ANALYSIS OF SEISMIC FORCES ON RCC MULTISTORY BUILDING & TO ECONOMIZE MODERN SKYSCRAPERS

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Abstract:
Different models were developed to investigate the seismic effect on high-rise structures, and then various techniques/alternatives were examined in order to reduce seismic pressures and, ultimately, to reduce the cost of building construction. We evaluated multiple models of the same architecture with alternative structural systems and infill materials to determine the best strategy to economize the building. For this, we created ETABS models of G+10, G+20, and G+30 story buildings with varying seismic configurations. By analyzing the base shear of RC buildings in the ETAB model, we investigated the influence of AAC infill masonry and brick infill masonry on seismic behavior.

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Introduction:
Structural analysis is mainly concerned with finding out the behavior of a structure when subjected to some action. This action can be in the form of load due to weight of things such as people, furniture, wind snow etc. or some other kind of excitation such as earthquake, shaking of the ground due to a blast nearby, etc. In essence all these loads are dynamic including the selfweight of the structure because at some point in time these loads were not there. The distinction is made between the dynamic and static analysis on the basis of whether the applied action has enough acceleration in comparison to the structure's natural frequency. If a load is applied sufficiently slowly, the inertia forces (Newton's second law of motion) can be ignored and the analysis can be simplified as static analysis. Structural dynamics, therefore, is a type of structural analysis which covers the behavior of structures subjected to dynamic (actions having high acceleration) loading. Dynamic loads include people, wind, waves, traffic, earthquake, and blasts. Any structure can be subjected to dynamic loading. Dynamic analysis can be used to find dynamic displacements, time history, and modal analysis.
In the present study, Response spectrum analysis is performed to compare results with Static analysis. The criteria of level adopted by codes for fixing the level of design seismic loading are generally as follows:

- Structures should be able to resist minor earthquakes (<DBE) without damage.
- Structures should be able to resist moderate earthquakes (DBE) without significant structural damage but with some non-structural damage.
- Structures should be able to resist major earthquakes (MCE) without collapse.

''Design Basis Earthquake (DBE)" is defined as the maximum earthquake that reasonable can be expected to experience at the site once during lifetime of the structure. The earthquake corresponding to the ultimate safety requirements are often called as "Maximum Considered Earthquake (MCE) ". generally," The (DBE) is half of (MCE)".
During an earthquake, Ground motion occur in a random fashion both horizontally and vertically, in all directions radiating from the epicenter. The ground accelerations cause structures to vibrate and induce inertial forces on them. Hence structures in such locations need to be suitably designed and detailed to ensure stability, strength and serviceability with acceptable levels of safety under seismic effects.
The magnitude of the forces induced in a structure to a given ground acceleration of earthquake will depend amongst other things on the mass of the structure, the material, and type of construction, the damping, ductility and energy dissipation capacity of structure. By enhancing ductility, and energy dissipation capacity in the structure obtained or alternatively, the probability of collapse reduced.
We constructed numerous models to study the seismic effect on high-rise structures, and then various techniques/alternatives were examined to minimize seismic pressures and, ultimately, save money on building construction by adopting different approaches to regulate the cost.in which we have to use the CSI Etabs software so that we can analysis multiple buildings in less time.

Reinforced Concrete Buildings
Reinforced concrete, Concrete in which steel is inserted in such a way, to the point that the two materials act together in opposing powers. The reinforcing steel— rods, bars, or meshes—ingests the tractable, shear, and occasionally the compressive stresses in a concrete structure. Plain concrete does not actually withstand pliably, and shear stresses caused by wind, tremors, vibrations, and different powers and is consequently inadmissible in most auxiliary applications. In fortified cement, the rigidity of steel and the compressive quality of solid cooperate to enable the part to continue these worries over significant ranges. The creation of fortified cement in the nineteenth century changed the development business, and cement wound up one of the world's most normal building materials. ("Reinforced concrete | building material", 2014)

Methods Of Analysis
Code-based procedure for seismic analysis
Main features of seismic method of analysis based on Indian standard 1893(Part 1): 2002 are described as follows
Equivalent static lateral force method
Response spectrum method
Square roots of sum of squares (SRSS method)
Complete Quadratic combination method (CQC)
Elastic time history methods.
By IS code method for dynamic analysis: -
By ETAB software Method- for static and dynamic analysis both.

Etabs Software:
The creative and progressive ETABS is a definitive integrated programming bundle for the basic examination and plan of structures. Incorporating 40 years of consistent innovative

work, this most recent ETABS offers unmatched 3D object based demonstrating and visualization tools, blazingly quick direct and nonlinear diagnostic power, refined and far-reaching plan capacities for an extensive variety of materials, and keen realistic showcases, reports, and schematic illustrations that enable clients to rapidly and effectively interpret and comprehend examination and analyses results.
The most comprehensive integrated software program for the structural analysis and design of buildings is the unique and groundbreaking new ETABS. The engineering design process is integrated by ETABS from the first stages of idea development through the creation of schematic drawings.
For the following scenarios, the RC Framed structure is designed using ETABS software.
As a result, when RC frames are erected in an earthquake-prone area, AAC block material may essentially take the place of traditional bricks as the infill material. The findings indicate that the least expensive materials and the strongest construction Buildings' deflection and story drift can be minimized by using AAC brick walls.
Software for finite element modeling has been utilized, namely ETABS. For modeling the building's structural parts, shell elements for edge-supported slabs and frame elements for beams and columns are used, respectively. The FE model's foundations were not used in the current project to support the shallow footing. Fixed supports are employed in every direction for simplicity.

Seismic Analysis
One of the most important things during designing a building that resist earthquake is not only to resist the force that's acting on it but rather the ability of the building to be ductile enough to transfer this energy and dissipate it. And this ability is based on the detail of the structure, if it is well detailed then it has a better chance of surviving earthquakes.
There are some strategies that could be used during a seismic resistant building to ensure the safety of the structure during a seismic activity. The floors and roof could act as a diaphragm to transfer the horizontal forces on the slabs and floor to the vertical parts of the building such as beams and walls.one of the advantages of shear wall is that it can transfer the forces from Shake Map of the earthquake, floors to the base of the building or the foundation. Braced frames have almost the same functions as shear wall which is transferring lateral loads to the foundation of the building. Moment resisting frames could be implemented on the building to dissipate the energy that comes from the earthquake waves, the columns and beams could be ductile enough to deform and dissipate the energy by taking advantage of the ductility of the steel that’s inside the columns and beams. Since the solution to dissipate this energy is through the movement and deformation of the structure, this movement will cause some damage if not controlled in a manner way. There are some devices that can be taken advantage of to control this deformation such devices act like shock absorbers that are in cars, it controls and keep the shaking of the building in a reasonable range.

