SEISMIC BEHAVIOR OF REINFORCED MASONRY STRUCTURE WITH HOLLOW CONCRETE BLOCKS

A Thesis Submitted
in Partial Fulfillment of the Requirements
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In

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By

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LUCKNOW

JULY, 2020

CERTIFICATE

Certified that MANISH GUPTA (1180444006) has carried out the research work presented in this Thesis entitled "SEISMIC BEHAVIOR OF REINFORCED MASONRY STRUCTURE WITH HOLLOW CONCRETE BLOCKS" for the award of MASTER OF TECHNOLOGY (Structural Engineering) from BABU BANARASI DAS UNIVERSITY, LUCKNOW under my supervision. The Thesis embodies results of original work, and studies are carried out by the student himself and the contents of the Thesis do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

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DECLARATION

I hereby declare that the Thesis entitled **“SEISMIC BEHAVIOR OF REINFORCED MASONRY STRUCTURE WITH HOLLOW CEMENT CONCRETE BLOCKS”** in the partial fulfillment of the requirements for the award of the degree of Master of Technology (Structural Engineering) of **BABU BANARASI DAS UNIVERSITY**, is record of the own work carried under the supervision and guidance of **Mr. FAHEEM AHMAD KHAN** to the best of my knowledge this Thesis has not been submitted to **BABU BANARASI DAS UNIVERSITY** or any other University or Institute for the award of any degree.

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ABSTRACT

The main concern in the tall building or earthquake prone areas is the mass and self-weight of structure. To reduce the mass and self-weight of the structure hollow cement concrete blocks are introduced. Hollow concrete blocks provide the horizontal and vertical force resisting system. An attempt is made to analyze the response of G+15 storied RC multi-story building due to the application of hollow concrete blocks different with normal conventional bricks into the infill wall structure during earthquake. ETABs software is used for modelling and analyzing the building. The building is taken in seismic zone V and analyzed with Time History Analysis. Various parameters such as story drift, story displacement, and story shear and story stiffness are studied. From the study it was concluded that building with hollow concrete blocks infill wall perform better during seismic activity as compared with building with normal conventional bricks.

ACKNOWLEDGEMENTS

I wish to express my deepest gratitude and indebtedness to my supervisors, **Mr. Faheem Ahmad Khan** and to the Head of Department **Mr. Anupam Mehrotra** for their stimulating ideas, numerous constructive suggestions and guidance, continuous encouragement and invaluable support throughout this study. Without their advice, encouragement and support, this thesis would not be completed.

Finally, I would like to dedicate this research work to my family and friends whose continuous love and support guided me through difficult times.

Manish Gupta
(M-Tech. Structural Engineering)

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF CONCRETE BLOCKS

Fig 1.1 Concrete block

Concrete blocks were firstly utilized as the sun clay bricks in the ancient times. After that the modern concrete block was introduced in the mid-1800s and revolutionized building pattern all over the world. There were so wonderful examples of masonry that can be discovered in most ancient cultures as well as in the modern world. The Pyramids are the examples of the heavy blocks structure. The Great Wall of China still draws the attention of thousands of visitors yearly and it can also be seen from the space that is the also one of the structure pattern which can blows the mind of researchers. The evolution of bricks and concrete blocks is the backbone of historical and modern architecture alike. The feats of masonry have survived fires, earthquakes and time and most feature artistic detail even current technologies have trouble in researching. Even the ancient masons do not have heavy machinery, they created complex and durable structure that influenced architecture for centuries.

The predecessor to the modern concrete block is the sun baked clay brick, which is coincidentally man's oldest manufactured product. This old type of brick has been used for 6,000 years. To help maintain the integrity of the rectangular shape, masons added grass or straw to the clay mix. In 4,000 BCE, manufacturers streamed lined the brick's shape and started firing them in kilns. This vastly improved the durability of the product as is evidenced by the various ruins of ancient civilizations. While concrete has replaced the sun baked clay, some regions still use the method to build durable low-cost housing. Concrete as the modern world knows it was first made in wooden frames in the early 1800s. Initially the material was dried and laid like brick with mortar. The first house to be made entirely of concrete blocks was built in New York during 1837. The inventor credited with the modern formula of concrete is an Englishman named Joseph Aspidin. He called it Portland cement after a type of stone native to the Isle of Portland. Joseph Monier invented reinforced concrete, which uses embedded metal, in 1849 and received a patent in 1867. Following these events, concrete began to replace other building materials for personal and commercial properties.

The cost of Portland cement fell as newly invented machines filled factories and shortened the manufacturing process. Builders responded to the pressure of building fire and weatherproof housing for investors and homeowners. Concrete blocks accomplished that goal and became the material of choice for many builders. Concrete structures are still very common especially for commercial and government buildings. These days even cheaper materials like dry wall are used for housing developments, but the foundations are still predominately concrete blocks and brick. Some theorists are now speculating whether the ancient Egyptians invented concrete, but while this is interesting, sufficient evidence has not been produced.

In the present days there are many inventions took place some are successful and some are not, first the houses were built from mud then there after stones are used in the construction of houses and then after normal conventional bricks which provides stability than after that concrete blocks were introduced to overcome the conventional bricks

1.1.1 NORMAL CONVENTIONAL BRICKS

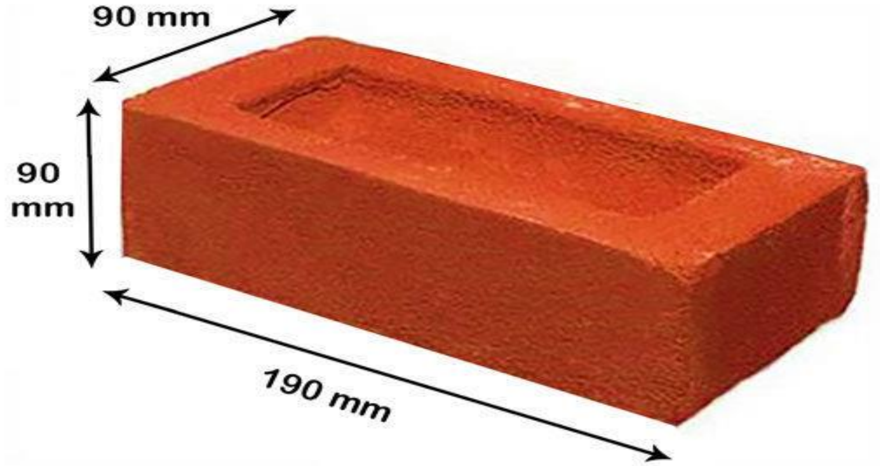


Fig 1.2 Normal conventional brick

Building material plays a very important role in this modern age of technology. No field of engineering is conceivable without its use. Bricks are one of the oldest building materials which are still a prominent and leading building material because of its low cost, wide availability, durability and easy handling. Most commonly used brick is Clay bricks which are used for building interior and exterior walls, piers, partitions, footings and other load bearing structure According to 'R Barry' (Author of The Construction of Building), the word 'brick' is used to describe a small block of burnt clay of such a size which can be conveniently held in one hand and is slightly longer than twice its width.

The common burnt clay bricks are usually pleasing to look at with warm colours ranging from cream to orange to sandy and to brown or even blue brown in colour. When built into a wall, interesting but, simple and pleasing patterns appear, just like people who all have one nose, one mouth, two ears and two eyes but, no two person looks exactly the same. So, each brick although simple in shape, has its own individuality.

As bricks are most common, basic and essential unit for house construction, they must be of good quality. The quality of bricks may vary depending upon the raw materials used and also in its manufacturing process. Good quality bricks should possess both physical and chemical properties.

A good brick should have a uniform size with plain and rectangular surfaces and should be parallel from the sides having sharp and straight edges, as per standards. A brick should not exceed 3 mm tolerance in length and 1.5 mm tolerance in width and height the standard or conventional size of clay brick is 190mm X 90mm x 90mm. However, the size of bricks may vary from country to country and from place to place even in big countries like India.

The shape of a brick should be uniform. The edges of a good brick should be sharp, straight and at a right angle. However, bricks used for special purpose may be either cut or manufactured in various other shapes. These are generally modifications of rectangular shapes.

There are wide range of colours, such as red, white, grey, brown, purple, blue and black, along with some intermediate shades. According to 'W. B McKay' (Author of Building Construction), the colour is influenced by the chemical constitution of the clay, its temperature while burning, the atmospheric condition of kiln, and staining. Good quality bricks should be well burnt and should have a uniform colour throughout the body of brick. Over burnt and under burnt bricks loses the uniformity of colour on its surface and strength. Very dark shades of red indicate over burnt bricks whereas, yellow colour indicates under burnt bricks.

A good quality brick should have a proper frog (Depression made on the face of bricks during moulding), so that the mortar can be properly filled in the frog. The size of the frog should be 100 mm in length, 40 mm in width and 10 mm in depth

The compressive strength of brick depends upon the composition of the clay and degree of burning. As per 'National Building Code of India' (1983), the compressive strength of brick should be of minimum 3.5 N/mm^2 i.e. 35 Kg/cm^2.

1.1.1 HOLLOW CONCRETE BLOCKS

Fig 1.3- Hollow Cement Concrete Blocks

In 1890 Harmon S. Palmer in the United States constructed the first hollow concrete block structured in comparison with stone and wood structure. Portland cement, sand, gravel and water are the main components through which the concrete block are made of. When the mixture is wet it is paste like and can be cast in the form of the block. When it dries, it hardens it becomes like stone.

Hollow concrete blocks are having at least one gap that are open at the two Sides of the cross section. These blocks have one or more hollow core. These cores reduce the total cross sectional area of the block by at least 25 percent. The full size blocks are rectangular and half size blocks are cubical in which have one core. Generally hollow concrete blocks are used instead of brick masonry work. The main objective is that to compare with normal conventional bricks with concrete block with that of a hollow concrete reinforced block." The hollow concrete reinforced block must have a higher compressive property in comparison with normal conventional and hollow concrete blocks.

Available Size: The nominal dimensions of concrete block with tolerance shall be as follows:

Length: 400, 500 or 600 mm

Height: 200 or 100 mm

Width: 50, 75, 100, 150, 200, 250 or 300 mm

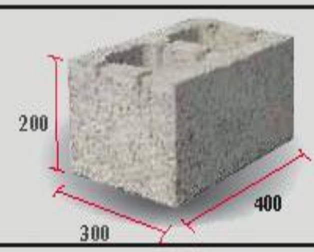
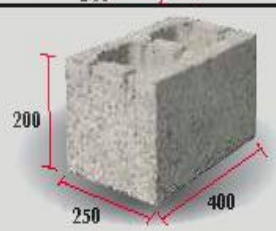
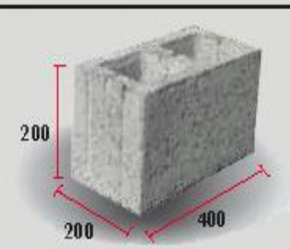
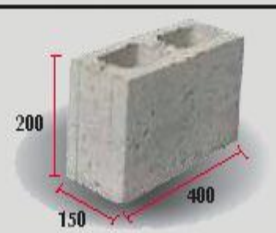
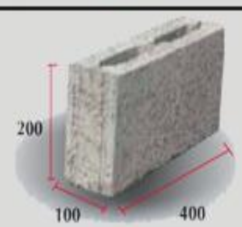
HOLLOW BLOCKS	
	Hollow Block 12" (200 X 300 X 400) Weight (kg) : 32
	Hollow Block 10" (200 X 250 X 400) Weight (kg) : 31
	Hollow Block 8" (200 X 200 X 400) Weight (kg) : 23
	Hollow Block 6" (200 X 150 X 400) Weight (kg) : 18
	Hollow Block 4" (200 X 100 X 400) Weight (kg) : 14

Fig1.4 Sizes of the hollow concrete blocks

Fig 1.5 Hollow concrete block and Solid concrete block

Generally, there are two kinds of concrete block, hollow and solid. Nowadays these blocks are widely used in the construction of the heavy structures. These are also used in multi-storeys or high rise structures. These hollow blocks are widely used because of its less weight and the ventilation properties due its hollowness. Hollow blocks resist the electrical conductivity and thermal conductivity and it also resists the soil seepage through it. Hollow blocks provide heat and cold resistance to the house that's why the room keeps cold in summer and keeps hot in winters.

Mainly the concrete blocks should provide good compressive strength to the structure. Apart from giving above property hollow concrete blocks provides stability
and durability to the structure.

These blocks are providing toughness in the structure along with other properties also like heat proof, faster in laying and placing of the blocks. The structure made from these type of bricks is stabilizing for many years without any maintenance. With using HCBs in the structure provides many new conventional ideas and to build structure in many designs and also to fulfilled the requirements of human needs in economical way.

1.1.2 Practical use of hollow concrete blocks

1. The requirement of block is to reduce the self-weight of the structure in comparison with the normal conventional bricks.

2. In these type of blocks the total weight of construction is less due to the less mortar which uses in laying of blocks.

3. These blocks have reaches to its high compression if its build-up quality like dimension and cross section is proper build.

4. The construction uses less mortar; thus the total construction costs are reduced.

5. It provides the thermal transmission between the walls.

6. Hollow concrete blocks build in that criteria to achieve the constructional goals.

7. Hollow concrete blocks are resisting the structure for very long years and years.

10. Hollow concrete blocks are mainly used in the factories and storage of huge quantities like go downs.

1.1.3 Merits of hollow concrete blocks in structure

1. Cheaper: Block masonry are quite cheaper compared to their brick counterpart. They are known to cost Rs. 1,500 lesser than brick masonry for per cubic meter. This is not a difference to be ignored.

Reports suggest that the cost of building walls from AAC blocks come out to be 17.65 per cent lesser than the cost of wall made from traditional bricks. With lesser cost of constructing these blocks, they are also easier to make which reduces the cost even more if built at site.

2. Made from concrete: They do not harm or deplete nature for being made. They are made from concrete, which is nothing but a mixture of cement, sand, and aggregate. Whereas red bricks consume top soil in the production and manufacturing which is like robbing nature of its precious protective layer of soil. That is the top reason why the National Green Tribunal is so much against the red bricks.

3. Lighter in weight: Hollow concrete blocks are lighter compared to red clay bricks which offers them more workability, flexibility and durability. Their dry density ratio reduces dead load on structures which makes it more efficient and suitable for modern constructions.

4. Strength: Concrete blocks are known to be better in enduring earthquakes which are happening quite frequently these days, hurricanes and tornadoes. Countries that promote and encourage the usage of blocks lay great emphasis on their durability to withstand such natural hazards. The way of construction also makes them further durableandstronger.

5. Soundproofing: For those residing in industrial areas or areas that are near busy roads, some sort of soundproofing can be a bliss. Block walls have higher density as compared to brick constructions and hence they offer more soundproofing. Their efficient acoustic insulation is a big help if your home is constantly surrounded by noise that could keep you from getting a sound sleep. You can think of the advantage of soundproofing if you ever resided close to railways or airport.

6. Space saving: Builders and contractors are mostly recommending concrete blocks because they save quite some space at large. The width is less and durability doesn’t decrease which adds to space required in building walls. The usual 9 inch walls of the traditional bricks are getting replaced for good, especially since there is a lot of fight for space in big cities.

1.1.5 It has a great deal of Advantages additionally, for example, -

1. It provides very utilized property in very tall structure like bridges.
2. The hollow concrete blocks are used to build large structures like boundary fences.
3. Due to the hollowness of the core of the blocks gives an adequate room to place reinforcing materials like steel bars which leads to increasing of the oppressiveness of structure.
4. Easy in painting of the surface of the wall due to cavity presented in the surface of the blocks and provide futuristic point in the paint option on the surface of the wall.
5. Very less chances of depositing of the salt in spraying the mortar on the surface of the wall.
6. These hollow blocks are very easier to place in comparison with normal conventional blocks and consumes very less time in laying the blocks.
7. These blocks are very lighter in weight which consumes less cement in the construction.
8. Hollow concrete blocks are eco-friendly to the society.
9. In hollow concrete blocks the factor of safety is more than in other conventional bricks.
10. In brick masonry have less workmanship but in hollow concrete blocks workmanship is very good.
11. Hollow concrete members can safely withstand the atmospheric action up to an extinct and it requires no protective covering.

RC FRAME STRUCTURE

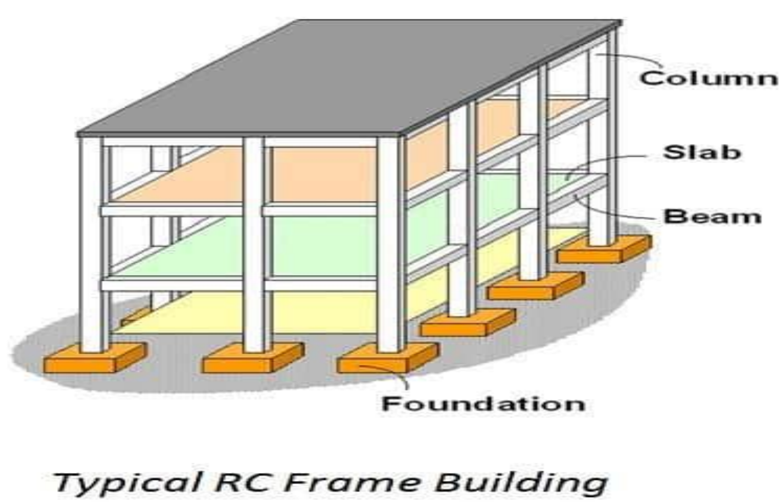


Fig 1.6 R C Frame structure

Reinforced concrete (RC) frames consist of horizontal elements (beams) and vertical elements (columns) connected by rigid joints. These structures are cast monolithically—that is, beams and columns are cast in a single operation in order to act in unison. RC frames provide resistance to both gravity and lateral loads through bending in beams and columns

Reinforced Concrete frames structure are the most advanced construction practices in India, as high-rise structures are increasing now days they are adding up to the landscape. There are most of cities of India that fall in highly active seismic zones. High-rise structures that are constructed especially in highly prone seismic zones, are analyzed and designed for ductility and also be designed with extra lateral stiffening system to overcome the seismic performance and reduce damages to the structure.

In many countries where the seismic activity is highly occurring the hollow concrete blocks are introduced to reduces the effect of seismic activity. Hollow concrete blocks are frequently used infill walls out of construction work.

