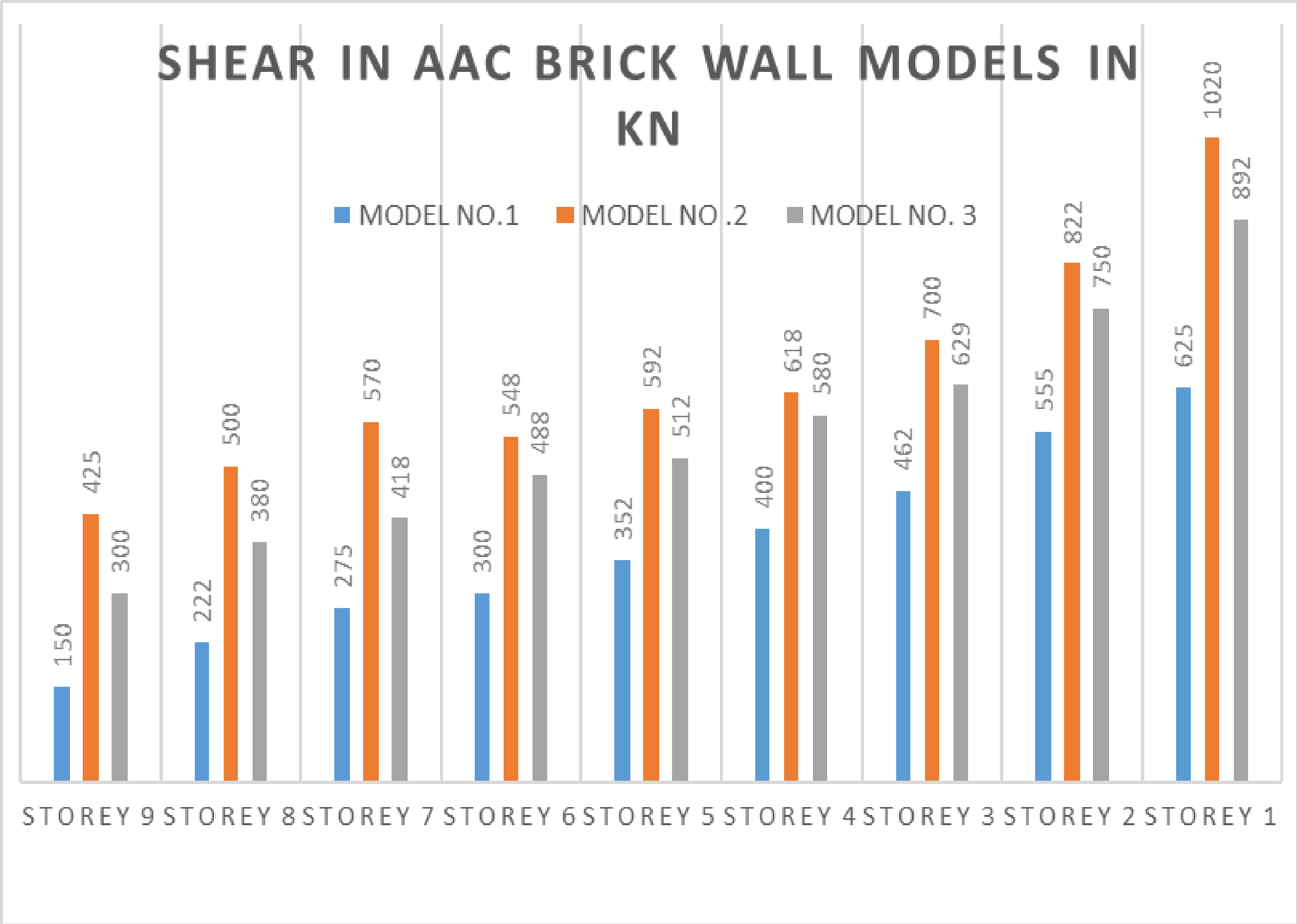

Fig. 4.6: Shear Force in each Storey of different models in KN

CHAPTER-5 CONCLUSION & FUTURE SCOPE

5.1 GENERAL:

For this research work following outcomes are observed:

1. From the results, it has been found that displacement of structure with AAC block in all three modal cases is found less than conventional brick masonry.While comparing the models 1, 2, 3 for displacements model 3 (infill frame) is having least displacement. In model 3 the strength and stiffness of material is replaced by an equivalent diagonal strut hence it has got least deflections.

2. It is observed from the results that storey shear with AAC and hollow concrete masonry is significantly less when compared to brick masonry infill panel. It is due to the light weight of AAC blocks and hollow concrete.

3. Model M-2 has more storey shear than M-1, and M-3 because Storey shear depend on stiffness of the frame. The struts in masonry infill resist the lateral seismic forces through axial compression along the strut. The contribution of infill increases the stiffness of the frame this resulting increase in seismic forces. Model M-1 has the least value of storey shear with all three types of infill materials because stiffness has not been considered in case M-1.

4. Following things we can see from the results that the physical properties of the walls has very significant effect in the ability of the structure to handle Lateral loading. The storey displacement was least in AAC block wall in Model 3 with the Diagonal strut in the place of strength and stiffness of the wall material. Storey shear also was seen the lowest in the AAC block walls And the Bending Moment also was seen the lowest in the AAC blocks. Hence we can conclude that the AAC blocks are a better replacement for conventional infill materials in Earthquake prone areas.

5. One more thing that we see from this study that neglecting the structural properties i.e. not considering walls as a structural element is not beneficial as seen from the Model 1 of every case. Models with structural properties of walls performed well in earthquake conditions.

6. Future Scope of this study is that by proving that the Walls too play an important role in the overall stiffness of the structure in the Earthquake conditions we can design structures with keeping that in mind.

7. In future studies will can analyze the different infill walls effect in the irregular building under the seismic loading dynamic analysis.

8. We can also analyze infill wall effect in large span building (like Flat or PT Slab).

9. Percentage increase and decrease of deflection between models,

Fly ash bricks, Model 2 has 33% more deflection than Model 3 and Model 1 has 35% more deflection than Model 2.

AAC bricks, Model 2 has 26% more deflection than Model 3 and Model 1 has 37% more deflection than Model 2.

Hollow concrete bricks, Model 2 has 33% more deflection than Model 3 and Model 1 has 39% more deflection than Model 2.

10. Percentage increase and decrease of Shear between models,

Fly ash bricks, Model 2 has 45% more shear than Model 1 and Model 3 has 10% less shear than Model 2.

AAC bricks, Model 2 has 39% more shear than Model 1 and Model 3 has 12.5% less shear than Model 2.

Hollow concrete bricks, Model 2 has 28.5% more shear than Model 1 and Model 3 has 25.7% less shear than Model 2.

11. Percentage increase and decrease of bending moment between models,

Fly ash bricks, Model 2 has 4% more bending moment than Model 1 and Model 3 has 7% less bending moment than Model 2.

AAC bricks, Model 2 has 7.5% more bending moment than Model 1 and Model 3 has 15.7% less bending moment than Model 2.

Hollow concrete bricks, Model 2 has 2% more bending moment than Model 1 and Model 3 has 16% less bending moment than Model 2.

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