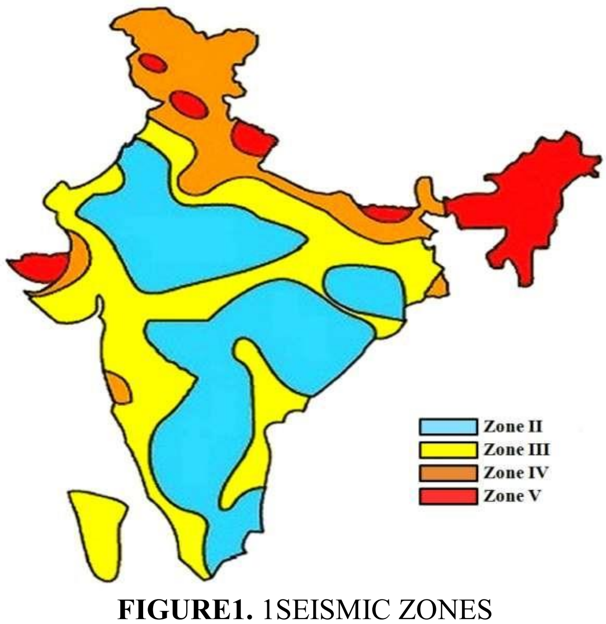


FIGURE1. 1SEISMIC ZONES

Zone categories

TABLE1. 1ZONE CATEGORIES

seismic zone	IIND	IIIrd	IVth	Vth
Z	0.1	0.16	0.24	0.36
Seismic intensity	Low	moderate	severe	very severe

Mohit Sharma and Dr. Savita Maru (2014)
The dynamic study of a multistore G+30 regular building was explored.
These structures have a plan area of 25m x 45m, a story height of 3.6m, and a depth of foundation of 2.4 m, for a total height of 114 m including the depth of foundation. The static and dynamic analyses were performed on a computer using STAAD-Pro software and the design parameters specified in IS-1893-2002-Part-1 for zones II and III, and the post-processing results were reported.

Sayed Mahmoud and Waleed Abdallah Saudi Arabia (2014)
I conducted study on the response analysis of multistory RC structures subjected to comparable static and dynamic loads in accordance with Egyptian code. The goal of this study is to evaluate the seismic performance of an existing shear wall residential structure in Cairo. The seismic analysis employs both the dynamic response spectrum (RS) and the equivalent static force (ESF) approaches. To accomplish the dynamic analysis, the Egyptian Code (EC) design RS curve for seismic design is used. ETABS, universal finite element analysis program for dynamic analysis, was used to analyze the building's reaction to the acting seismic loads. The study's findings reveal considerable disparities in building reactions derived using ESF and RS analysis approaches. It has been discovered that using the static approach in a specific direction leads in answers in the same direction. However, the use of the dynamic RS technique causes reaction in both directions, independent of loading direction.

AnirudhGottala, Kintali Sai Nanda et al (2015)
A comparative study of static and dynamic seismic analysis of a multistory structure was carried out. A (G+9) pattern multi-story framed building is chosen. Linear seismic analysis is performed for the building utilizing STAAD-Pro and the static technique (Seismic Coefficient technique) and dynamic method (Response Spectrum Method) in accordance with IS-1893-2002-Part-1. The static and dynamic analyses are compared, and the findings such as Bending Moment, Nodal Displacements, and Mode Shapes are observed, compared, and reported for Beams, Columns, and the Structure as a Whole during both analyses.

Methodology
Materials
AAC Blocks
In this investigation, 108 AAC eco-blocks of a single lot with dimensions of 600 mm × 200 mm x 100 mm were gathered from a local industry. The samples were transported for testing to the Tribhuvan University Institute of Engineering's Central Material Testing Laboratory. Three blocks underwent compressive strength testing, 63 blocks had shear strength testing, and 42 blocks underwent tensile strength testing.

Joint Materials
The characteristics of the cement, sand, and AAC blocks used in the test were established prior to beginning the assessment of the shear and tensile bond strengths of AAC masonry. In compliance with IS 4031-4 (2005), a Vicat apparatus with a 10mm diameter plunger was used to assess the typical consistency of cement paste. Similar to this, IS 2386-Part I (1963) was used to examine the particle size distribution (grading) of sand. Two types of joint materials, PMM and cement-sand mortar (CSM), were employed in our study to examine the bond strength of AAC construction.
PMM is a composite made by combining cement, aggregates, and polymer. In AAC block masonry, a thin coating of PMM with a thickness of 2-3 mm is often employed (Thamboo & Dhanasekar, 2015). In this investigation, PMM was made by mixing 1 kilogram of dry mortar mix with 300 cc of water.
Two ratios of 1:4 and 1:6 were used to produce cement sand mortar. The thicknesses for each cement-sand mortar mixture were 10, 15, and 20 mm. After that, it was used to evaluate the binding strength on the AAC block surface. According to Raj et al. (2020), cement-water slurry was first applied to the block surface before cement-sand mortar. According to IS:2250 (1981 Reaffirmed 2000, 1981), the compressive strength of cement sand mortar in the ratios of 1:4 and 1:6 and PMM was assessed.

Conventional burnt clay brick
Sand, lime, clay-bearing soil, or concrete components can all be used to make bricks. Bricks are made from a variety of grades, varieties, and

sizes that change with time and place, and are created in large numbers. two fundamental types of There are burnt bricks and unfired bricks. A fired brick is one of the most durable and powerful structures materials, often known as "artificial stone," and are in use as of 210 B.C. [1]. aerated bricks, often referred to as mud bricks, date back more than burned bricks with a further component of a straw serves as a mechanical binder. Standard Size brick according to the Nepal Building Code 240mm*115mm*57mm, with a 10mm thick side mortar.

AAC Block

A rectangular building block made of identical materials is referred to as a "block"; nevertheless, a block is often bigger than a brick. Expanded clay aggregate or concrete is used to make lightweight bricks, which are often referred to as lightweight blocks or AAC blocks. The Swedish architect and inventor Dr. Johan Axel Eriksson developed AAC in the middle of the 20th century while collaborating with Professor Henrik Kreüger at the Royal Institute of Technology.
According to Indian Standards, AAC blocks are 600mm*200mm*100/150/200 mm in size.

Standard Test

A. Density
B. Water Absorption.
C. Direct Compressive Strength

Density Test

The porous solid's density is determined by dividing its mass by its apparent volume, which includes any internal empty spaces, pores, and fissures. Better thermal insulation results from higher volumes of empty spaces or holes due to lower bulk density. A lower apparent density also means lower loads on the structural system, which will result in structural elements with smaller sections and less reinforcing steel being used. It is common knowledge that a building's seismic force during an earthquake is proportional to its mass, hence it would be ideal to develop structures that are as light as possible while yet upholding all safety and comfort requirements.
Density= Weight / Volume

Water Absorption Test

The porosity of bricks and blocks may be measured using a common soaking-in-water test, and this information can be used to predict the possibility of developing issues like salt attack and efflorescence that are connected to the entry of salts and other materials into the units. Initial absorption rates the brick begins to absorb water from the mortar as soon as the bricklayer places it on it. The water, which contains some of the partially dissolved cement and lime, is absorbed by the tiny pores in the brick. The majority of the link between the brick and mortar, which gives the wall its strength, is provided by the Cementous material settling within the brick pores.
%age water absorption= (Wet weight-oven dried weight/Oven dry weight) * 100

Direct Compressive Strength test

When a substance is compressed, it eventually breaks down at a certain strain. When choosing a structural system with loadbearing masonry walls, higher compressive strength results in increased bearing capacity, which leads to smaller wall sections (which utilize less material). The compressive strength of the material is irrelevant if the building's structural system is based on frames (boards, beams, and columns that withstand all external forces) or on concrete structural walls because these elements do not support the building's weight and only need to withstand the load from the finishing to be used.
Compressive Strength= Ultimate Compressive load/Contact area

Analytical Study

A thorough analytical research comparing AAC block masonry and RCC frame construction was completed. For this, several building types, including 1-, 2-, and 3-bedroom homes, a hospital, a market, a school, and an industrial shed, were constructed. The building's double line layout was created with conventional 9" thick walls in mind. The identical building layout using AAC blocks and a 6" wall thickness was employed for the comparison research. AutoCAD 2021 software was used to create the developed plan and center line plan for the buildings' respective 9-inch and 6inch walls. The carpet area was computed using a created plan with 9-inch-thick walls and 6-inchthick walls. ETAB was used to analyze a building's structural integrity using the center line plan of a 9-inch- and 6-inch-thick wall structure. The structural examination of both buildings followed the same process. All columns were provided fixed support, and then member properties were supplied to the beams and columns, followed by loading according to Indian standard code.