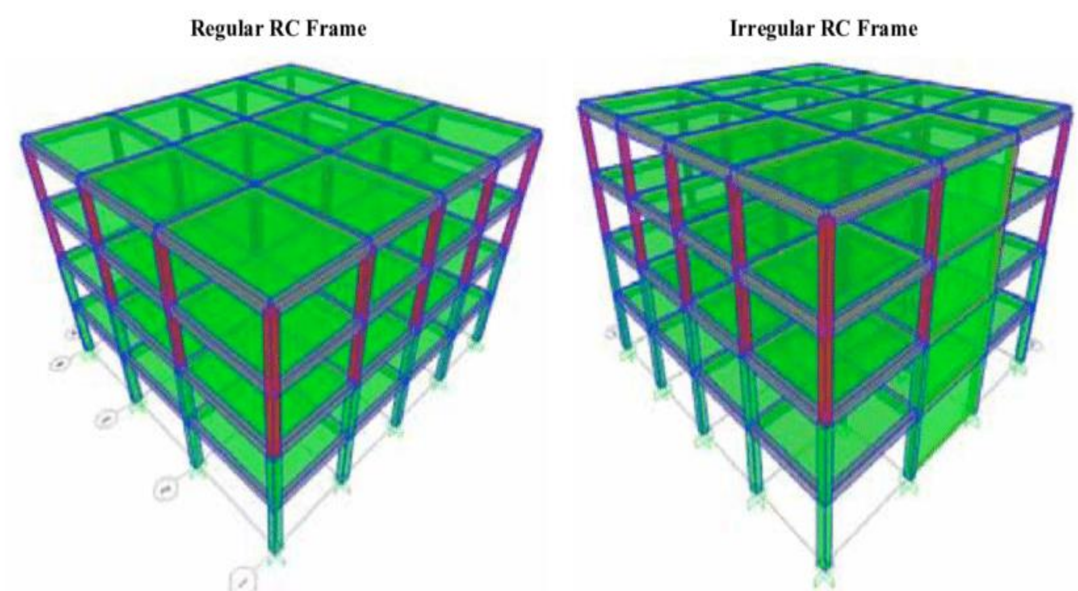


Fig1.7 – Regular RC frame and Irregular RC frame

Advantages of Framed Concrete Structure

1. It is good in compression when compared to the other materials used for construction. Besides, the structure is good in tension as well.
2. Its resistance to fire is better than steel so it is capable of resisting fire for a longer time.
3. It has a long service life with low maintenance cost.
4. In some structures like piers, dams, and footings, it is the most economical structural material.
5. It can be cast to any shape required, making it the most economical structural material.
6. It yields rigid members with minimum deflection.
7. The yield strength of steel is about 15 times the compressive strength of structural concrete and well over 100 times its tensile strength.
8. By using steel in concrete the cross-sectional dimension would get reduced.
9. Less skilled labors are required for erection as compared to other structural systems.

Three distinct building model cases (i.e. made from normal conventional bricks, made from hollow concrete blocks, made from hollow concrete blocks in which steel bars provided in grout of hollow concrete blocks) each RC frame buildings are analyzed and designed on ETABS 2016.

1.1.4 RESEARCH INVESTIGATION

Hollow concrete block masonry now days practicing in almost every earthquake prone areas like Nepal and many more other places like in Himalayan region. Many recent surveys have been conducted in the India the Kashmir region is one of them on hollow concrete block masonry. In this study, the traditional brick masonry has been compared with the hollow concrete block masonry with the stiffness and strength to check the stability of structure with every possible way in the constructional gain. The main requirement is that to achieve the maximum strength of the structure with the economy

1.2 OBJECTIVES

The objective of this research is focused on various techniques used to study the seismic behavior of R.C buildings with seismic zone V of India using Hollow concrete blocks. The whole design was carried out in ETABs which covers all aspects of structural engineering. More specifically, the salient objectives of this research are:

1) To perform a comparative study of the various seismic parameters.

2) Comparison among building with (made from normal conventional bricks and made from hollow concrete blocks) on the basis of story displacement, story drift, Story shear.

3) To propose the best suitable technique for seismic analysis.

In this report, a multi-storey residential building is studied for earthquake and wind load using Time history method and ETABs. This analysis is carried out by considering seismic zone V, and for this zone, the behavior assesses by taking the medium soil. A different response for displacements, story drift, story shear is plotted for zone V for medium type of soil.

1.3 SCOPE OF THE PRESENT STUDY

In the present study, modeling of the RCC frame under the time history analysis by taking two models of building's. (made from normal conventional bricks and made from hollow concrete blocks) using ETABs software and the results so obtained are compared. The study attempts to determine the effectiveness of the building in highly seismic zone. The scope of study involves the technique which is a software based work namely ETABS through which the analysis done. In this various parameters are compared to give the results which can distinguish the building with in the terms of economy and safety.

1.4 ORGANIZATION OF THE THESIS

The thesis is organized as per detail given below:

Chapter 1: Introduces to the topic of thesis in brief.

Chapter 2: Discusses the literature review i.e. the work done by various researchers.

Chapter 3: Work methodology for the analysis

Chapter 4: Analysis and Result

Chapter 5: Conclusions

CHAPTER -2

LITERATURE REVIEW

2.1 General

A brief review of previous studies which focuses on recent contributions related to seismic analysis of multi-storey building using Hollow concrete blocks infill RC frame by various analysis method.

2.1.1 Tushar Raju [2019]

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. B. While comparing the modals 1,2,3 for displacements in all the three models model 3 (infill frame) is having least displacement. In model 3 we have considered the strength and stiffness of material is replaced by a equivalent diagonal strut hence it has got least deflections. C. 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. D. 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.

2.1.2 Ardra.M. S [2019]

The following conclusion can be drawn from the present investigation 1. There is 0.91 % and 18.5 % reduction in maximum storey drift for 7 storied building (seismic zone II) and 14 storied building Fig 10: Max storey shear for seismic zone IV Base shear is lesser in case of Hollow members than solid members in RCC framed building. It is observed that the storey shear of RCC framed building having hollow members is decreased by 12.93% as compared to solid members in 7-storied building.

Also, storey shear of RCC framed building having hollow members is decreased by 23.48% as compared to solid members in 14-storied building. C. Storey Drift for different stories 0.018 0.016 0.014 0.012 (seismic zone IV) respectively, due to Hollow members in R.C.C framed building. 2. There is 12.93% and 23.48% reduction in base shear for 7 storied building (seismic zone II) and 14 storied building (seismic zone IV) respectively, due to Hollow members in R.C.C framed building. 3. Base shear is lesser in case of Hollow members than solid members in RCC framed building. 4. Hollow beams and columns in RCC framed building help in reducing storey drift as compared to solid beams and columns. 5. The storey shear and storey drift in building with irregularity is more than that of building with regular plan. i.e., the value of storey shear, storey drift is more in building in seismic zone IV when compared to seismic 0.01 0.008 0.006 0.004 0.002 0 Solid Hollow 14 storied building Max storey drifts 7 storied building Max storey drift zone II due to presence of irregularity. 6. Maximum storey shear & storey drift increases as number of stories increases in case of both solid and hollow members provided when irregularity is present in the building Fig 11: Max storey drift for different story's plan and they tend to decrease as number of stories increases in a regular plan. 7. The buildings with Hollow members perform better than buildings with solid members, in storey shear & storey drift point of view.

2.1.3 Jaimin Dodiya [2018]

In the present work the lateral structural system i.e., shear wall system considered for 20 story structure. Conclusions that can be made from the above study is by comparing the different location of shear wall in multi-story building. Form the study it is clear that gives less displacement value in opposite direction in shear wall building for moderate seismic zone.

Providing shear wall at opposite direction performing better and more efficient than all other cases. The provision of shear wall position in an appropriate location is advantageous and the structure performs better for an existing or a new structure

2.1.4 Chaure A.P. [2018]

The hollow concrete blocks of sizes 400 x 200 x 200 mm made with the concrete grade 1:3:6 proportion gives the average compressive strength of 11.25 kg/cm2 considering the gross area.

2.1.5 Devi Priya et. al. [2017]

Paper focus on the E Shaped high rise building behavior under the consideration of effect of infill walls or without infill wall. Dynamic analysis is done for the structure. Infill wall taken as in the form of the bricks, AAC blocks, GFRS panels. Under these The model without infill wall experiences high storey displacement, storey drift and larger time period than the models with infill wall. Model with GFRG panel has comparatively less storey displacement, storey drift and time period. Base shear of models with AAC blocks and GFRG panels was significantly smaller than that with conventional clay bricks, which results in reduction in member forces which leads to reduction in required amount of area of steel to resist member forces

2.1.6 Ms. Deshpande M. S [2017]

In this paper, the analysis and design of three types of building such as Square, L, C shape with different brick and densities were done. So, here the results are time period calculated by analytical method is same in all types of masses, but if compared with software analysis, time period varies with different masses. Light structure is more suitable during seismic vibration. The Scope of this study to calculate the fundamental natural period of the structure with respect to variation of different size and different type of structure with using different densities of bricks. Prepare various models in ETAB with their respective dimensions. This is results by table format in which there is a comparison of the time period by analytical and Using ETAB software. Different brick with different densities effect on mass of the structure. When an earthquake occurs, the natural period of vibration is more on heavy loaded building and less in light loaded building When mass of each building is different than the natural time period of the building is also different, but IS 1893:2000 do not incorporate the effect of mass in a formula which they have mentioned for brick infilled structure.

When the natural time period of each structure is calculated by manually with time period formula mentioned in IS code 1893-2000 is same for all types of structures, but when the time period is calculated by ETAB software analysis it's different to the different mass of the structure.

2.1.7 Omprakash Netula and Shailender Pal Singh [2017]

The density of AAC block masonry is less (1/3rd of brick) and the density of hollow concrete blocks are also less (3/5th of brick) as compared to brick masonry, the dead load of the structure is reduced in AAC block and hollow concrete masonry and hence economy may be achieved in design by replacing brick masonry with AAC block masonry and hollow concrete blocks. From the analysis results it is found 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 infill wall changes frame action of a moment resisting frame to a truss action which affect the seismic response of the building. From all the results it can also be concluded that if infill is not considered in the design then seismic analysis of the bare frame structure will lead under estimation of base shear and this will lead to collapse during earthquake. Thus the 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.

2.1.8 Sherin G Ponnachen [2017]

On the basis of results obtained from structural analysis of R.C.C. framed building using ETABS the following conclusions can be drawn: ¬ There is 27% to 37% reduction in maximum storey drift (seismic zone V) and 21%-33% reduction in maximum storey drift (seismic zoneIII) due to Hollow members in RCC framed building. ¬ There is 12% to 29% reduction in base shear (seismic zone V) and 2%-11% reduction in base shear (seismic zoneIII) due to Hollow members in RCC framed building. ¬ Maximum storey shear, storey drift increases as number of stories increases in the case of both solid and hollow members provided ¬ The value of storey drift, storey shear is more in seismic zone V when compared to seismic zone III. ¬ In storey shear, storey drift point of view buildings with hollow members performs better than buildings with solid members

2.1.9 Lini and Kavitha [2016]

The research was made on research of the significance of secured block infills multistoried structures accordingly receiving flat sliding joints in Strengthened solid edges. Nonlinear static experiment was performed on multistoried edges with strong and bolted block infills. The impacts of bolted block infill wall on the seismic presentation of the multistoried structures were concentrated in subtleties as the height of the structures are expanded. Numerical nonlinear static experiment of medium to skyscraper 2D working with bolted block infill wall and strong block infill dividers were performed to think about the viability of utilizing bolted block infills rather than strong block infills. The greatest diversion, story float and so on were resolved for the two cases. From the investigations, it was presumed that with the expansion in number of stories, there are extra horizontal burdens included for expanded story level. Thus, the most extreme top avoidance of the casing increments steadily. The greatest diversion of edges with strong block infill divider and bolted block infill divider are looked at and it was discovered that, the most extreme avoidance of every accounts diminished by around 30 - 60 % when number of stories is expanded from 5 to 10.

2.1.10 Uma Devi et al [2015]

She examined the boundaries, for example, base shear, time period, story drift and bending moment for various kinds of structure, infill outlines for shut and open story working for the various models. The software ETABS, StaadPro is utilized for investigate the frame models. Examination are conveyed to acquire normal frequencies, mode shapes and results contrasted and test results got from shake table tests directed on lab and models are approved stacking and angle proportions have likewise been evaluated alongside the wall thickness. This assists with defining the whole exploratory arrangement consolidating genuine limit condition with certain changes.

2.1.11 Songbo Li et al [2015]

investigate the failure process of reinforced and unreinforced masonry under seismic loadings with the lower level of reinforcement, mortar grades and its discuss forms of reinforcement and their effects, determine the shear strength of brick walls under axial and seismic loading. And author suggests reinforced masonry wall better performance due to material strength has been increased on reinforcement and distribution of steel bars.

2.1.12 Farzad et .al [2015]

Different sorts of interlocking mortar less (dry-stacked) square stone work frameworks have been created around the world. Nonetheless, the attributes of dry joints under compressive stress, and their impact on the general conduct of the interlocking mortar less framework, are as yet not surely knew. The examination introduced an examination concerning the dry-joint contact conduct of brick work and the conduct of interlocking mortar less empty squares wall development exposed to seismic excitation. In the framework created, the squares were stacked on each other and three-dimensional interlocking distensions were given in the squares to incorporate the squares into dividers. A limited component model was figured and a program code was created to anticipate the conduct of the framework under pressure load. The reaction of the mortar less empty square divider as for increasing speed uprooting and stress has been examined. The examination indicated that the interlocking keys accommodated this framework had the option to incorporate the squares into a durable divider and can re-place the mortar layers that are utilized for customary brick work development in low seismic region. Considered divider framework isn't reasonable to oppose in high seismic risk level as removal of divider surpasses admissible qualities. Subsequently, this sort of wall that developed by clarified empty squares simply oppose low seismic excitation.

2.1.13 Karuna and Annapurna [2015]

RC frame structures frequently join stone work infill panels as segments to isolate spaces inside a structure or as cladding to finish the structure envelope. In any case, the properties and development subtleties of infilled panel can impact the general conduct of a structure. An infilled outline commonly comprises of a steel or fortified solid edge with plain or strengthened block stone work, square work infilling which restriction against horizontal burdens is given by the composite activity of the infill and the edge. In this work, an investigation of non-straight conduct of fortified cement infilled outline with block brick work were completed under parallel and joined burdens utilizing ANSYS programming. The examination looked at straight and nonlinear conduct of single inlet four story fortified cement infilled outlines for various relative solidness of casing with infill exposed to parallel burden and consolidated burden up to a definitive burden opposed by the infilled outline. Horizontal misshapenness of infilled outlines was looked at. Sidelong misshaping under horizontal burden and joined burden was seen to be same in both the instance of direct and nonlinear examination in the event of full contact, anyway if there should arise an occurrence of partition the parallel distortion in non-straight investigation was seen to be higher than the straight examination for higher burdens. The outcome likewise indicated that sidelong disfigurement increments with increment in relative solidness in both instance of contact under parallel burden and joined burden and in the two kinds of investigation.

2.1.14 Vladimir and Davorin [2013]

The behavior of masonry-infilled steel and reinforced concrete frames under in-plane lateral loading has been the subject of many investigations. A suitable model has been designed for RC frames infilled with masonry, as a system, with- or without opening. On the basis of the results of original experiments performed on the specimens of R/C frames infilled with masonry, important parameters for the lateral response of the system were derived. Influence of opening size, type and position in the infill to the lateral response of reinforced-concrete frames were experimentally investigated and compared to frames without infill with respect to the capacities at different drift levels to developed correction factors.

This correction factors are then defined as an improvement of the equivalent diagonal compression strut model. This improvement enables use of R/C frames with masonry infill, with or without openings, as structural element. Its use would result in better seismic assessment of the masonry infilled R/C frames.

2.1.15 Pujol and Fick [2010]

An exploration has been performed on pseudo-static tests on a full-scale, three-story, level plate reinforced concrete structure which was planned by current codes just for gravity loads. At first, the uncovered casing was exposed to four patterns of parallel stacking demonstrating a triangular circulation. The structure was pushed to rooftop floats of 0.22%, 0.45%, 1.5% and 3.0% in back to back cycles. After the rooftop float proportion came to 2.8%, shear disappointment saw at a segment section association on the third story. After the primary test was finished, the infill dividers were included into one of the two bayous in every story. The infilled structure was exposed to twenty patterns of expanding rooftop float proportions extending from 0.025% to 1.25%. Each float target was applied twice. Askew breaks, sliding planes and corner pulverizing in the infilled narrows were seen from the split guides. The aftereffects of the examinations showed that the additional infill dividers expanded the horizontal quality of the structure by roughly 100% and the parallel solidness by around 500%. The infilled structure kept up its horizontal burden limit up to a rooftop float proportion of 1.5%. That float limit was esteemed acceptable. The examination suggested that infill dividers might improve the exhibition of more established structures by controlling interstory floats.

2.1.16 P. G. Asteris [2008]

In numerous quake inclined nations, a solid board infill is fortified with a stone work board. Despite the fact that the infill board altogether builds the firmness and quality of the casing, its commitment is regularly neglected because of absence of information in composite conduct of the edge and its infill board. Be that as it may, consistent exploration on this theme has indicated the presence of a solid association between an infill board and its encompassing edge, prompting the accompanying ends,

• Conduct of a composite edge doesn't just rely upon relative firmness of the casing and its infill board and their geometry, yet in addition on the quality of the brick work.

• Increment in absolute firmness and idleness of a composite board is equal to the expansion in dissemination vitality.

• Nearness of redistribution of activity and impact powers just as the infrequent terrible spontaneous harms of the edge.

• The current principles overestimate shear power by not considering the impact of the infill board.

• Decrease that has an impact to disappointment prospects, in spite of the fact that in infill outline cases don't effective, after has been structured appropriately.

2.1.17 Hashemi and Mosalam [2006]

considered a theoretical 5-story model second opposing fortified cement (RC) outline and unreinforced brick work (URM) wall. The paper concentrated on a shake-table examination directed on a base of this model comprising of the center coves of its first story. A test structure was developed to speak to the chose base and the connection between request boundaries of the test structure and those of the model structure was built up utilizing computational demonstrating. The consequences of the shake-table test regarding the worldwide and nearby reactions and the impacts of the URM infill divider on the basic conduct and the dynamic properties of the RC test structure were unmistakably introduced. At last, the test outcomes were contrasted with logical ones got from further computational displaying of the test structure on Open Sees exposed to the deliberate shake-table increasing velocities. The exploratory investigation effectively calibrated diagnostic models being created utilizing Open Framework for Seismic tremor Building Reproduction (Open Sees). The goals of the displaying exertion are to empower precise portrayal of the in-plane conduct of URM infill wall, and to refine the demonstrating strategies of hysteretic quality and firmness debasement in RC components and joints of RC second edges cooperating with URM infill wall. Utilizing the Open Sees model, a non-straight time history examination of the model structure exposed to various degrees of chose ground movement was performed.