Geometry of Building

Understanding the location where the construction is being built is crucial. The model represents a multistory RCC structure with infill walls. Seismic zone-IV of IS 1893 is used as the research region in the current investigation, with soil Type I, II, III. An RC framed structure with the following features is chosen for the initial investigation and technique validation.

Working stress method

Designing reinforced concrete use, the working stress approach. In this approach, brick and aac blocks are compared to elastic materials, and the linear connection between loads and stress is assumed to exist between steel and concrete. This approach is a dated one for concrete design work.

Limit state method

From the design loads, stresses are calculated, and they are compared to the design strength. This approach adheres to the linear strain relation; however, it has no relationship to the linear stress relation. The maximum stresses that the material can withstand have been utilized as the allowed stresses. Partial safety factors are used in limit state approaches. This is a brand-new, design approach for architectural projects.

Result and Discussion

General

In the case of a structure with floors idealized as Rigid Diaphragms, the masses dispersed over the diaphragm can be expected to collect at the floor's center of mass. The inertial force, like the seismic force, will act via the floor's center of mass. We can assume that the center of mass is the master node for that floor in order to have a suitable deflected form. The story's deflection is linked to the deflection of the rigid diaphragm's master node. The Rigid Diaphragm in ETAB refers to a rigid diaphragm capable of stiff motion in the XY plane.

Overturning Moments

Overturning moments are applied moments, shears, and uplift pressures that strive to make the footing unstable and induce it to roll over. Resisting moments are those that attempt to secure the footing and resist toppling. These overturning tests are done for overturning around each footing edge.

Max Story Displacements

The lateral displacement of the tale relative to the base is referred to as story displacement. The lateral force-resisting system can reduce the building's excessive lateral displacement. For wind load cases, the acceptability lateral displacement limit might be H/500 (others may choose H/400).

Story Drift

The maximum permissible drift for light-frame structures is 2.5% of the story height. This restriction is imposed not just for serviceability reasons, but also as an inherent impact of existing seismic design restrictions that must be reviewed to assure life safety.

Following are some comparisons of story stiffness, Base shear, Overturning moment, and Lateral displacement for various instances.

<u>Story Shear</u>

Story: G+10. R=5

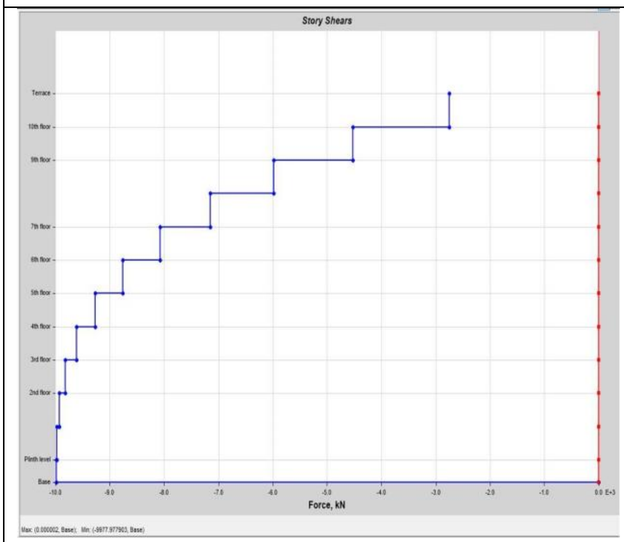
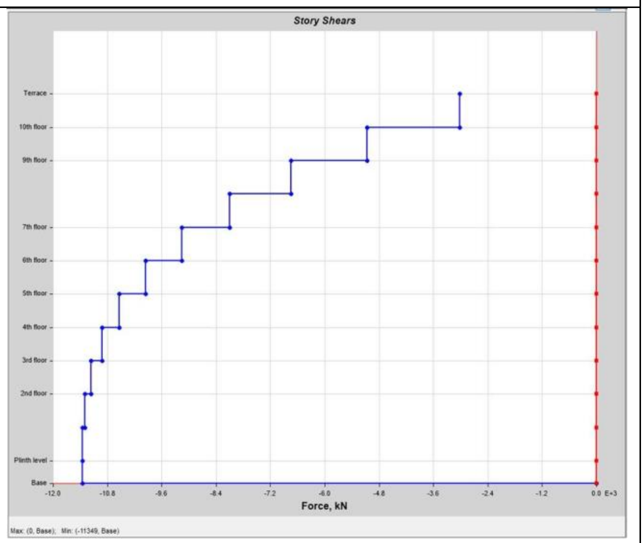
AAC BLOCK	BRICK
	

FIGURE6. 1 STORY SHEAR IN X DIRECTION

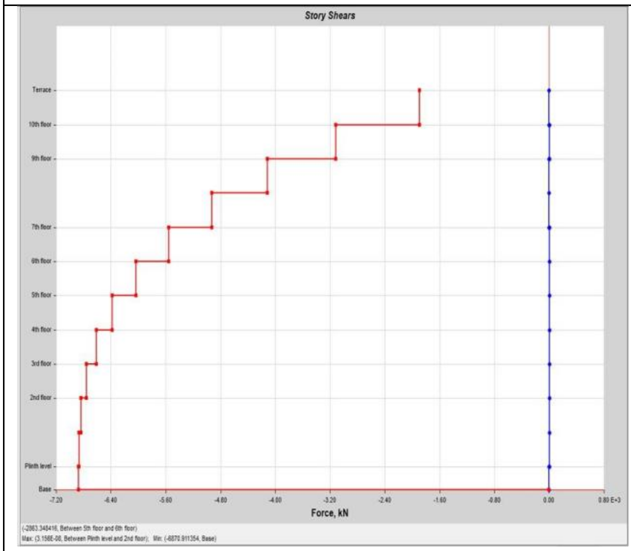
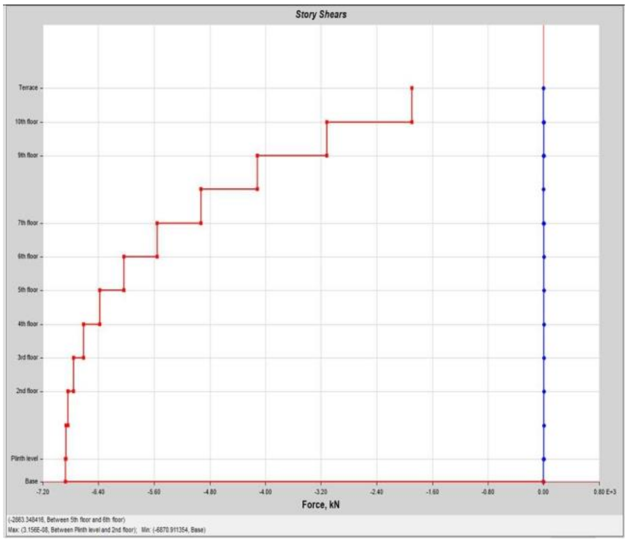
AAC BLOCK	BRICK
	

FIGURE6. 2STORY SHEAR IN Y DIRECTION

<u>Story Shear</u>
Story: G+20. R=5

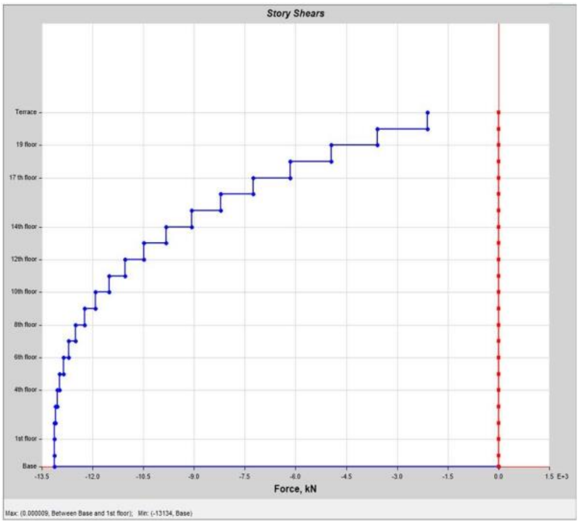
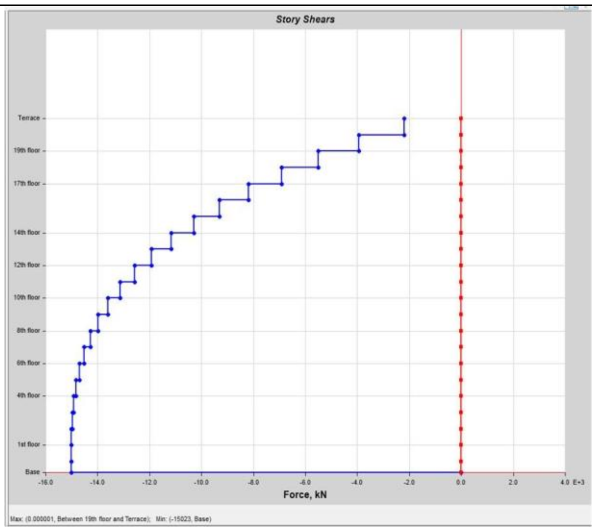
AAC BLOCK	BRICK
	

FIGURE6. 3STORY SHEAR IN X DIRECTION

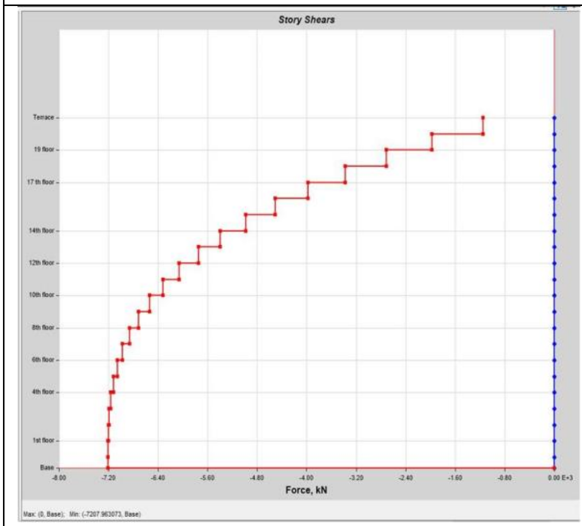
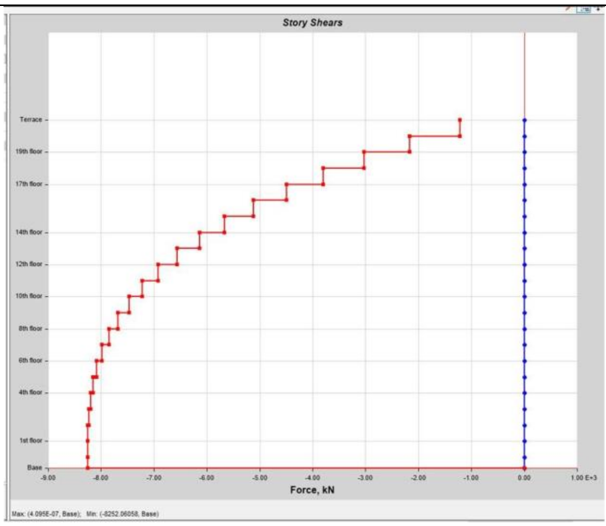
AAC BLOCK	BRICK
	

FIGURE6. 4STORY SHEAR IN Y DIRECTION

<u>Story Shear</u>
Story: G+30. R=5

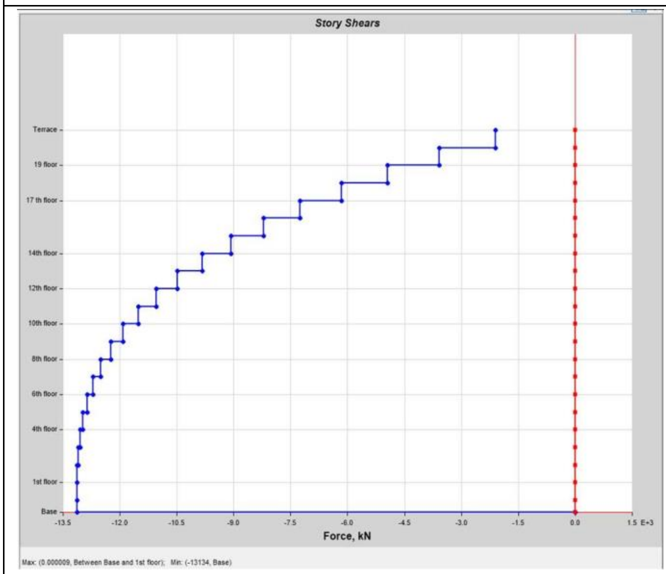
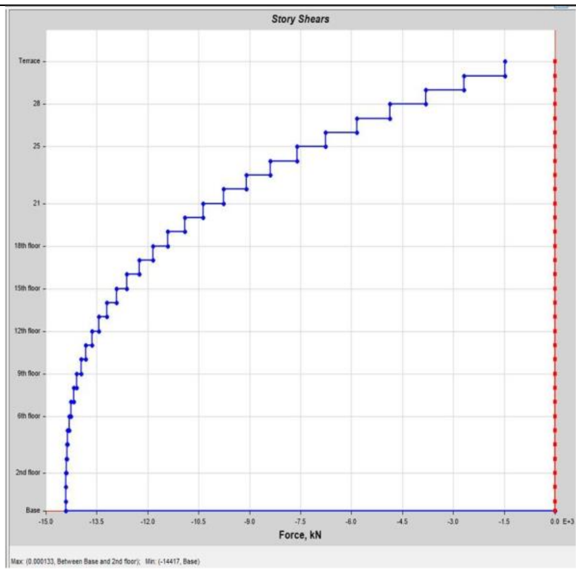
AAC BLOCK	BRICK
	