Considering the basic model utilized with a solitary swagger for the URM infill wall, the Open Sees reproduction results are in acceptable concurrence with the test results. From the above rigorous study, the came about indicated that the URM infill wall had a significant job in the quality and malleability of the test structure and ought to be considered in both examination and plan. All inclusive, it makes the test structure stiffer by a factor of 3.8, abbreviates the normal time of the test structure by half, builds the damping coefficient relying upon the degree of shaking from around 4 to 5–12% and expands the disseminated vitality in the framework. Such changes significantly influence the degree of interest powers on the structure and for the most part lessen the dislodging requests. Locally, the URM infill wall changes the heap way and the dissemination of powers between various components of the test structure by expanding the interest powers on its contiguous components, for example the top and base of the RC segments and the RC chunk. Quantitatively, the URM infill wall causes about 30% expansion in the interest powers on the diaphragm and gatherer components in the test structure.

2.1.18 Fardis et al. [1999]

Constrained information exists on the dynamic properties of brick work wall infilled outlines, since not many shake-table analyses are performed on stone work infilled structures. covered the shake-table test performed on single-narrows two-story RC outlines with erratic (topsy-turvy in plan) brick work infill dividers exposed to bidirectional ground increasing speeds. Their investigation concentrated on the impacts of the whimsy on the dislodging requests on the corner sections. They additionally revealed that the infill boards made due out-of-plane pinnacle increasing velocities of 0.6g at the base of the test structure or 1.3–1.75g at their mid-height.

2.1.19 Tomaževič [1999]

Pivotal pressure load changes during seismic tremor because of restrictions that forestall the revolution of wall everywhere removals as a general rule. Be that as it may, it is hard to recreate definite limit conditions; the wall is typically tried with consistent vertical burden. IS 4326 (1993) gives common subtleties of giving vertical steel bars in holes in block brick work. Bed-joint reinforcement can be tied down to vertical support and this encourages yield of bed-joint support during testing.

IS 4326 (1993) has arrangements for support at corners of the wall inside grouted segments which, go about as a binding component (tie segment) opposing bigger powers because of expanded solidness. In any case, the job of these components in expanding the uprooting flexibility needs trial confirmation.

CHAPTER 3

WORK METHODOLOGY

3.1 General

The research methodology was started with problem identification in RC multi-storey buildings under seismic activity and setting up the objectives and scope of study. Then all the related background information was collected and studied for the literature review for knowledge updating. The major part of this study was structural modeling and computational analysis using time history analysis method in ETABs. The results thus obtained then being assessed, interpreted and compared.

The work methodology can be briefly divided into following:

1) Literature review and problem identification
2) Description of building plan
3) Problem formulation
4) Method of analysis
5) Structural modelling
6) Analysis and results using ETABs software
7) Conclusions

A RC Multi-storey building of G+15 storey was analyzed to resist the gravity loads and earthquake loads using ETABs software. Seismic parameters such as storey drift, storey displacement, storey stiffness and fundamental time period were computed in the analysis phase using ETABs. The result obtained from the analysis was compared among different bracing system.

The time history analysis was used which was most suited to the present problem and was

used in the analysis and conclusions were made on the basis of analysis performed. This is the summary of the work methodology adopted in achieving the target objectives defined.

3.2 Description of Building Plan

For analysis a 15 storied high rise building is modelled in ETABs software. The building does not represent any real existing building. RC framed (G+15) multi-storey building have same floor plan with 5 bays of 3m each along longitudinal direction and along transverse direction. The building is 45.5m high. The building is analyzed by Time history Analysis, which is a linear dynamic analysis. Dynamic Analysis is adopted since it gives better results than static analysis.

The dead load is taken as wall load and parapet wall load which depend upon the wall thickness and the height of wall. the thickness of wall is taken as 250 mm. All the specifications of the frame are given in Table 1.

Table 3.1 Building description

1.	Building type	Residential building
2.	No. of story’s	G+15
3.	Bottom storey height	3.5m
4.	Total height	45.5m
5.	Floor height	3m
6.	Size of column	300mm*400mm
7.	Size of beam	230mm*300mm
8.	Thickness of slab	150mm
9.	Masonry wall thickness	250mm

10.	Seismic zone	V
11.	Importance factor	1
12.	Response reduction factor	5
13.	Soil type	II
14.	Grade of concrete	M20
15.	Grade of steel	Fe415
16	Unit weight of brick	20 kN/m^3
17.	Damping	5%
18.	IS Code for concrete	IS 456:2000
19.	IS Code for earthquake	IS 1893:2006 (part I)
20.	Self-weight factor	1

Load combination

Building is analyzed on the basis of Various load combinations in the limit state of design for reinforced concrete structures as per IS 1893:2002(part1). these all are given below:

1) 1.5(DL+IL)

2) 1.2 (DL+IL+EL_x)

3) 1.2 (DL+LL+EL_Y)

4) 1.2(DL+IL-EL_X)

5) 1.2(DL+IL-EL_Y)

6) 1.5(DL+EL_X)

7) 1.5(DL+EL_Y)

8) 1.5(DL-EL_X)

9) 1.5(DL-EL_Y)

10) 0.9DL+1.5EL_X

11) 0.9DL+1.5EL_Y

12) 0.9DL-1.5EL_X

13) 0.9DL-1.5EL_Y

As we know that 1.5(DL+IL) is not the Earthquake load combo. It is purely the gravity load combination. But when we are designing a structure, we need to consider all the different load combinations as specified by the respective design code. So, 1.5 (DL+LL) has nothing to do with the earthquake loading. 1.5(DL+LL) as defined in the IS-1893 code is one of the load combination as specified in IS 456 for the RCC structure. See below the factors these factors are same as IS 456:2000.

Load Combination	Limit State of Collapse			Limit States of Serviceability		
	DL	IL	WL	DL	IL	WL
(1)	(2)	(3)	(4)	(5)	(6)	(7)
DL + IL	1.5		1.0	1.0	1.0	-
DL + WL	1.5 or 0.9[1)]	-	1.5	1.0	-	1.0
DL + IL + WL	1.2			1.0	0.8	0.8

Fig 3.1 Showing Load combination

3.3 Problem Formulation

The study was focused on the behavior of the multi-storey building with Red clay brick and Hollow concrete block under seismic activity. As it is clear from the previous studies that multi-storey buildings are unstable for seismic forces. The analysis was done as per IS Code provision using ETABs software. In this comparison is done for G+15 multi storey residential building.

The seismic data is taken according to the IS 1893(Part 1):2002 for the Zone V as given below in table 2.

Table 3.2 Seismic Data

Serial No	Model Description	
1	Zone	V
2	Zone Factor	0.36
3	Type of building	Residential
4	Importance Factor	1
5	Soil Type	II
6	Soil Condition	Medium
7	Damping Ratio	5%
8	Response Reduction Factors	5

3.4 Method of Analysis - Seismic analysis may be carried out by:

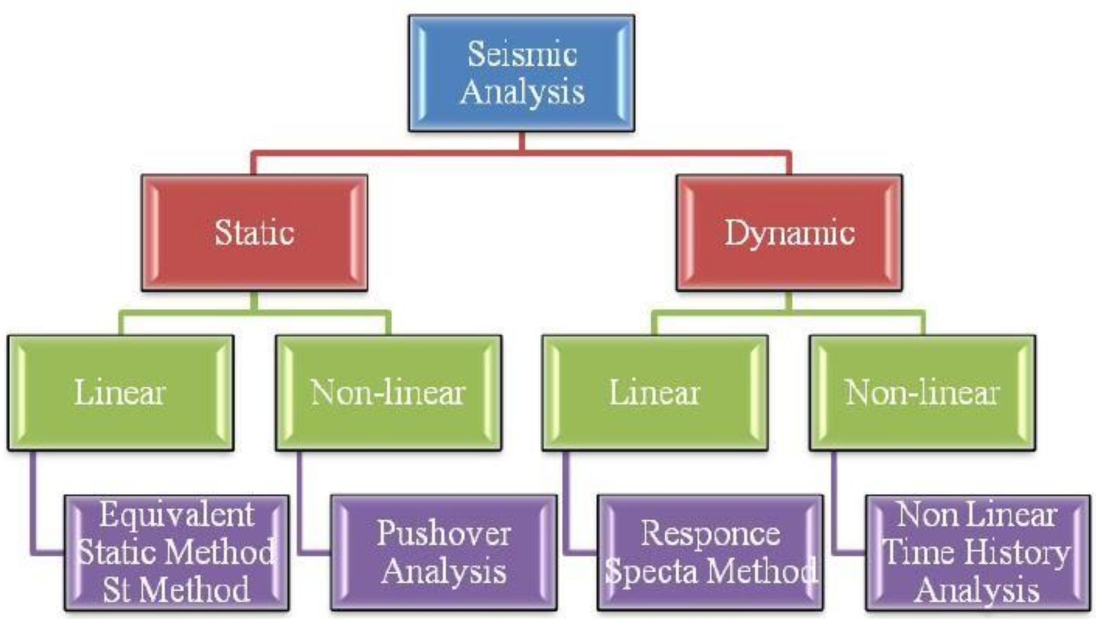


Fig.3.2- Method of Analysis

3.4.1 Static Method

The design base shear shall be computed as a whole, and then be distributed along the height of the building based on simple formulas appropriate for the building with regular distributing of mass and stiffness according to IS Code 1893 (part 1): 2002.

3.4.1.1 Equivalent static method

This approach defines a series of forces acting on a building to represent the effect of earthquake ground motion, typically defined by a seismic design response spectrum. It assumes that the building responds in its fundamental mode. For this to be true, the building must be low-rise and must not twist significantly when the ground moves. The response is read from a design response spectrum, given the natural frequency of the building (either calculated or defined by the building code). The applicability of this method is extended in many building codes by applying factors to account for higher buildings with some higher modes, and for low levels of twisting. To account for effects due to "yielding" of the structure, many codes apply modification factors that reduce the design forces (e.g. force reduction factors).

For determination of seismic forces, the country is classified in four seismic zones:

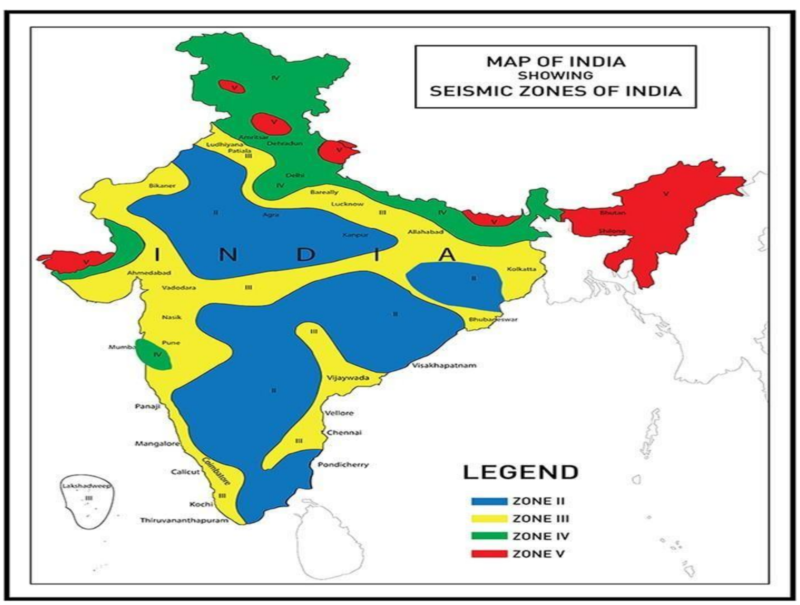


Fig 3.3- seismic zones of India

Each zone has their own zone factor value and as per IS 1893 (Part 1):2002 these values are given below:

Seismic Zone Factor (1)	II (2)	III (3)	IV (4)	V (5)
Z	0.10	0.16	0.24	0.36

As per IS Code 1893(part 1) :2002 the following were the major steps for determining the seismic forces:

3.4.1.1.1 Determination of base shear

The total design lateral force determined by the following expression, (clause 7.6.1 of IS 1893 (part 1): 2002)

$$V_b = A_h * W$$

Where, A_h= Design horizontal seismic coefficient for structure

W= Seismic weight of the building

$$A_h = \frac{\left(\frac{Z}{2}\right)\left(\frac{Sa}{g}\right)}{\left(\frac{R}{I}\right)}$$

Where, R=response reduction factor

Z= zone factor

I= importance factor

Sa/g is the average response acceleration coefficient for rock and soil sites as given in figure 2 of IS 1893:2002 (part 1).

The values are given for 5% damping of the structure for S_a/g.

For rocky, or hard soil sites

$$\frac{S_a}{g} = \begin{cases} 1+15T; & 0.00 \le T \le 0.10 \\ 2.50 & 0.10 \le T \le 0.40 \\ 1.00/T & 0.40 \le T \le 4.00 \end{cases}$$

For medium soil sites

$$\frac{S_a}{g} = \begin{cases} 1+15T; & 0.00 \le T \le 0.10 \\ 2.50 & 0.10 \le T \le 0.55 \\ 1.36/T & 0.55 \le T \le 4.00 \end{cases}$$

For soft soil sites

$$\frac{S_a}{g} = \begin{cases} 1+15T; & 0.00 \le T \le 0.10 \\ 2.50 & 0.10 \le T \le 0.67 \\ 1.67/T & 0.67 \le T \le 4.00 \end{cases}$$

Fig 3.4 Soil type

Where T is the fundamental natural period for buildings calculated as per clause 7.6 of IS 1893:2002 (part1) and shown further.

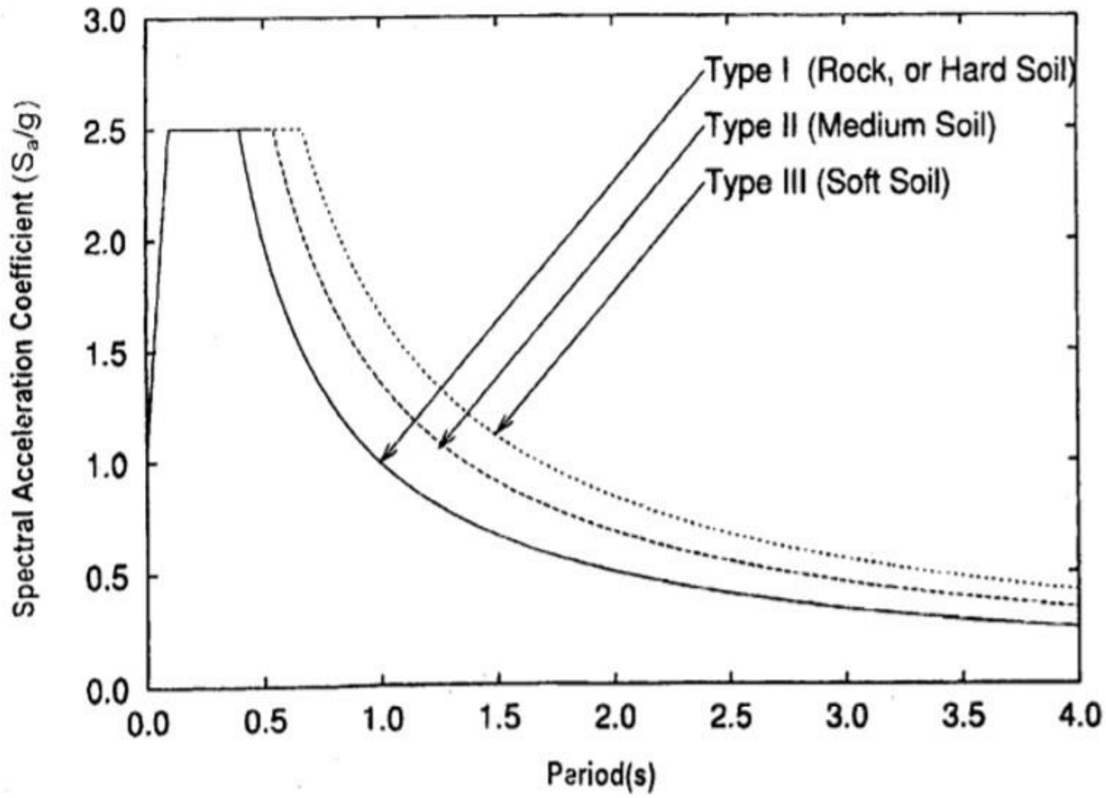


Fig 3.5 Soil type graph

3.4.1.1.2 Lateral distribution of base shear

In equivalent lateral force procedure, the magnitude of lateral force is based on the fundamentals period of vibration, IS 1893 (part 1):2002 uses of parabolic distribution of the lateral force as per the following expression:

$$Q_i = \left(\frac{W_i h_i^2}{\sum_{j=1}^{n} W_j h_j^2} \right) V_B$$

Where,

Q_i= Design lateral force at floor i

W_i= seismic weight of the floor i

h_i= height of the floor i from the base

n= number of stories of the building at which masses are located.

3.4.1.1.3 Fundamental natural time period

The approximate fundamental natural period of vibration (T), in seconds, of all other buildings, including moment resisting frame buildings with brick infill panels, maybe estimated by the empirical expression given in clause 7.6.2 of IS 1893(part 1):2002.

$T_a=0.075h^{0.75}$ for RC frame building without brick infill wall

$T_a= 0.085h^{0.75}$ for steel frame building without brick infill wall

$T_a=0.09h/\sqrt{d}$ all other buildings including moment resisting RC frame with brick infill

3.4.1.2 Nonlinear static analysis

In general, linear procedures are applicable when the structure is expected to remain nearly elastic for the level of ground motion or when the design results in nearly uniform distribution of nonlinear response throughout the structure. As the performance objective of the structure implies greater inelastic demands, the uncertainty with linear procedures increases to a point that requires a high level of conservatism in demand assumptions and acceptability criteria to avoid unintended performance. Therefore, procedures incorporating inelastic analysis can reduce the uncertainty and conservatism.

This approach is also known as "pushover" analysis. A pattern of forces is applied to a structural model that includes non-linear properties (such as steel yield), and the total force is plotted against a reference displacement to define a capacity curve. This can then be combined with a demand curve (typically in the form of an acceleration- displacement response spectrum (ADRS). This essentially reduces the problem to a single degree of freedom (SDOF) system. Nonlinear static procedures use equivalent SDOF structural models and represent seismic ground motion with response spectra. Story drifts and component actions are related subsequently to the global demand parameter by the pushover or capacity curves that are the basis of the non-linear static procedures.

3.4.2.1 Linear Dynamic Methods

Static procedures are appropriate when higher mode effects are not significant. This is generally true for short, regular buildings. Therefore, for tall buildings, buildings with torsion irregularities, or non-orthogonal systems, a dynamic procedure is required. In the linear dynamic procedure, the building is modeled as a multi-degree-of-freedom (MDOF) system with a linear elastic stiffness matrix and an equivalent viscous damping matrix. The seismic input is modeled using either modal spectral analysis or time history analysis but in both cases, the corresponding internal forces and displacements are determined using linear elastic analysis. In linear dynamic analysis, the response of the structure to ground motion is calculated in the time domain, and all phase information is therefore maintained. Only linear properties are assumed. The analytical method can use modal decomposition as a means of reducing the degrees of freedom in the analysis.