FIGURE6. 5STORY SHEAR IN X DIRECTION

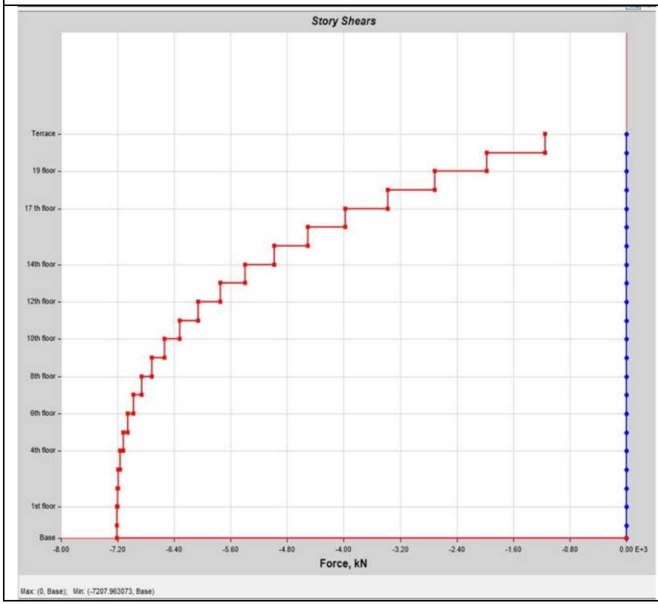
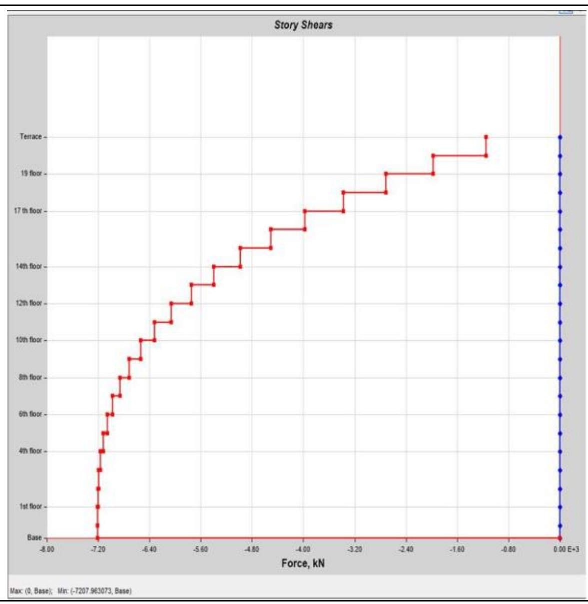
AAC BLOCK	BRICK
	

FIGURE6. 6STORY SHEAR IN Y DIRECTION

STORY STIFFNESS
Story: G+10. R=5

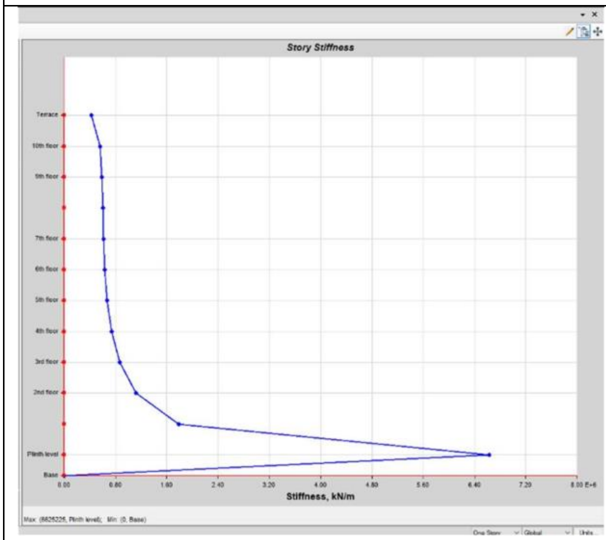
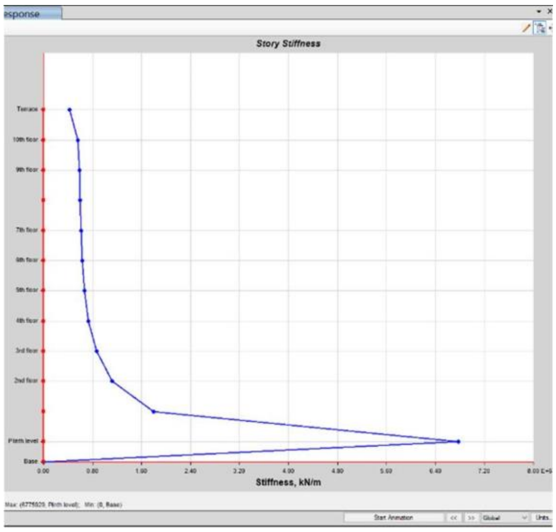
AAC BLOCK	BRICK
	

FIGURE6. 7STORY STIFFNESS IN X DIRECTION

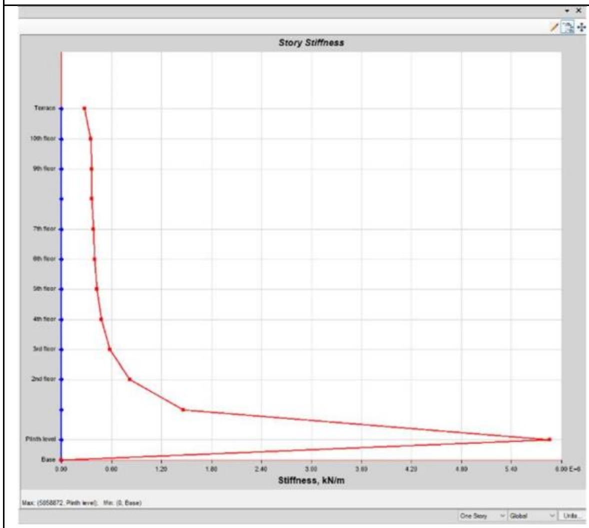
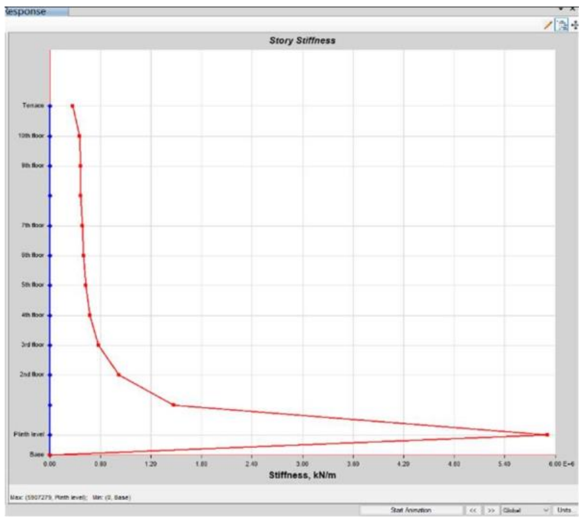
AAC BLOCK	BRICK
	

FIGURE6. 8STORY STIFFNESS IN Y DIRECTION

<u>Story Stiffness</u>
Story: G+20. R=5

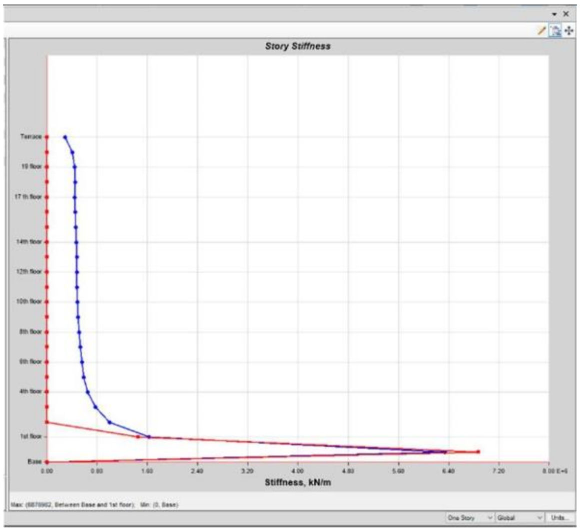
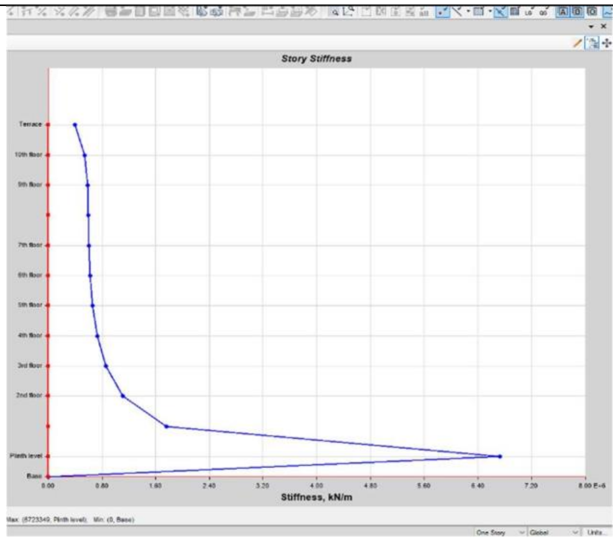
AAC BLOCK	BRICK
	

FIGURE6. 9STORY STIFFNESS IN X DIRECTION

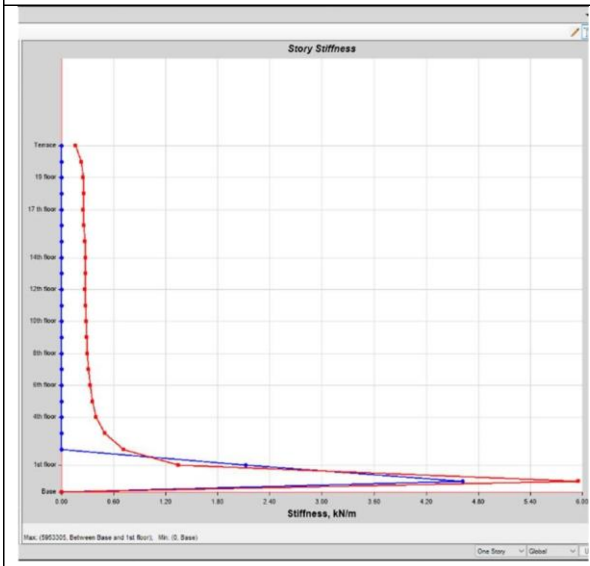
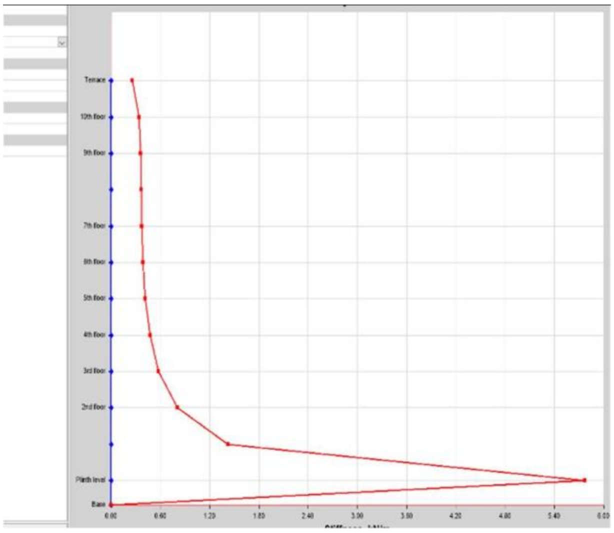
AAC BLOCK	BRICK
	

FIGURE6. 10STORY STIFFNESS IN Y DIRECTION

Story Stiffness
Story: G+30.   R=5

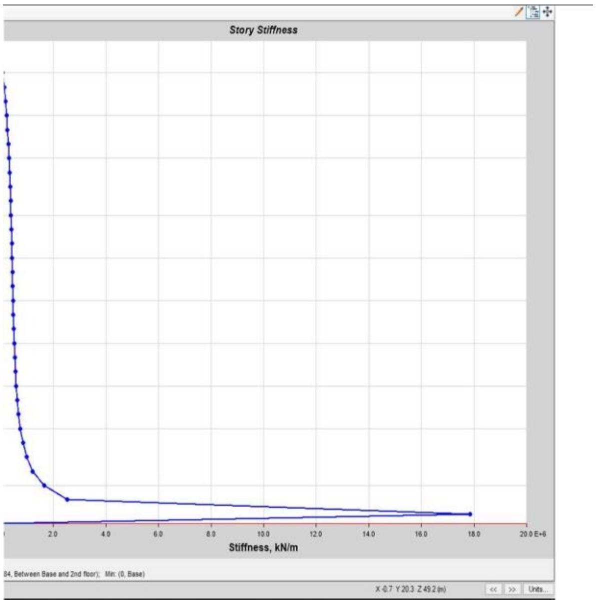
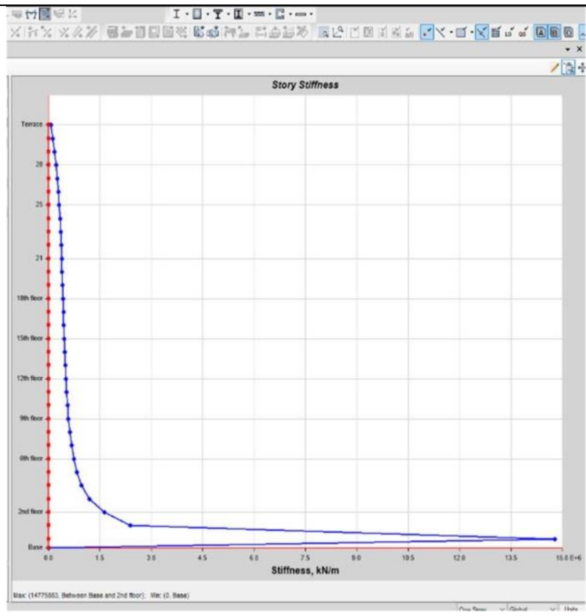
AAC BLOCK	BRICK
	

FIGURE6. 11STORY STIFFNESS IN X DIRECTION

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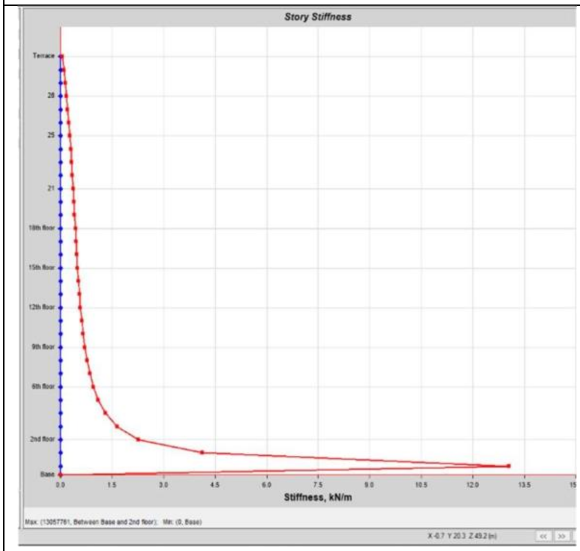
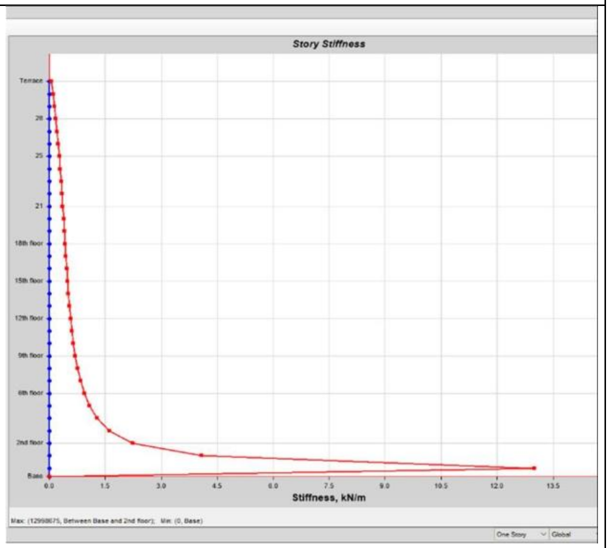
<tr><td>
</td><td>
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FIGURE6. 12STORY STIFFNESS IN Y DIRECTION