The advantage of linear dynamic procedures with respect to linear static procedures is that higher modes can be considered. However, they are based on linear elastic response and hence the applicability decreases with increasing nonlinear behavior, which is approximated by global force reduction factors. The type of linear dynamic methods is as follows-

3.4.2.1.1 Response Spectrum Analysis

Response spectrum analysis is a procedure for calculating the maximum response of a structure when applied with ground motion. Each of the vibration modes that are considered are assumed to respond independently as a single degree of freedom system. Design codes specify response spectra which determine the base acceleration applied to each mode according to its period (the number of seconds required for a cycle of vibration). Having determined the response of each vibration mode to the excitation, it is necessary to obtain the response of the structure by combining the effects of each vibration mode because the maximum response of each mode will not necessarily occur at the same instant, the statistical maximum response, where damping is zero, is taken as sum of squares (SRSS) of the individual responses.

The results of response spectrum are all absolute extreme values and so they need to be combined as they do not correspond to any equilibrium state nor they take place at the same time. There are several methods to execute this, one of them being the (SRSS) method, Square root of sum of squares method. In this method, the maximum response in terms of given parameter, G (displacement, acceleration, velocity) may be estimated through the square root of sum of m modal response squares, contributing to global response:

$$G = \Sigma mn=1 \ (Gn)2$$

3.4.2.2 Nonlinear dynamic analysis

Nonlinear powerful investigation uses the blend of ground movement records with a nitty gritty auxiliary model, in this manner is fit for creating results with moderately low vulnerability. In nonlinear powerful investigations, the point by point basic model exposed to a ground-movement record produces appraisals of segment for every level of opportunity in the model and the modal responses are combined using schemes such as the square-root-sum-of-squares.

In non-linear dynamic analysis, the non-linear properties of the structure are considered as part of a time domain analysis. This approach is the most rigorous, and is required by some building codes for buildings of unusual configuration or of special importance. However, the calculated response can be very sensitive to the characteristics of the individual ground motion used as seismic input; therefore, several analyses are required using different ground motion records to achieve a reliable estimation of the probabilistic distribution of structural response. Since the properties of the seismic response depend on the intensity, or severity, of the seismic shaking, a comprehensive assessment calls for numerous nonlinear dynamic analyses at various levels of intensity to represent different possible earthquake scenarios.

3.4.2.2.1 Time History Method

It is known as Time history analysis. It is an important technique for structural seismic analysis especially when the evaluated structural response is nonlinear. Time history analysis is a step-by- step analysis of the dynamic response of a structure to a specified loading that may vary with time. A full time history will give the response of a structure over time during and after the application of a load. To find the full time history of a structure's response A linear time history analysis overcomes all the disadvantages of a modal response spectrum analysis provided nonlinear behavior is not involving. This method requires greater computational efforts for calculating the response at discrete times. It is used to determine the dynamic response of a structure to arbitrary loading.

3.4.3 Method chosen for analysis – "Time History Analysis Method"

Reason- Time history analysis is the study of the dynamic response of the structure at every addition of time, when its base is exposed to a particular ground motion. Static techniques are applicable when higher mode effects are not important. This is for the most part valid for short, regular structures. Thus, for tall structures, structures with torsional asymmetries, or no orthogonal frameworks, a dynamic method is needed. In linear dynamic method, the structures are modeled as a multi degree of freedom (MDOF) system with a linear elastic stiffness matrix and an equivalent viscous damping matrix. The seismic input is modeled utilizing time history analysis, the displacements and internal forces are found using linear elastic analysis. The playing point of linear dynamic procedure as for linear static procedure is that higher modes could be taken into account.

3.4.4 Parameters considered for analysis

1. Storey drift
2. Storey displacement
3. Story shear
4. Storey stiffness

3.4.4.1 Story drift- It is the relative displacement of one level relative to other level above or below. According to IS 1893(Part 1):2002 (part 1), the storey drift should not exceed 0.004 times of relative storey height.

3.4.4.2 Storey displacement- It is the displacement of each storey with respect to ground level. According to IS 1893 (part1) :2002 the max value of displacement is 1/250 times of storey height with respect to ground.

3.4.4.3 Story shear - According to IS 1893 (Part 1):2002

3.4.4.4 Storey stiffness- As per IS 1893(Part 1):2002 the lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of average lateral stiffness of the three storey above.

3.5 Structural Modeling

Software ETABs is used for seismic analysis and to study the behavior of multistory building with and without bracing. Different models are made and compared with different parameters of analysis. Complete analysis including structural modeling is performed in this software.For the purpose of this study, a RC framed (G+15) multistory building having same floor plan with 5 bays of 3m each along longitudinal direction and along transverse direction as shown in figure 3.3. Two models with different infill wall were selected in order to determine the behavior of structural member during seismic activity. The columns are fixed at the ground and are taken as restrains. The total height of the building is 45.5. The bottom storey height is 3.5m and rest are of 3m. All the values of loads and dimensions are given in table no.3.1.the figure 3.3 shows the plan of the building.

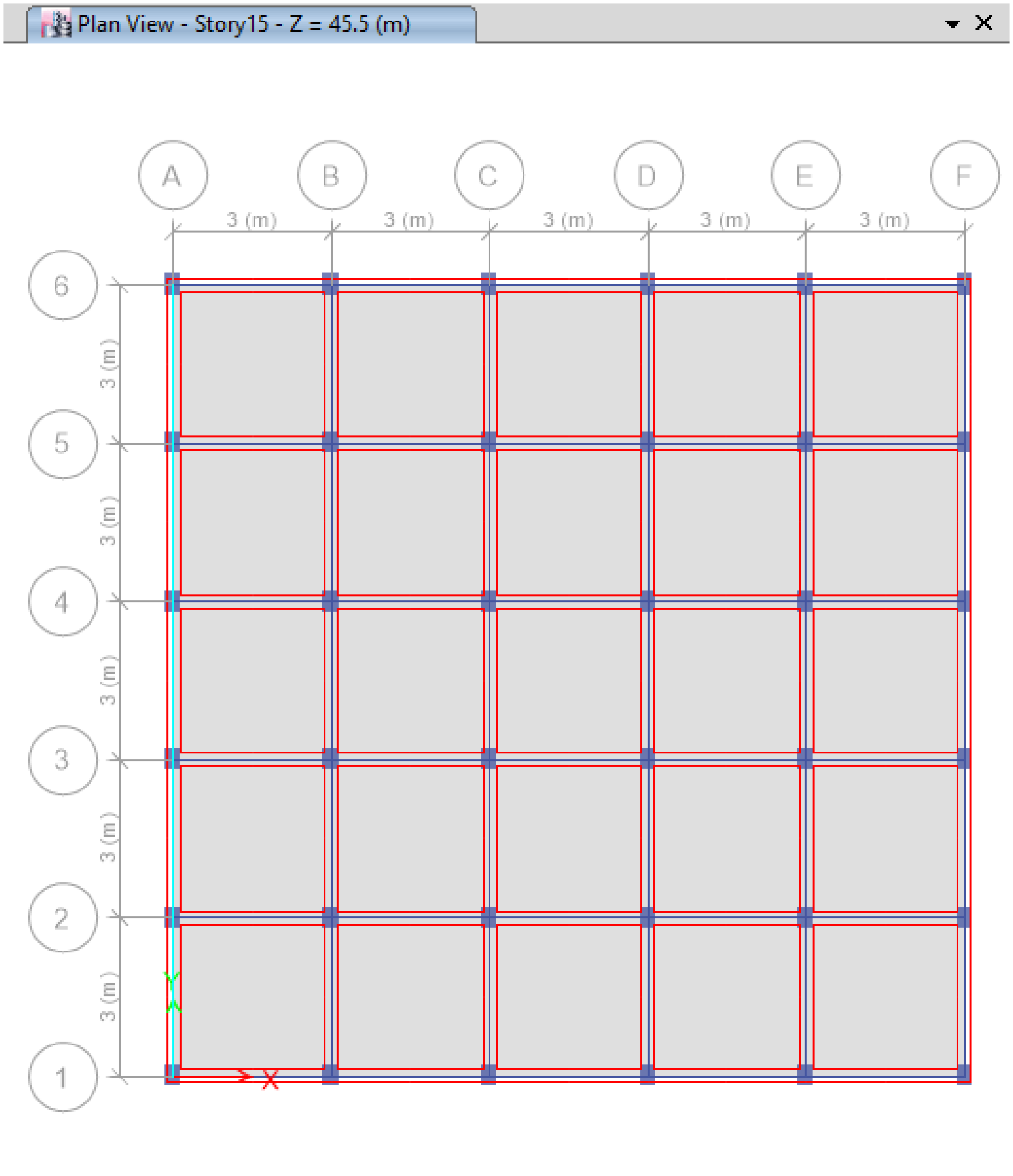


Fig.3.6 Plan of Building

The two models are selected for the study which are shown below. the figure 3.4 and 3.5 shows the 3D view and elevation of the building without bracing.

MODEL 1- BUILDING MADE WITH NORMAL CONVENTIONAL BRICKS

In this model RC frame Building with conventional bricks as infill wall. This is simple RC framed structure. The figure 2 and 3 shows the 3D view and elevation of the building without bracing.

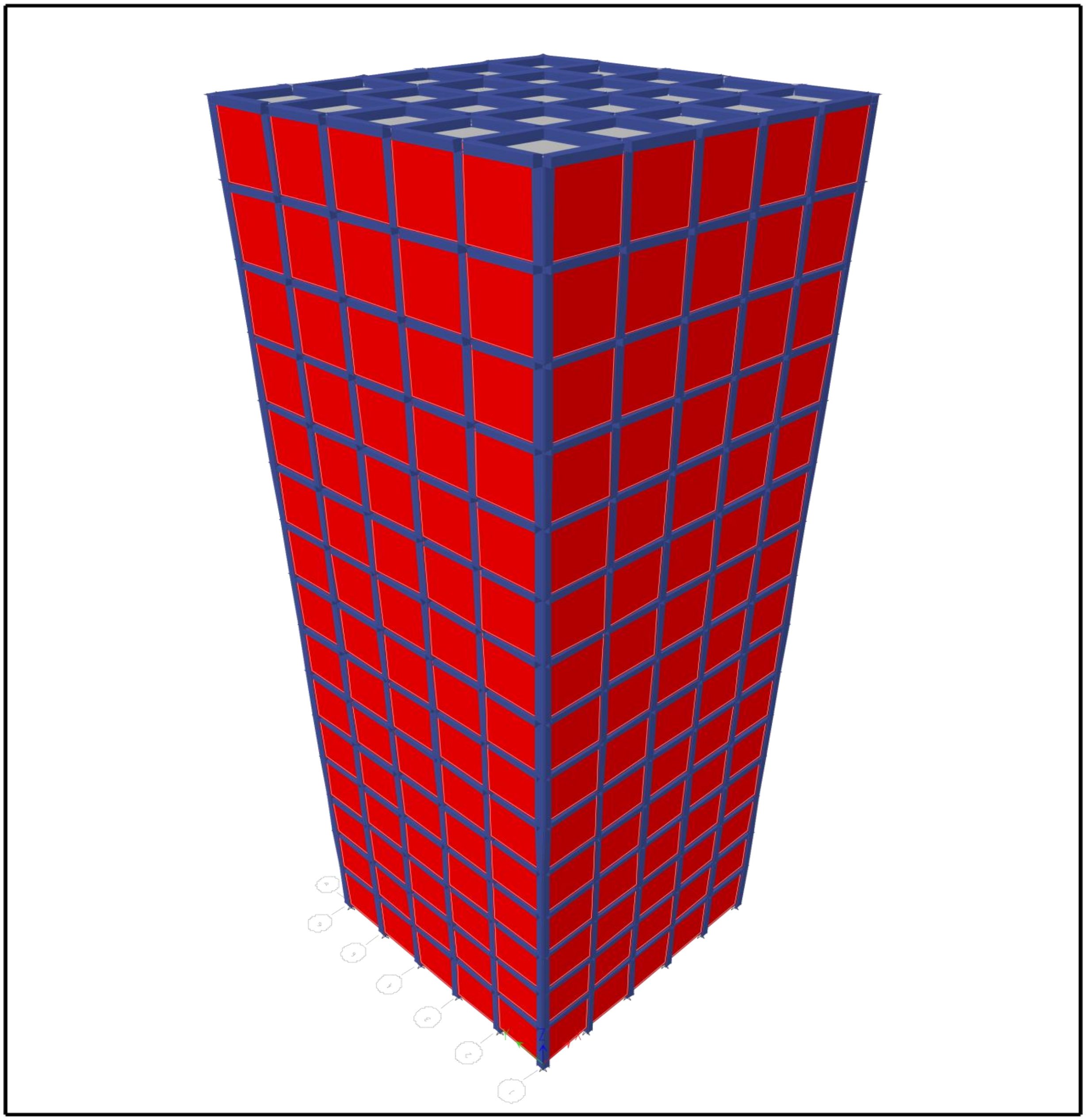


Fig 3.7- 3D View of Building with conventional bricks infill wall

ELEVATION OF BUILDING WITH CONVENTIONAL BRICKS INFILL WALL

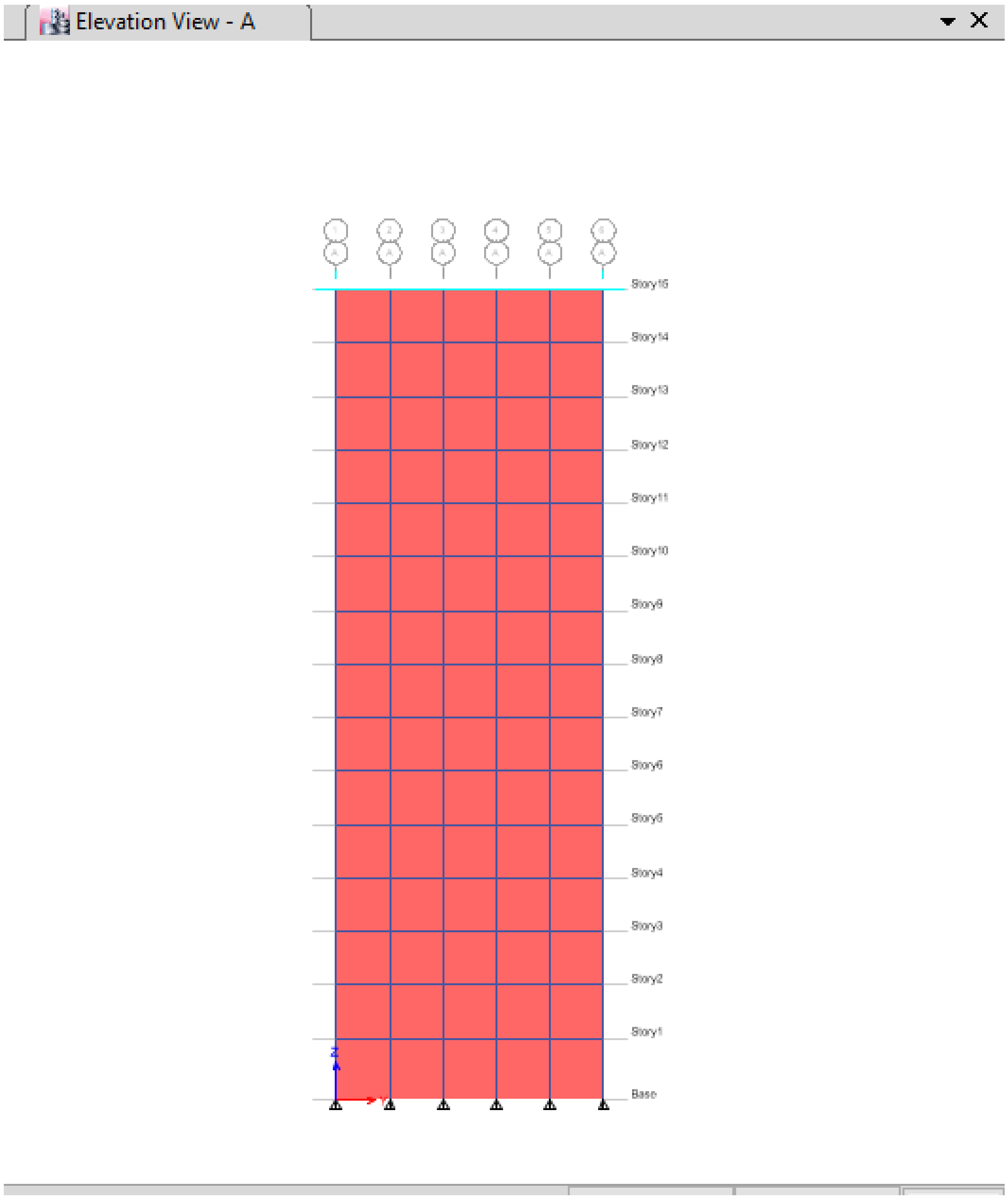


FIG.3.8- Elevation View of Building Without Bracing

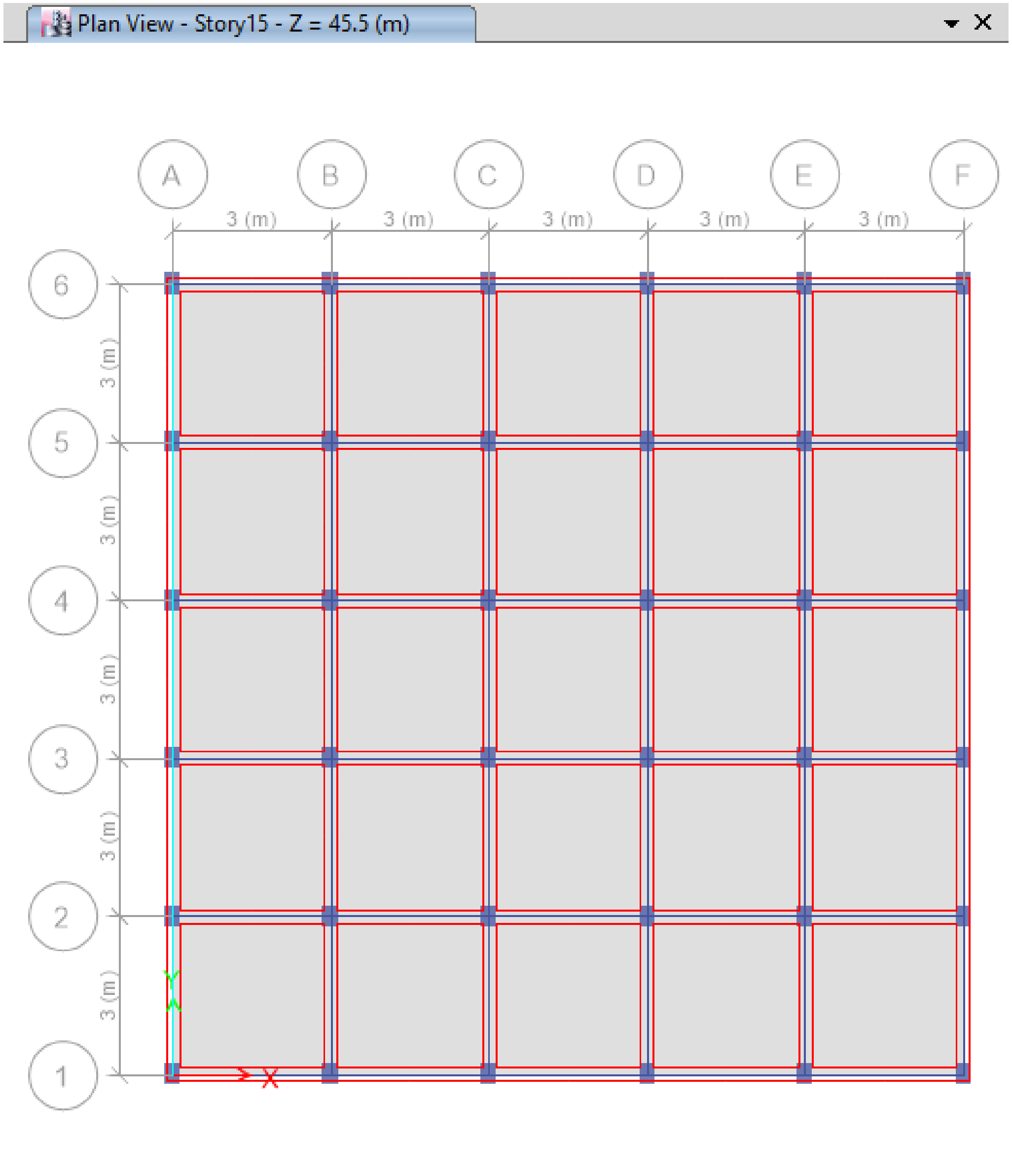


Fig.3.9- Plan of Building

MODEL 2- BUILDING WITH HOLLOW CONCRETE BLOCKS INFILL WALL

In this model we have Hollow concrete blocks infill wall all over the four sides of the building. Figure 3.6 and 3.7 shows the 3D view and elevation of the building with Hollow concrete blocks infill wall.

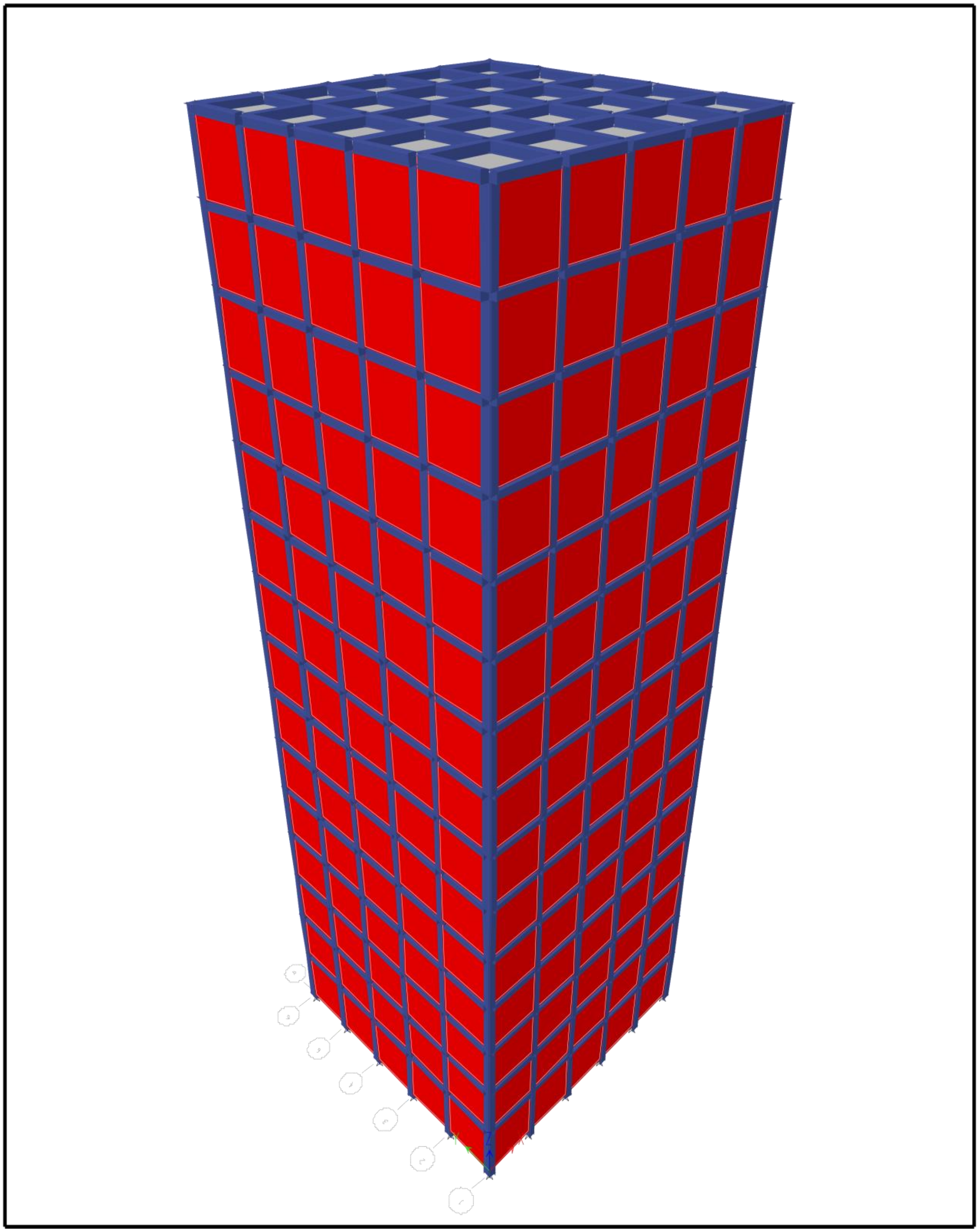


FIG.3.10- 3D View of Building with Hollow concrete blocks infill wall

ELEVATION OF BUILDING WITH X-BRACING

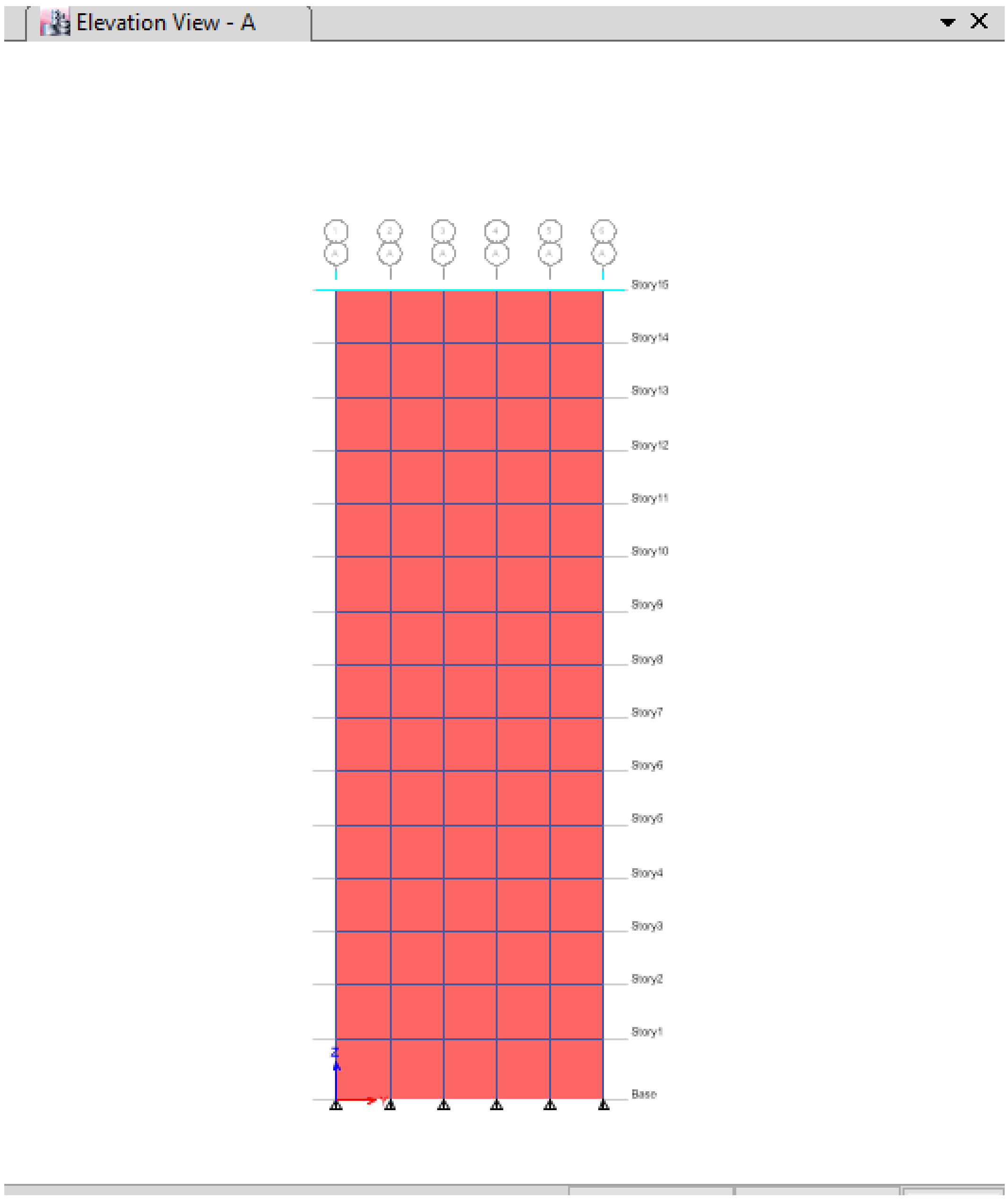


Fig. 3.11- Elevation View of Building with Hollow concrete block

Analysis Using ETABs Software

The analysis has been done using ETABs software which involves following steps: -

1. Defining dimensions of the plan
2. Defining the members and material properties
3. Assigning loads and load combinations
4. Run and check model to find errors
5. Run analysis
6. Extract results and discuss

As we know, we are using the time history method for seismic analysis of all four models of the structure. For that we need to define the time history function in the ETABs. For time history function we need to take a specific data on which our analysis is based. For this need we have taken Elcentro data which is the most accurate data of the earthquake in Maxico in 1940.

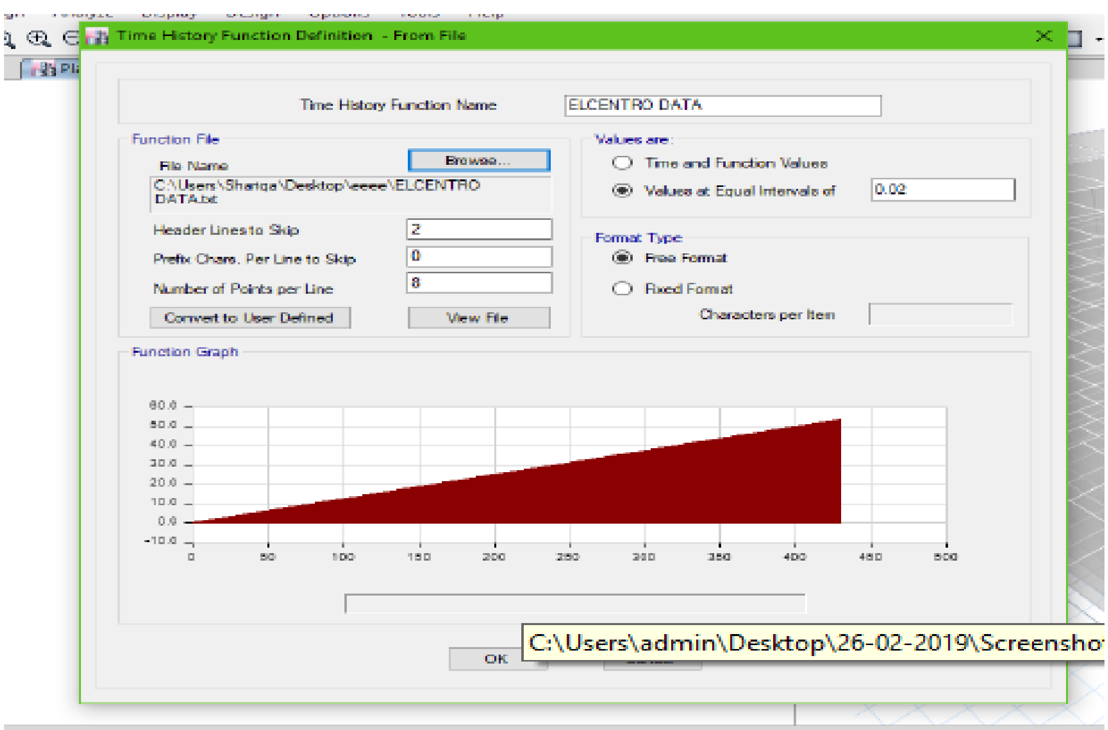


Fig.3.12- Defining Elcentro data

CHAPTER-4

RESULT

4. RESULT

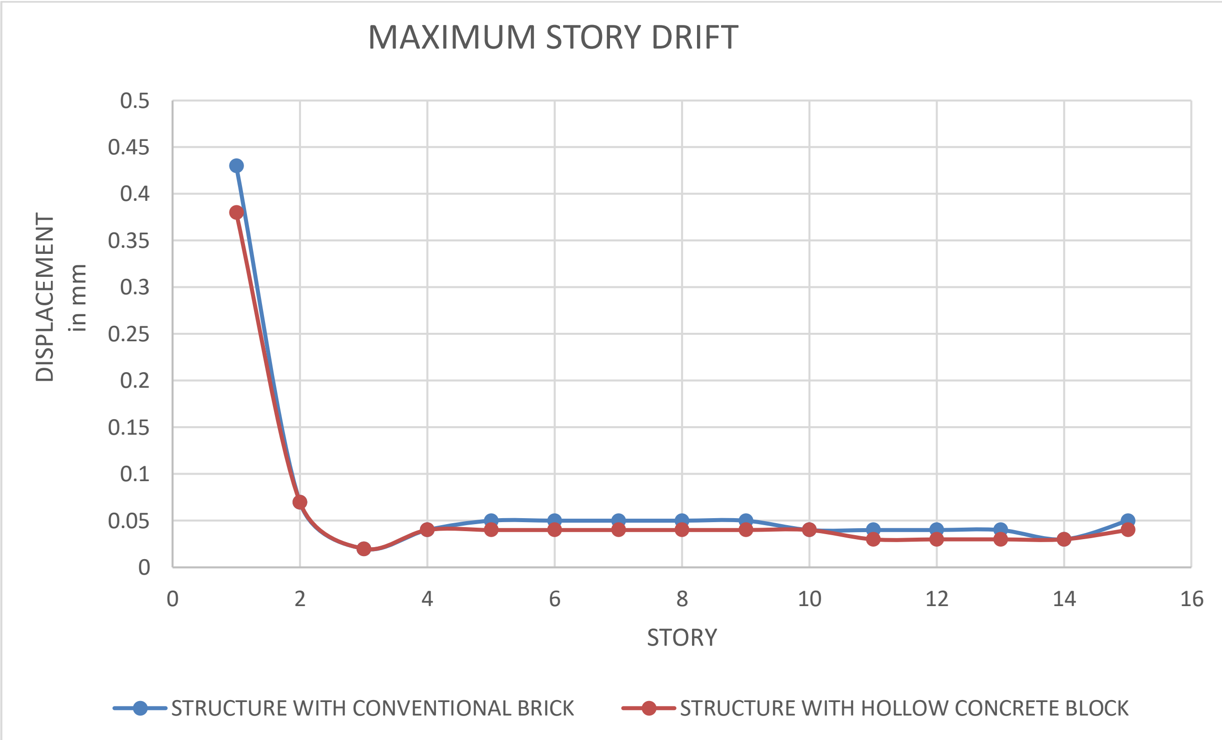
4.1 Story Drift

It is the relative displacement of one level relative to other level above or below. According to IS 1893:2002 (part 1), the story drift should not exceed 0.004 times of relative story height.

4.1.1 Maximum Story drift (mm) comparison in X direction- The table 3 and the graph1 below shows the comparison of Red clay brick and Hollow concrete block in terms of story drift in X direction.