<u>Story Drift</u>

Story: G+10. R=5

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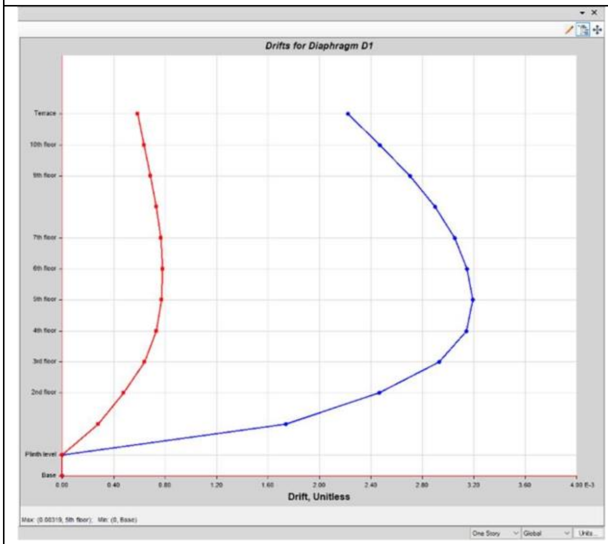
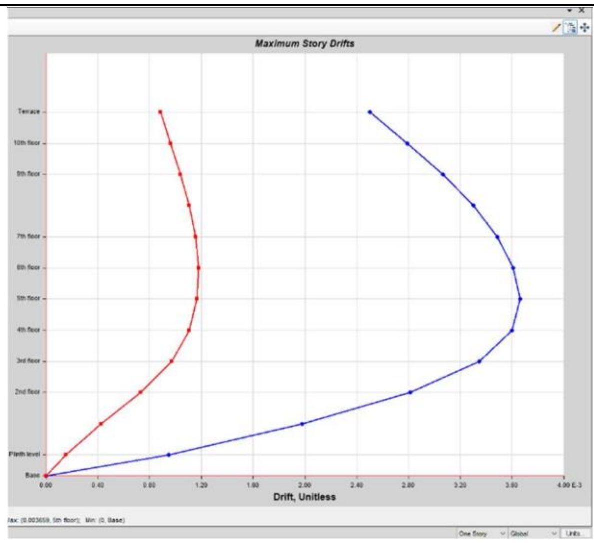
<tr><td>
</td><td>
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FIGURE6. 13STORY DRIFT IN X DIRECTION

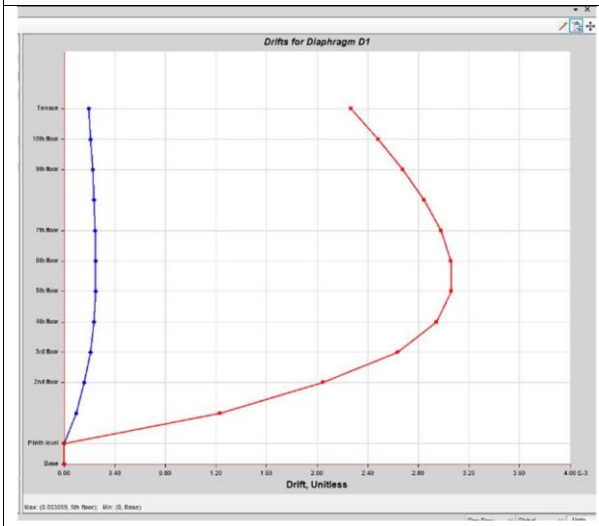
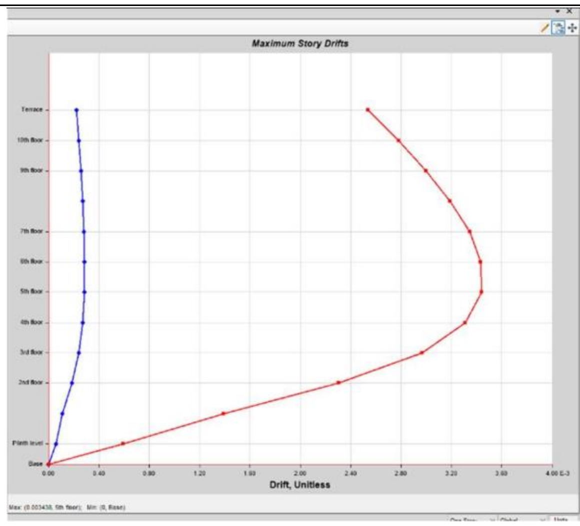
AAC BLOCK	BRICK
	

FIGURE6. 14STORY DRIFT IN Y DIRECTION

<u>Story Drift</u>

Story: G+20. R=5

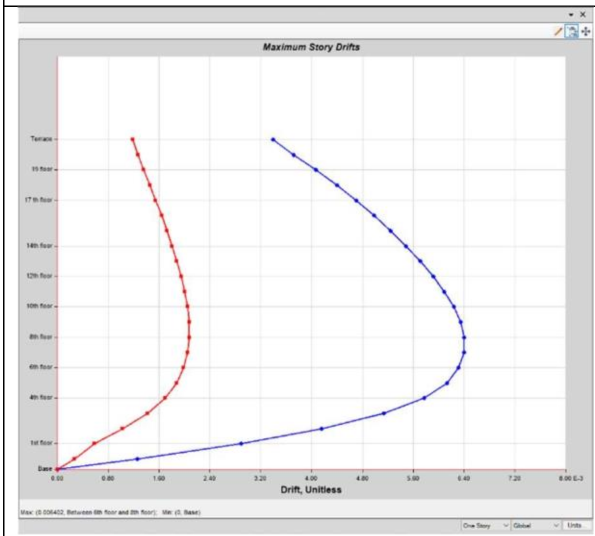
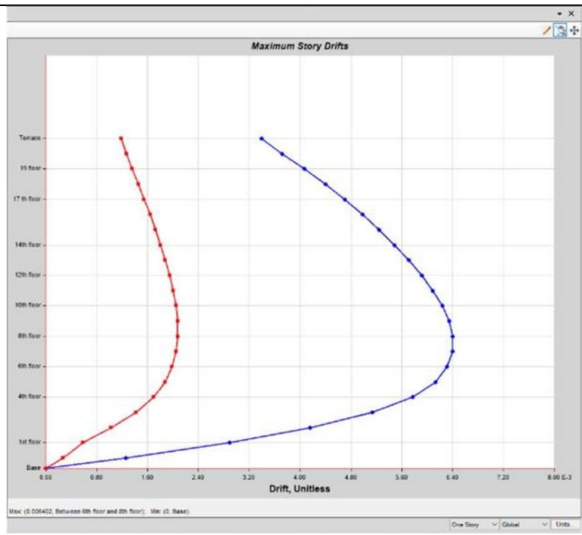
AAC BLOCK	BRICK
	