Number of story	RED CLAY BRICKS	HOLLOW CONCRETE BLOCK
Story15	0.05	0.04
Story14	0.03	0.03
Story13	0.04	0.03
Story12	0.04	0.03
Story11	0.04	0.04
Story10	0.04	0.04
Story9	0.05	0.04
Story8	0.05	0.04
Story7	0.05	0.04
Story6	0.05	0.04
Story5	0.05	0.04
Story4	0.04	0.04
Story3	0.02	0.02
Story2	0.07	0.07
Story1	0.43	0.38

Table 4.1 story drift comparison in X direction



Graph- 4.1 story drift comparison in X direction

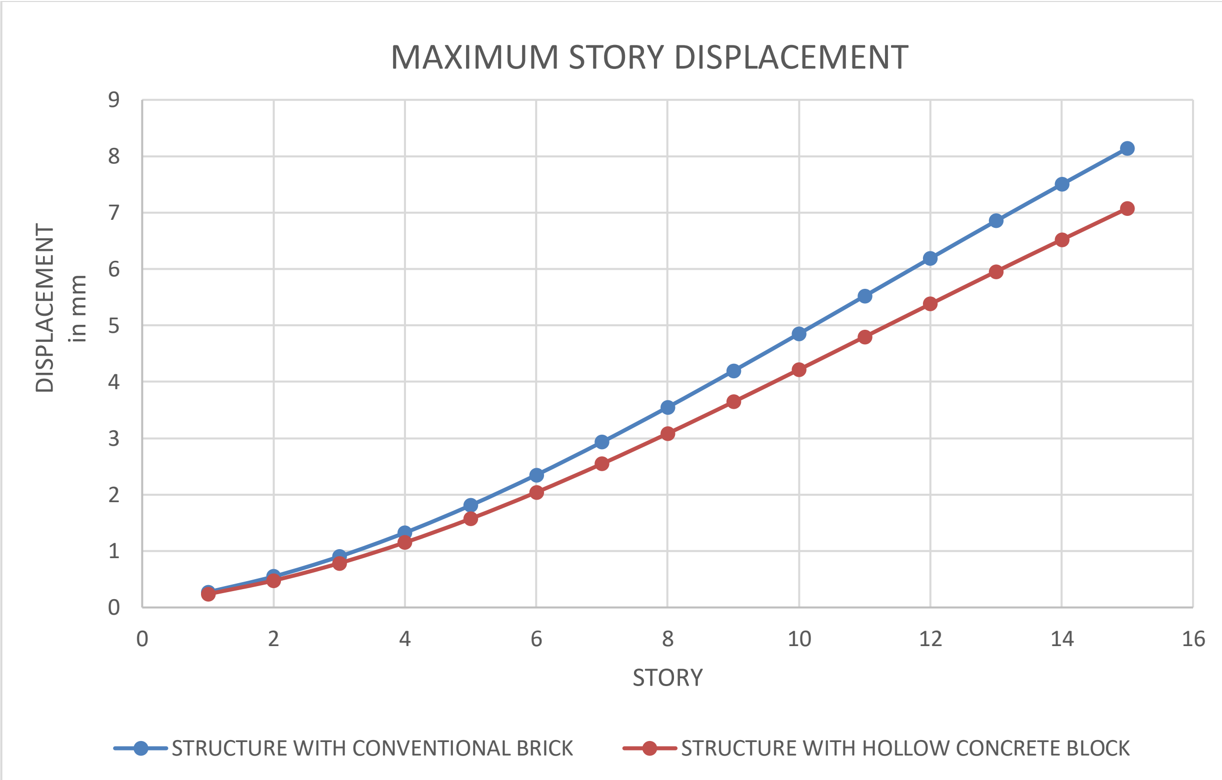
4.2 Story Displacement

It is the displacement of each story with respect to ground level. According to IS 1893 (part1) :2002 the max value of displacement is 1/250 times of story height with respect to ground**.**

4.2.1 Maximum Story displacement (mm) comparison in x direction- The table and graph below shows the comparison of Red clay brick and Hollow concrete block in terms of storey displacement in X direction.

Number of story	**RED CLAY BRICK**	**HOLLOW CONCRETE BLOCK**
Story15	8.139	7.075
Story14	7.501	6.519
Story13	6.852	5.955
Story12	6.19	5.379
Story11	5.521	4.798
Story10	4.853	4.217
Story9	4.193	3.643
Story8	3.549	3.084
Story7	2.932	2.547
Story6	2.349	2.041
Story5	1.81	1.573
Story4	1.325	1.152
Story3	0.902	0.784
Story2	0.548	0.477
Story1	0.271	0.237

Table 4.2 Story Displacement comparison in X direction



Graph 4.2 Story Displacement comparison in X direction

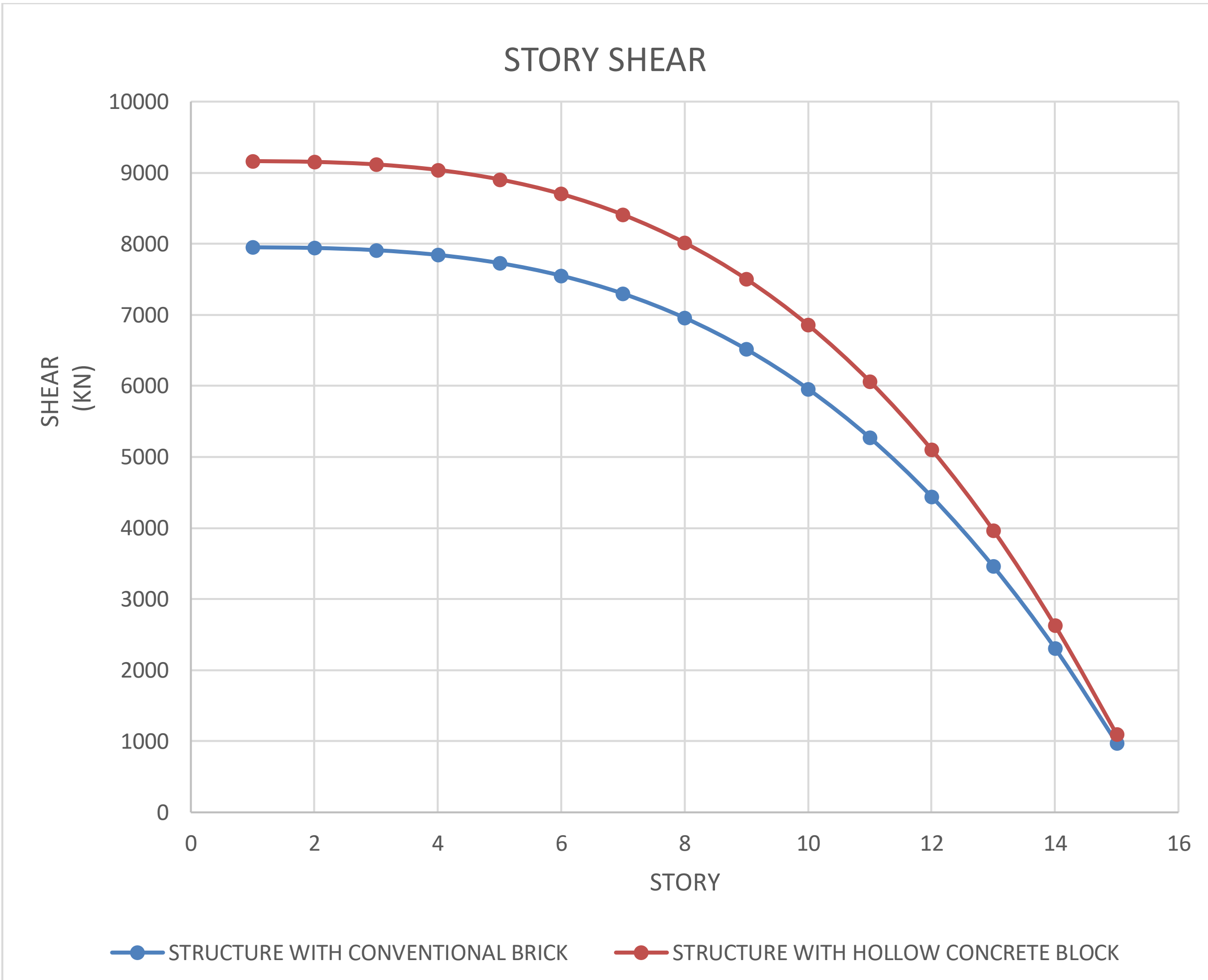
4.3 Story shear

According to IS 1893(Part 1):2002

4.3.1 Story shear comparison-The table and the graph below shows the comparison of Red clay brick and Hollow concrete block in terms of fundamental time period.

Number of Storey	RED CLAY BRICK	HOLLOW CONCRETE BLOCK
Story15	976.612	1096.7753
Story14	2309.056	2637.9619
Story13	3460.0294	3969.2485
Story12	4442.8105	5105.9936
Story11	5270.6778	6063.5558
Story10	5956.9095	6857.2936
Story9	6514.784	7502.5655
Story8	6957.5796	8014.7301
Story7	7298.5746	8409.1458
Story6	7551.0474	8701.1714
Story5	7728.2762	8906.1652
Story4	7843.5396	9039.4858
Story3	7910.1157	9116.4918
Story2	7941.2829	9152.5417
Story1	7950.8625	9163.6545

Table 4.3 Story shear comparison in x direction



Graph 4.3 Story shear comparison in x direction

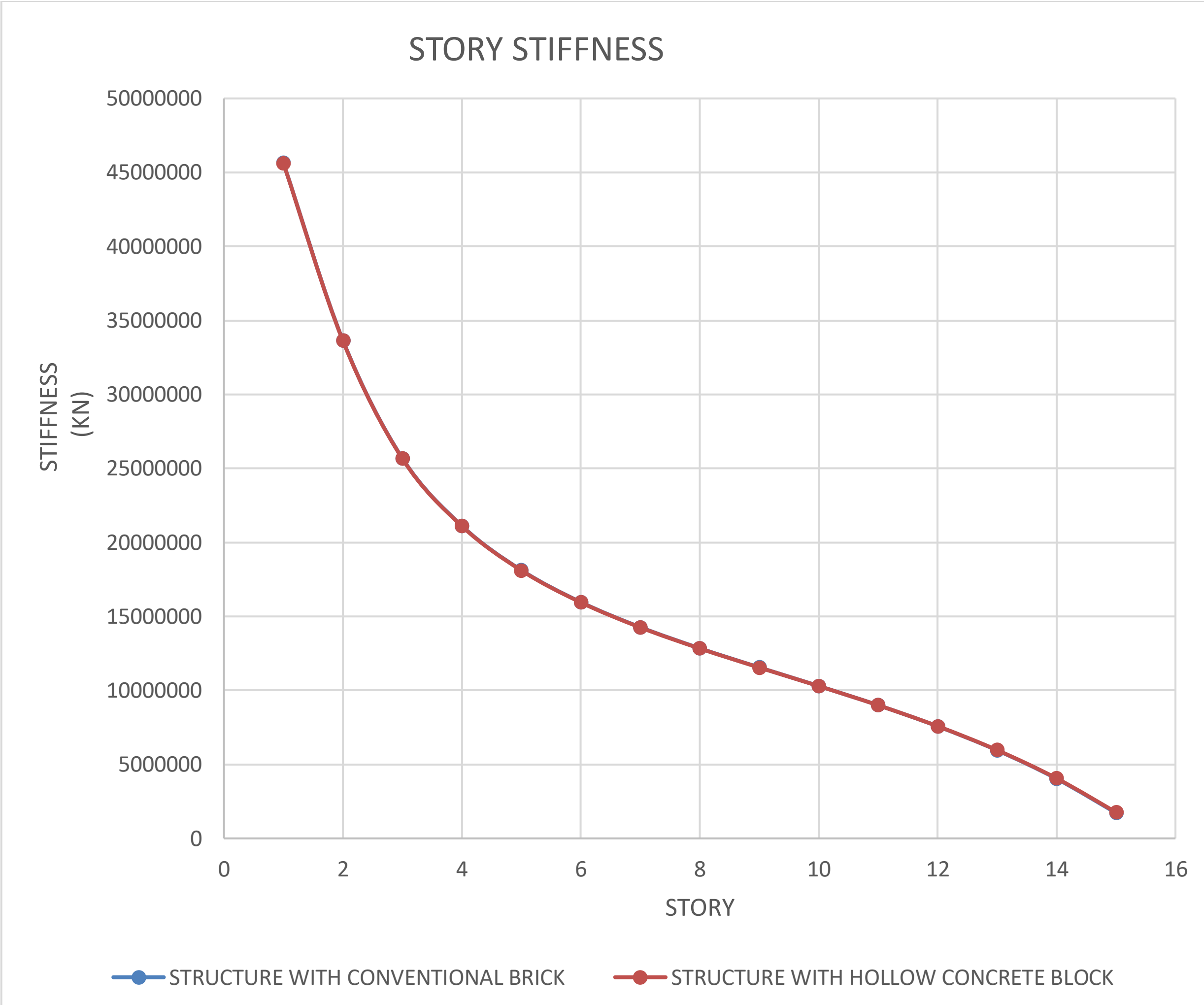
4.4 Story stiffness

As per IS 1893:2002 the lateral stiffness is less than 70 percent of that in the story above or less than 80 percent of average lateral stiffness of the three story above.

4.4.1Maximum Story stiffness (KN/m) comparison in x direction-The table and graph below shows the comparison of Red clay brick and Hollow concrete block in terms of story stiffness in X direction.

Number of story	**RED CLAY BRICK**	**HOLLOW CONCRETE BLOCK**
Story15	1722934.046	1763271.744
Story14	4035621.599	4060865.397
Story13	5953205.466	5967025.47
Story12	7578356.735	7583610.857
Story11	9000698.713	8999529.442
Story10	10301022.786	10295017.608
Story9	11556505.627	11546826.549
Story8	12848477.932	12835959.974
Story7	14273891.823	14259113.504
Story6	15964609.542	15947939.827
Story5	18124782.88	18106409.196
Story4	21123832.879	21104016.936
Story3	25684410.703	25662533.767
Story2	33653964.714	33630504.8
Story1	45620420.58	45641311.976

Table 4.4 story stiffness comparison in x direction



Graph 4.4 story stiffness comparison in X direction

CHAPTER-5

CONCLUSION

5. CONCLUSIONS

Figure 5.1 conclusion between hollow concrete block and normal conventional brick

Storey displacement was decreased in model with hollow concrete block. The storey displacement decreased in hollow concrete block model about 13.07% as compared with normal conventional bricks.

Storey shear is increased in the model with the hollow concrete block. The storey shear increased in hollow concrete block model about 13.23 % as compared with normal conventional bricks models.

In this report story stiffness behavior about same as we compared hollow concrete block model and normal conventional brick.

The Brick v/s block debate is a very close one and anyone who is about to get a construction
started with have to deal with the comparing of pros and cons of both. However, a lot depends on place, budget and situation of the builder. For some, brick masonry constructions are necessary because they ultimately want lesser maintenance even when the cost of building is higher. Some people, on the other side would prefer less cost of construction and regular

Making of red bricks is not so eco-friendly it seems but the same can be said about the blocks not being up for the purpose of recycle. Red brick-kilns remain under the scrutiny of government and NGT while concrete block industry are on the rise at many places.

From the above study and results several conclusions can be drawn such as:

- The providing hollow concrete block are more efficient in reducing lateral displacement of building as a drift and horizontal deflection influence in hollow concrete block are much less when compared with normal conventional bricks.
- Providing red clay bricks is effective but the hollow concrete blocks are more effective.
- Making of red bricks is not so eco-friendly it seems but the same can be said about the blocks not being up for the purpose of recycle. Red brick-kilns remain under the scrutiny of government and NGT while concrete block industry are on the rise at many places
- Building with hollow concrete blocks is more earthquake resistance than building with red clay bricks.
- Hollow blocks provide high strength and provide less self-weight to the existing structures.
- Displacements and Drifts are reduced in Building with hollow concrete blocks as compared to building with normal conventional bricks.
- For story stiffness in hollow concrete block is slightly more effective as compared with normal conventional bricks
- Being light in weight HCBs due to which transmits less load to the foundation.

- Laying of blocks saves mortar as compared with normal conventional brick work. There is saving in mortar plaster work too.
- Cavity of blocks helps achieving insulation of walls and provides energy saving for all times. Hollowness results in sound insulation.
- There is no problem of appearance of salts thereby saving in maintenance of final finishes to the walls.
- Laying of blocks is much quicker as compared to brick work hence, saving in time.
- HCBs are environmentally eco-friendly.
- Factor of safety HCB masonry is more than brick masonry.

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APPENDIX

URKUND

Document Information

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Seismic Behaviour of Reinforced Masonry structure with hollow cement concrete blocks: A Review

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Abstract

Hollow Concrete Block have open or closed cavity and can be used in the construction of load-bearing and non-load bearing partition walls. This type of section is commonly used for column design for example in very tall bridges and in earthquake prone areas to reduces its mass and the self-weight during an earthquake. If *the good concrete compacted by high pressure and vibration gives substantial strength to the block and if it is provided proper curing, then it increases compressive strength of the blocks. It is also eco-friendly to the surrounding and environment. These blocks are having at least one gap that are open at the two Sides of the cross section. The main objective is that to compare with normal conventional bricks with concrete block with that of a hollow concrete reinforced block." The hollow concrete reinforced block must have a higher compressive property in comparison with normal conventional and hollow concrete blocks.*

Key Words**: Block masonry, hollow concrete block, strength of masonry, reinforced concrete block masonry, environment friendly.**

1. Introduction

FIG.1: Hollow concrete blocks in structure

Harmon S. Palmer in the United States constructed the first hollow concrete block structured in comparison with stone and wood structure. They are made out of a mixture of Portland cement, sand, gravel and water. When the mixture is wet it is paste like and can be cast in the form of the block. When it dries, it hardens it becomes like stone. Generally, there are two kinds of concrete block, hollow and solid. Nowadays these blocks are widely used in the construction of the heavy structures. These are also used in multi-storeys or high rise structures. These hollow blocks are widely used because of its less weight and the ventilation properties due its hollowness. Hollow blocks resist the electrical conductivity and thermal conductivity and it also resists the soil seepage through it. The air in hollow of the block, does not allow outside heat or cold in the house that why the room keeps cold in summer and keeps hot in winters.

Hollow concrete blocks are having at least one gap that are open at the two Sides of the cross section. These blocks have one or more hollow core. These cores reduce the total cross sectional area of the block by at least 25 percent. The full size blocks are rectangular and half size blocks are cubical in which have one core. The main objective is that to compare with normal conventional bricks with concrete block with that of a hollow concrete reinforced block." The hollow concrete reinforced block must have a higher compressive property in comparison with normal conventional and hollow concrete blocks.

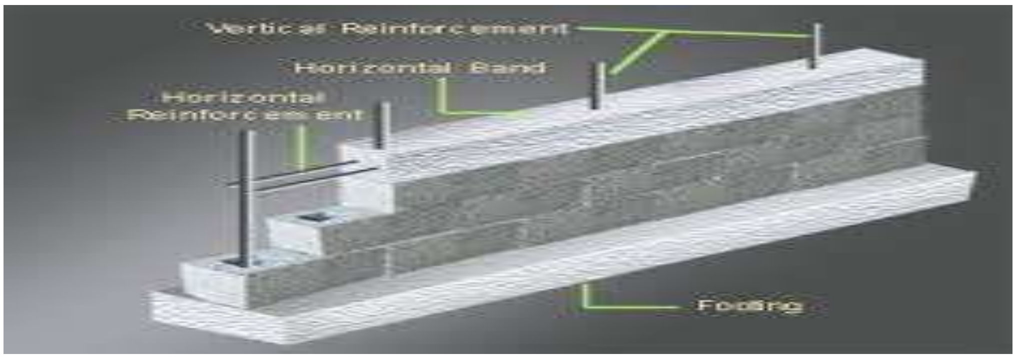

FIG.2: Placing of hollow concrete blocks in vertical and horizontal reinforcement

It has a great deal of Advantages additionally, for example, -

1. It provides very utilized property in very tall structure like bridges.

2. The hollow concrete blocks are used to build large structures like boundary fences.

3. Due to the hollowness of the core of the blocks gives an adequate room to place reinforcing materials like steel bars which leads to increasing of the oppressiveness of structure.

4. Easy in painting of the surface of the wall due to cavity presented in the surface of the blocks and provide futuristic point in the paint option on the surface of the wall.

5. Very less chances of depositing of the salt in spraying the mortar on the surface of the wall.

6. These hollow blocks are very easier to place in comparison with normal conventional blocks and consumes very less time in laying the blocks.

7. These blocks are very lighter in weight which consumes less cement in the construction.

8. Hollow concrete blocks are eco-friendly to the society.

9. In hollow concrete blocks the factor of safety is more than in other conventional bricks.

10. In brick masonry have less workmanship but in hollow concrete blocks workmanship is very good.

1.1 Basics of hollow concrete blocks

Mainly the concrete blocks should provide good compressive strength to the structure. Apart from giving above property hollow concrete blocks provides stability and durability to the structure. These blocks are providing toughness in the structure along with other properties also like heat proof, faster in laying and placing of the blocks. The structure made from these type of bricks is stabilizing for many years without any maintenance. With using HCBs in the structure provides many new conventional ideas and to build structure in many designs and also to fulfilled the requirements of human needs in economical way.

1.2 Practical use of hollow concrete blocks

1. The requirement of block is to reduce the self-weight of the structure in comparison with the solid blocks.

2. In these type of blocks the total weight of construction is less due to the less mortar which uses in laying of blocks.

3. These blocks have reaches to its high compression if its build-up quality like dimension and cross section is proper builded.

4. The construction uses less mortar, thus the total construction costs is reduced.

5. It provides the thermal transmission between the walls.

6. Hollow concrete blocks build in that criteria to achieve the constructional goals.

7. Hollow concrete blocks are resisting the structure for very long years and years.

10. Hollow concrete blocks are mainly used in the factories and storage of huge quantities like go downs.

1.3 Reinforced hollow concrete blocks in structure

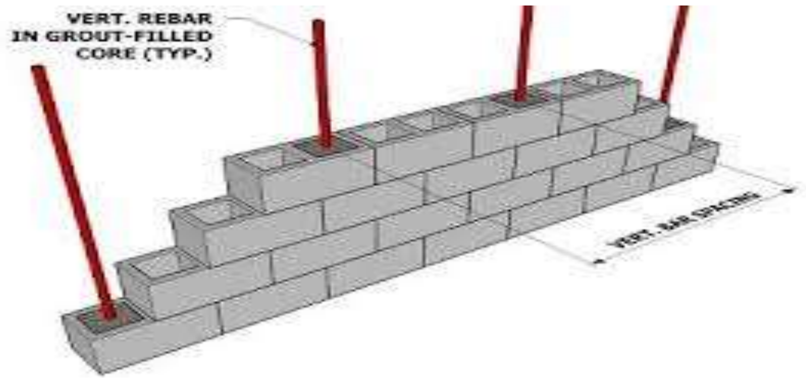

FIG.3: Grouting of vertical bar

In the present days there are many inventions took place some are successful and some are not, first the houses were built from mud then there after stones are used in the construction of houses and then after normal conventional bricks which provides stability than after that concrete blocks were introduced to overcome the conventional bricks now these days the reinforced hollow concrete blocks are introduced to advancement of improved plan and construction strategies. Reinforced hollow unit concrete masonry is a technique where steel bar is inserted in grout inside the concrete blocks with the end goal with the masonry. The grout and steel are act together to oppose the applied forced which comes from the structural load. Therefore, reinforced beams were applied with the hollow concrete blocks to opposes the lateral forces. And up to certain height the vertical bars are re-joined with the horizontal bed joint to bind the structure in both horizontal and vertical direction. It is provided to resist the structure from flexural damage. The hollow concrete blocks are bind with the bars through the filling of hollowness of the blocks by wet concrete paste into it so that it can bind the blocks with bars and provides more strength to the structure.

2. Research Investigation

Hollow concrete block masonry now days practicing in almost every earthquake prone areas like Nepal and many more other places like in Himalayan region. Many recent surveys have been conducted in the India the Kashmir region is one of them on hollow concrete block masonry. In this study, the traditional brick masonry has been compared with the hollow concrete block masonry with the effect of addition of reinforcement to hollow block wall in terms of stiffness and strength to check the stability of structure with every possible way in the constructional gain. The main requirement is that to achieve the maximum strength of the structure with the economy.

3. Objective of the study

- In this study focus on the behaviour of structures during earthquake made from hollow reinforced concrete blocks
- To study the parameters of storey shear, storey displacements, Maximum storey drift of all models during earthquake.
- To study the frequencies and periods in different mode

4. Model of the structure

Parameters consider

In the present study three different buildings

- Made from normal conventional bricks
- Made from hollow concrete blocks
- Made from hollow concrete blocks in which reinforcement are provided in hollow concrete blocks

in which soft storey is provided at bottom storey level are modelled using ETABS package and analysed. The properties of the considered building configurations in the present study are summarized below.

5. Analysis of the structures

This model is analysed as special moment resisting frame using response spectrum analysis

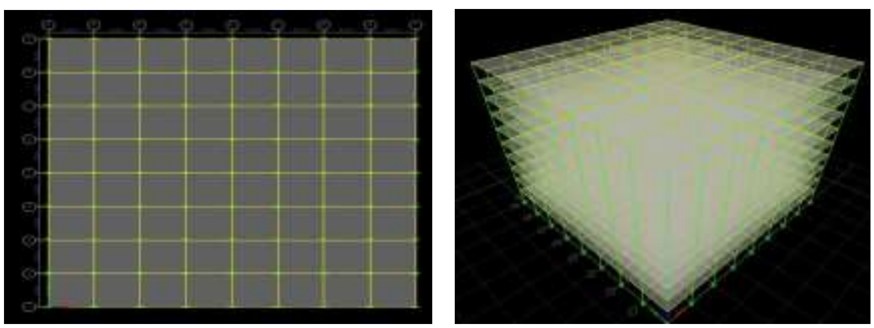

FIG.4: Analysis of model

6. Conclusion

1. The substructure are designed for the low load since the hollow concrete blocks are in lighter weight due to which the structure weight should be also lighter.

2. Excess time reduces in spraying the mortar and laying the blocks which could leads to economy of the structure.

3. Plastering work is also reduced due to smooth surface hollow concrete blocks.

4. Due to the hollowness property of the blocks, the wall becomes sound insulation.

5. The compressive strength achieved in reinforced hollow concrete blocks are comparably high with that of normal conventional bricks and with hollow concrete blocks.

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SEISMIC BEHAVIOR OF REINFORCED MASONRY STRUCTURE WITH HOLLOW CEMENT CONCRETE BLOCKS

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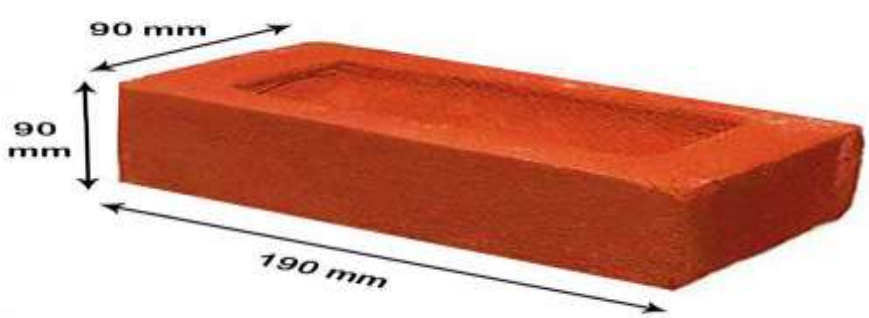
Abstract

In multi-storey the main concern in the tall building or earthquake prone areas is the mass and self-weight of structure. To reduce the mass and self-weight of the structure hollow cement concrete blocks are introduced. Hollow concrete blocks provide the horizontal and vertical force resisting system. An attempt is made to analyse the response of G+15 storied RC multi-story building due to the application of hollow concrete blocks different with normal conventional bricks into the infill wall structure during earthquake. ETABs software is used for modelling and analysing the building. The building is taken in seismic zone V and analysed with Time History Analysis. Various parameters such as story drift, story displacement, and story shear and story stiffness are studied. From the study it was concluded that building with hollow concrete blocks infill wall perform better during seismic activity as compared with building with normal conventional bricks.

***Key Words**: Hollow concrete block, brick masonry, ETAB, Seismic analysis, economical, High strength*

1. INTRODUCTION

1. RED CLAY BRICKS



Building material plays a very crucial role in this modern age of technology. No field of engineering is conceivable without its use. Bricks are one of the oldest materials which are still a dominant and leading building material because it is very economical, easy availability, durability and easy handling. Most commonly used brick is Red Clay bricks which are used for building interior and exterior walls, piers, partitions, footings and other load bearing structure.

The common burnt clay bricks are look at with warm colours which are ranging from cream to orange to sandy and to brown or even blue brown in colour. When clay bricks lay into a wall interesting and pleasing patterns appear. So, each brick although look alike simple in shape and has its own advantages. As we know bricks are most common, basic and essential unit for construction of houses. The quality of bricks may vary depending upon the raw materials used and also in its manufacturing process. Good quality of bricks possesses both physical and chemical properties.

A good conventional brick have a uniform size with plain and rectangular surfaces and should be parallel from the sides having sharp and straight edges, as per standards. A brick should not exceed 3 mm tolerance in length and 1.5 mm tolerance in width and height the standard or conventional size of clay brick is 190mm X 90mm x 90mm.The size of bricks may vary from country to country and from place to place even in big countries like India. The shape of a brick should be uniform. The edges of a good brick should be sharp, straight and at a right angle. However, bricks used for special purpose may be either cut or manufactured in various other shapes. These are generally modifications of rectangular shapes.

2. HOLLOW CONCRETE BLOCKS

Concrete blocks were firstly utilized as the sun clay bricks in the ancient times. After that the modern concrete block was introduced in the mid-1800s and revolutionized building pattern all over the world. There were so wonderful examples of masonry that can be discovered in most ancient cultures as well as in the modern world. The Pyramids are the examples of the heavy blocks structure. The Great Wall of China still draws the attention of thousands of visitors yearly and it can also be seen from the space that is the also one of the structure pattern which can blows the mind of researchers. The evolution of bricks and concrete blocks is the backbone of historical and modern architecture alike. The feats of masonry have survived fires, earthquakes and time and most feature artistic detail even current technologies have trouble in researching. Even the ancient masons do not have heavy machinery, they created complex and durable structure that influenced architecture for centuries.

In 1890 the United States constructed the first hollow concrete block structured in comparison with stone and wood structure. They are made out of a mixture of Portland cement, sand, gravel and water. When the mixture is wet it is paste like and can be cast in the form of the block. When it dries, it hardens it becomes like stone. Hollow concrete blocks are having at least one gap that are open at the two Sides of the cross section. These blocks have one or more hollow core. These cores reduce the total cross sectional area of the block by at least 25 percent. The full size blocks are rectangular and half size blocks are cubical in which have one core. Hollow concrete blocks are frequently used infill walls among the most commonly used masonry. The main objective is that to compare with normal conventional bricks with concrete block with that of a hollow concrete reinforced block." The hollow concrete reinforced block must have a higher compressive property in comparison with normal conventional and hollow concrete blocks.

Available Size: The nominal dimensions of concrete block with tolerance shall be as follows:

Length: 400, 500 or 600 mm

Height: 200 or 100 mm

Width: 50, 75, 100, 150, 200, 250 or 300 mm

HOLLOW BLOCKS	
200 / 300 / 400	Hollow Block 12" (200 X 300 X 400) Weight (kg) : 32
200 / 250 / 400	Hollow Block 10" (200 X 250 X 400) Weight (kg) : 31
200 / 200 / 400	Hollow Block 8" (200 X 200 X 400) Weight (kg) : 23
200 / 150 / 400	Hollow Block 6" (200 X 150 X 400) Weight (kg) : 18
200 / 100 / 400	Hollow Block 4" (200 X 100 X 400) Weight (kg) : 14

Practical use of hollow concrete blocks

1. The requirement of block is to reduce the self-weight of the structure in comparison with the normal conventional bricks.
2. In these type of blocks the total weight of construction is less due to the less mortar which uses in laying of blocks.
3. These blocks have reaches to its high compression if its build-up quality like dimension and cross section if it is proper build.
4. The construction uses less mortar; thus the total construction costs are reduced.
5. It provides the thermal transmission between the walls.

6. Hollow concrete blocks build in that criteria to achieve the constructional goals.
7. Hollow concrete blocks are resisting the structure for very long years and years.
10. Hollow concrete blocks are mainly used in the factories and storage of huge quantities like go downs.

Merits of hollow concrete blocks in structure

1. Cheaper: Block masonry are quite cheaper compared to their brick counterpart. They are known to cost Rs. 1,500 lesser than brick masonry for per cubic meter. This is not a difference to be ignored. Reports suggest that the cost of building walls from AAC blocks come out to be 17.65 per cent lesser than the cost of wall made from traditional bricks. With lesser cost of constructing these blocks, they are also easier to make which reduces the cost even more if built at site.

2. Made from concrete: They do not harm or deplete nature for being made. They are made from concrete, which is nothing but a mixture of cement, sand, and aggregate. Whereas red bricks consume top soil in the production and manufacturing which is like robbing nature of its precious protective layer of soil. That is the top reason why the National Green Tribunal is so much against the red bricks.

3. Lighter in weight: Hollow concrete blocks are lighter compared to red clay bricks which offers them more workability, flexibility and durability. Their dry density ratio reduces dead load on structures which makes it more efficient and suitable for construction.

4. Strength: Concrete blocks are known to be better in enduring earthquakes which are happening quite frequently these days, hurricanes and tornadoes. Countries that promote and encourage the usage of blocks lay great emphasis on their durability to withstand such natural hazards. The way of construction also makes them further durableandstronger.

5. Soundproofing: For those residing in industrial areas or areas that are near busy roads, some sort of soundproofing can be a bliss. Block walls have higher density as compared to brick constructions and hence they offer more soundproofing. Their efficient acoustic insulation is a big help if your home is constantly surrounded by noise that could keep you from getting a sound sleep. You can think of the advantage of soundproofing if you ever resided close to railways or airport.

6. Space saving: Builders and contractors are mostly recommending concrete blocks because they save quite some space at large. The width is less and durability doesn’t decrease which adds to space required in building walls. The usual 9 inch walls of the traditional bricks are getting replaced for good, especially since there is a lot of fight for space in big cities.

2. OBJECTIVE

The objective of this research is focused on various techniques used to study the seismic behavior of R.C buildings with seismic zone V of India using Hollow concrete blocks. The whole design was carried out in ETABs which covers all aspects of structural engineering. More specifically, the salient objectives of this research are:

- To perform a comparative study of the various seismic parameters.

- Comparison among building with (made from normal conventional bricks and made from hollow concrete blocks) on the basis of story displacement, story drift, story shear and story stiffness.
- To propose the best suitable technique for seismic analysis.

In this report, a multi-story residential building is studied for earthquake and wind load using Time history method and ETABs. This analysis is carried out by considering seismic zone V, and for this zone, the behaviour assesses by taking the medium soil. A different response for displacements, storey drift, storey shear and story stiffness is plotted for zone V for medium type of soil., an RC multi-storey residential building is studied for earthquake using Time history method in the ETABs software

3. STRUCTURAL MODLING

For the purpose of this study, a RC framed (G+15) multi-storey building having same floor plan with 5 bays of 3m each along longitudinal direction and along transverse direction as shown in figure 1. Two models with simple RC frame structure comparison among building with (made from normal conventional bricks and made from hollow concrete blocks). The columns are fixed at the ground and are taken as restrains. The bottom storey height is 3.5m and rest are of 3m. All the values of loads and dimensions are given in table No.1.The load cases considered in the seismic analysis are as per IS 1893:2002 (part 1). Figure 1 shows the geometrical configuration of the building. The model was prepared for red clay bricks and hollow concrete blocks. Table1 gives the material properties of the member's structure:

Table 1: Material and section properties

1	Building type	Residential building
2	No of storey	G+15
3	Bottom storey height	3.5m
4	Total height	45.5m
5	Floor height	3m
6	Size of column	300×400
7	Size of beam	230×300
8	Thickness of slab	150mm
9	Masonry wall thickness	250mm
10	Seismic zone	5
11	Importance factor	1
12	Response reduction factor	5
13	Soil type	medium
14	Grade of concrete	M20
15	Grade of steel	Fe250
16	Unit weight of brick	$16KN/m^3$
17	Unit weight of hollow concrete block	$19KN/m^3$
18	Damping	5%
19	IS Code for earthquake	IS1893:2002(part1)
20	Self-weight factor	1
21	IS Code of Concrete	IS 456:2000

Model 1- Building with Red clay bricks

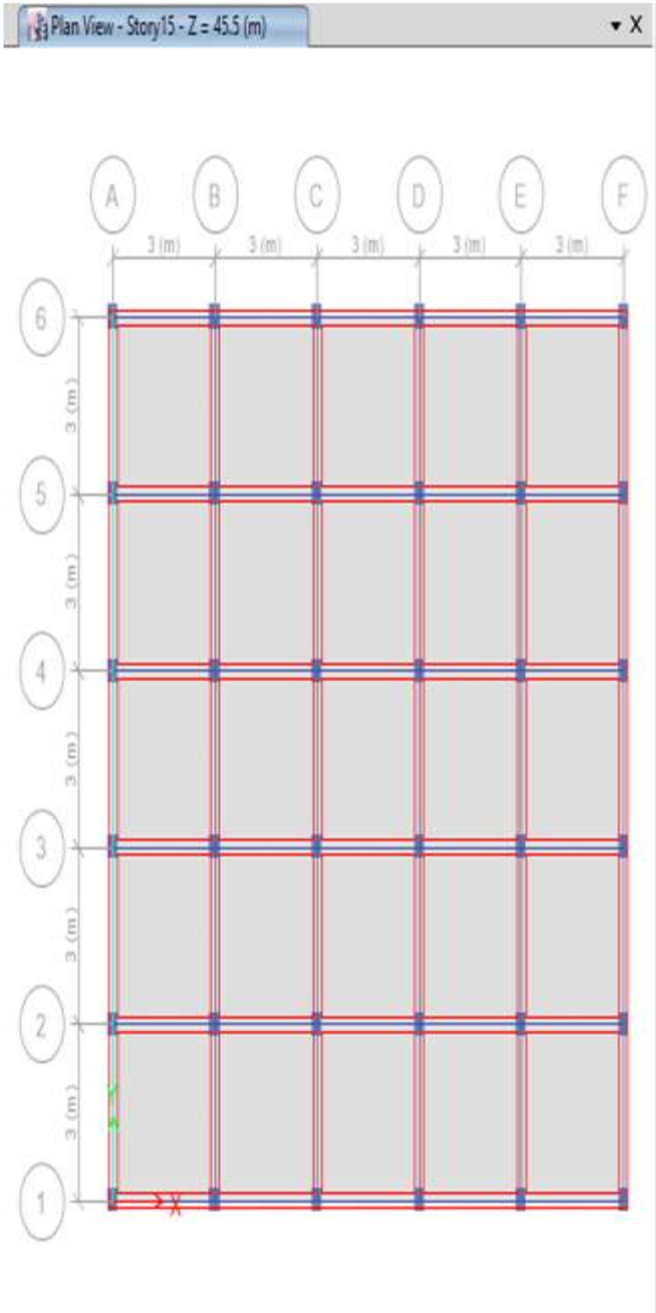


Figure 1- plan of red clay brick structure

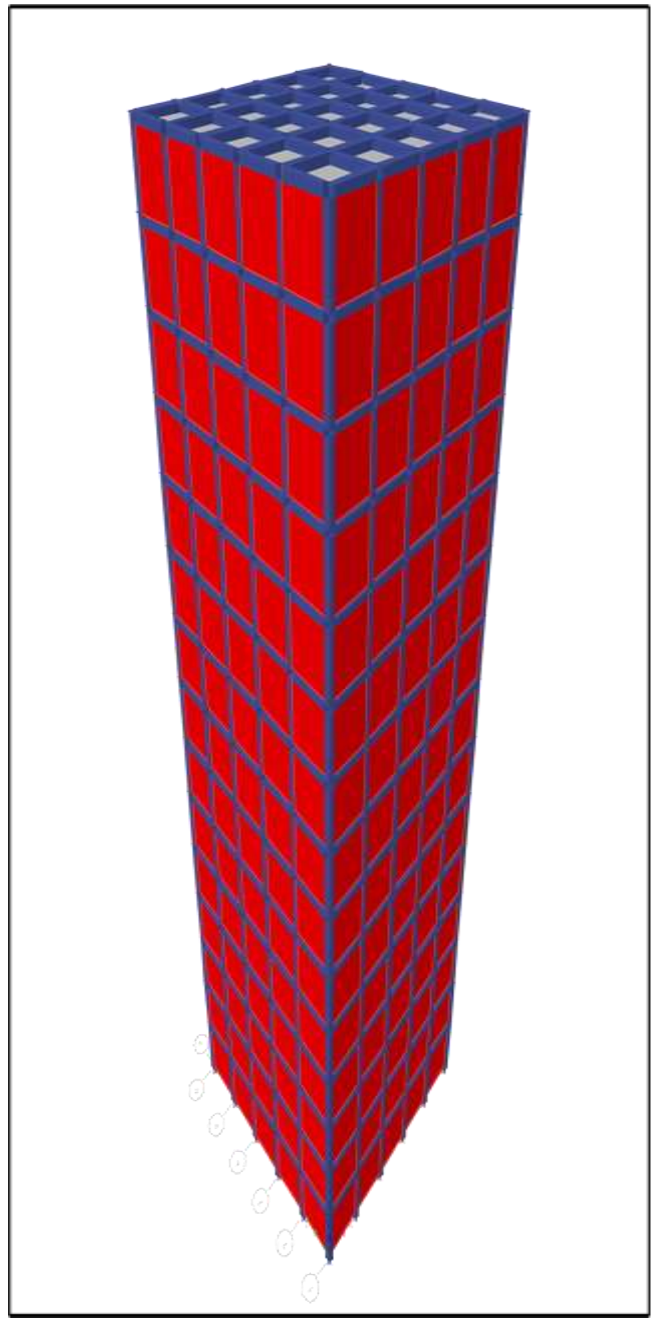


Figure 2- 3D View of Building with red clay bricks infill wall

Model 2- Building with Hollow concrete block

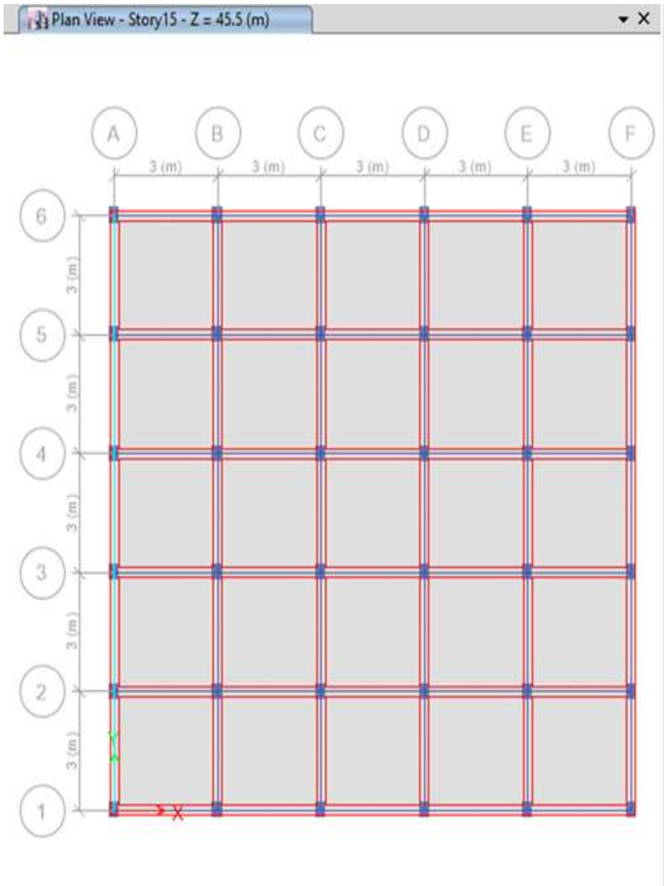


Figure 1- Plan of Hollow concrete block structure

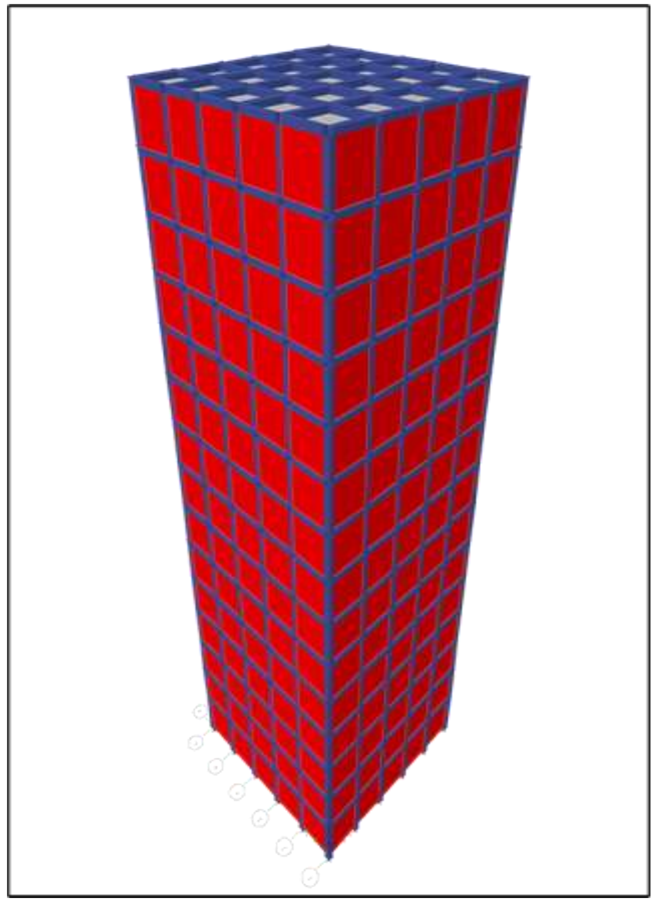


Figure 2- 3D View of Building with hollow concrete block infill wall

3.1 ETABs Overview

ETABs is used for seismic analysis and study the optimum position of shear wall and bracing of a multi-storey building at specific soil condition are compared with specific parameter of evaluation. Complete evaluation including structural modelling is accomplished in this software programme. The evaluation has been accomplished by the use of ETABs software which Involve following steps: -

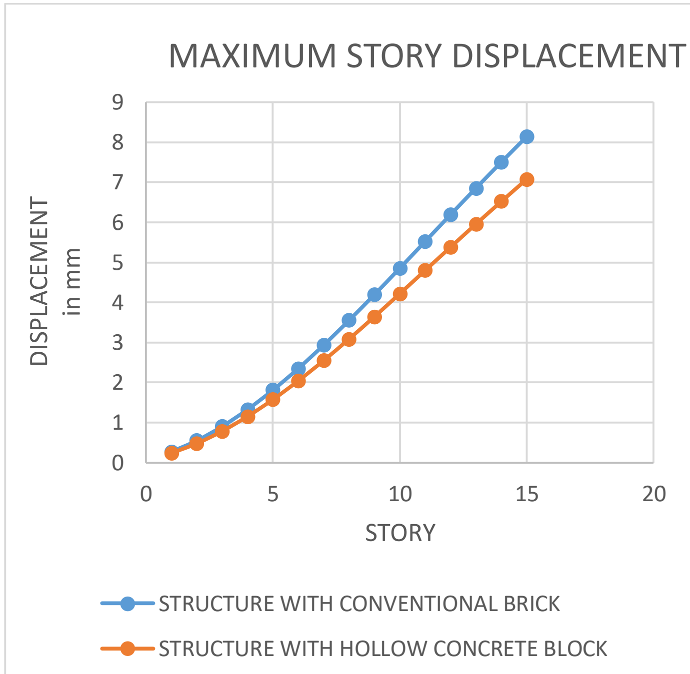
1. Defining dimensions of the plan
2. Defining the members and material properties
3. Assigning loads and load combinations
4. Run and check model to find errors
5. Run analysis
6. Results and discuss

4. RESULTS

4.1 Story Displacement

It is the displacement of every storey with respect to ground level. According to IS 1893 (part1) :2002 the max value of displacement is 1/250 times of storey height with respect to ground. Maximum Storey displacement (mm) comparison in x direction-the table and graph below shows the comparison of effective location of shear wall and in terms of storey displacement in X direction.

No of Storey	M-1	M-2
15	8.139	7.075
14	7.501	6.519
13	6.852	5.955
12	6.19	5.379
11	5.521	4.798
10	4.853	4.217
9	4.193	3.643
8	3.549	3.084
7	2.932	2.547
6	2.349	2.041
5	1.81	1.573
4	1.325	1.152
3	0.902	0.784
2	0.548	0.477
1	0.271	0.237



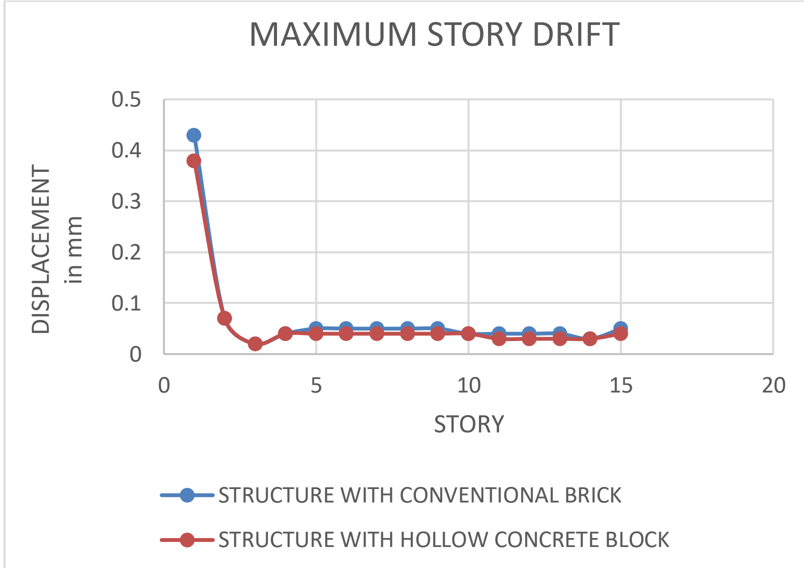
Max. storey displacement (mm) comparison in x direction

4.2 Story drift

According to IS 1893:2002 (part 1), the storey drift of building should not exceed 0.004 times of relative storey height. Maximum Storey drift(mm) comparison in X direction the table and the graph below shows the comparison of red clay bricks and hollow concrete blocks in terms of storey drift in X direction.

No of Storey	M-1	M-2
15	0.05	0.04
14	0.03	0.03
13	0.04	0.03
12	0.04	0.03
11	0.04	0.04
10	0.04	0.04
9	0.05	0.04
8	0.05	0.04

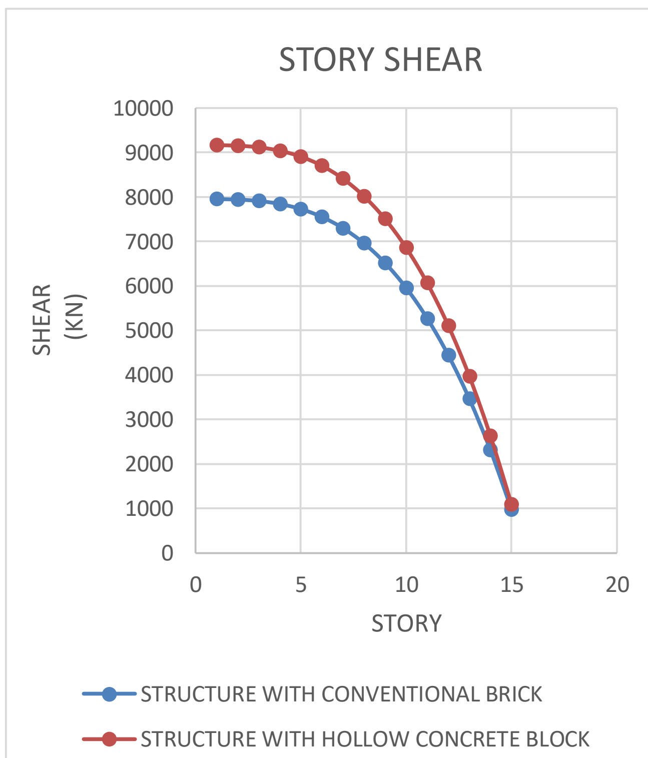
7	0.05	0.04
6	0.05	0.04
5	0.05	0.04
4	0.04	0.04
3	0.02	0.02
2	0.07	0.07
1	0.43	0.38



4.3 Story shear

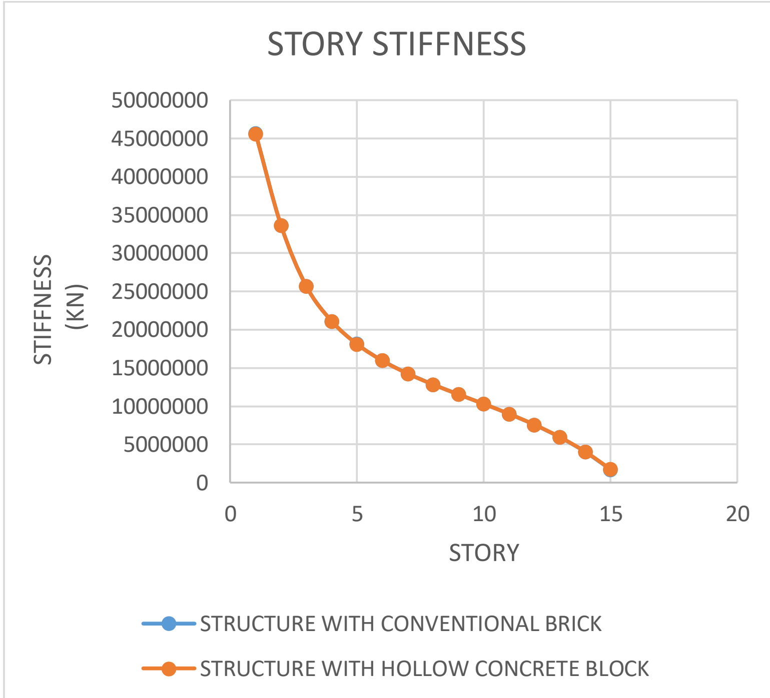
The table and graph below shows different storey shear values for G+15 storey different models.

No of Storey	M-1	M-2
15	976.612	1096.7753
14	2309.056	2637.9619
13	3460.0294	3969.2485
12	4442.8105	5105.9936
11	5270.6778	6063.5558
10	5956.9095	6857.2936
9	6514.784	7502.5655
8	6957.5796	8014.7301
7	7298.5746	8409.1458
6	7551.0474	8701.1714
5	7728.2762	8906.1652
4	7843.5396	9039.4858
3	7910.1157	9116.4918
2	7941.2829	9152.5417
1	7950.8625	9163.6545



4.4 Story stiffness

No of Storey	M-1	M-2
15	1722934.046	1763271.744
14	4035621.599	4060865.397
13	5953205.466	5967025.47
12	7578356.735	7583610.857
11	9000698.713	8999529.442
10	10301022.786	10295017.608
9	11556505.627	11546826.549
8	12848477.932	12835959.974
7	14273891.823	14259113.504
6	15964609.542	15947939.827
5	18124782.88	18106409.196
4	21123832.879	21104016.936
3	25684410.703	25662533.767
2	33653964.714	33630504.8
1	45620420.58	45641311.976



4.5 Discussion of result

Storey displacement was decreased in model with hollow concrete block. The storey displacement decreased in hollow concrete block model about 13.07% as compared with normal conventional bricks.

Storey shear is increased in the model with the hollow concrete block. The storey shear increased in hollow concrete block model about 13.23 % as compared with normal conventional bricks models.

In this report story stiffness behaviour about same as we compared hollow concrete block model and normal conventional brick.

5. CONCLUSION

- The providing hollow concrete block are more efficient in reducing lateral displacement of building as a drift and horizontal deflection influence in hollow concrete block are much less when compared with normal conventional bricks.
- Providing red clay bricks is effective but the hollow concrete blocks are more effective.
- Making of red bricks is not so eco-friendly it seems but the same can be said about the blocks not being up for the purpose of recycle. Red brick-kilns remain under the scrutiny of government and NGT while concrete block industry are on the rise at many places
- Building with hollow concrete blocks is more earthquake resistance than building with red clay bricks.
- Hollow blocks provide high strength and provide less self-weight to the existing structures.

- Displacements and Drifts are reduced in Building with hollow concrete blocks as compared to building with normal conventional bricks.
- For story stiffness in hollow concrete block is slightly more effective as compared with normal conventional bricks
- Being light in weight HCBs provide economy in design of sub-structure due to reduction of the loads.
- Laying of blocks saves mortar as compared with normal conventional brick work. There is saving in mortar plaster work too.
- Cavity of blocks helps achieving insulation of walls and provides energy saving for all times. Hollowness results in sound insulation.
- There is no problem of appearance of salts thereby saving in maintenance of final finishes to the walls.
- Laying of blocks is much quicker as compared to brick work hence, saving in time.
- HCBs are environmentally eco-friendly.
- Factor of safety HCB masonry is more than brick masonry.

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