FIGURE6. 15STORY DRIFT IN X DIRECTION

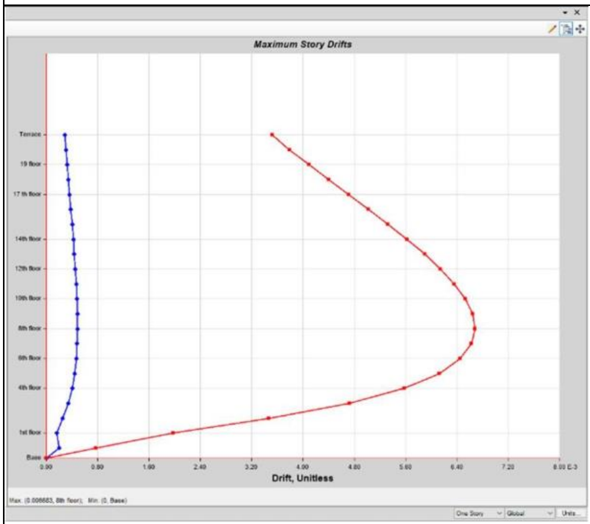
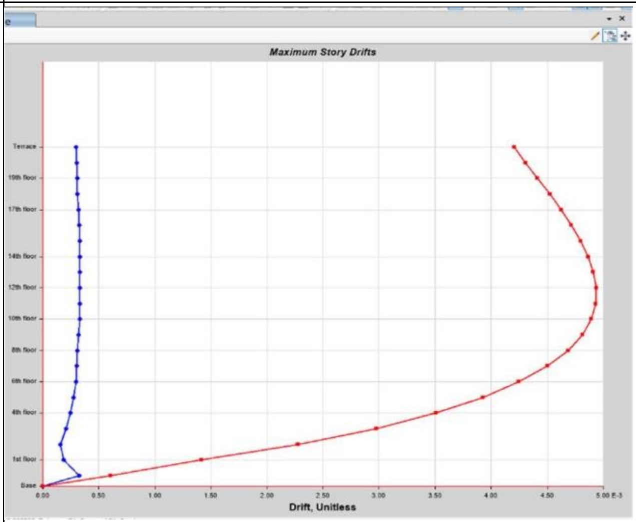
AAC BLOCK	BRICK
	

FIGURE6. 16STORY DRIFT IN Y DIRECTION

<u>Story Drift</u>
Story: G+30. R=5

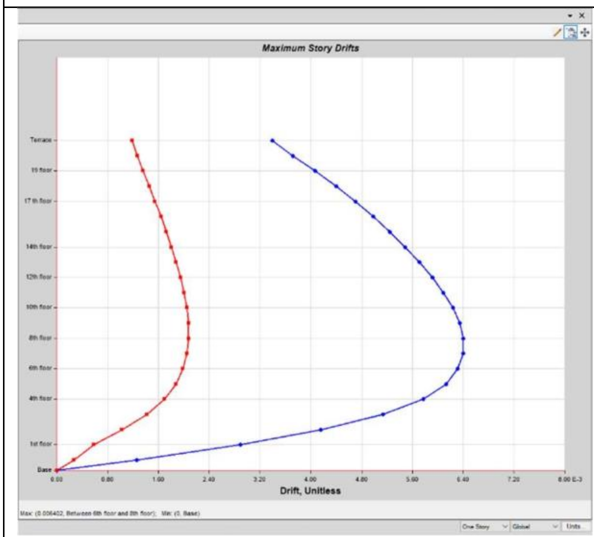
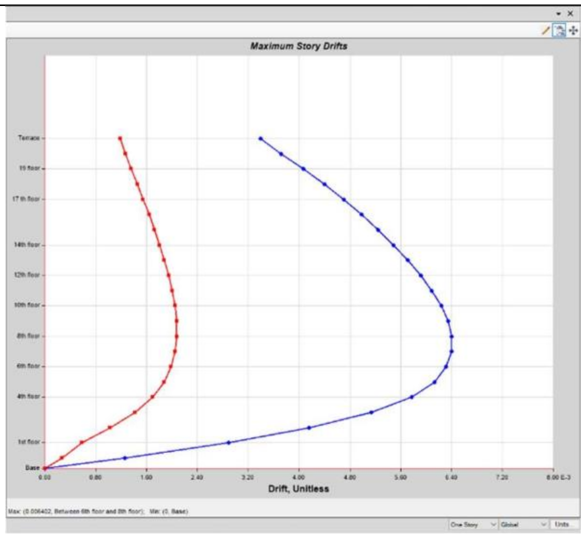
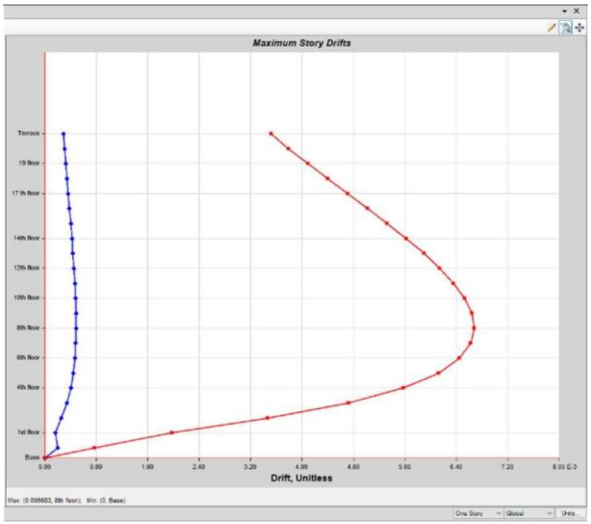
AAC BLOCK	BRICK
	

FIGURE6. 17STORY DRIFT IN X DIRECTION

AAC BLOCK



BRICK

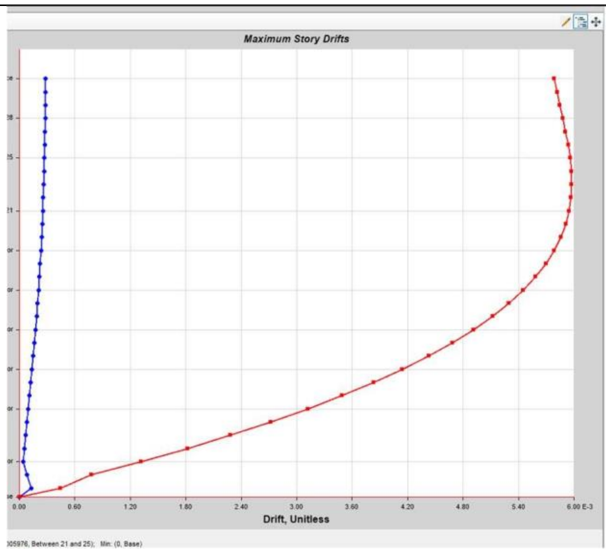
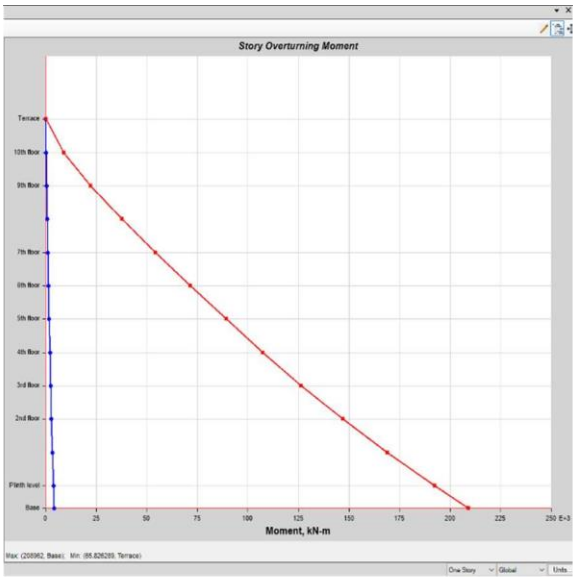


FIGURE6. 18STORY DRIFT IN Y DIRECTION

<u>Overturning Moment</u>

Story: G+10. R=5

AAC BLOCK



BRICK

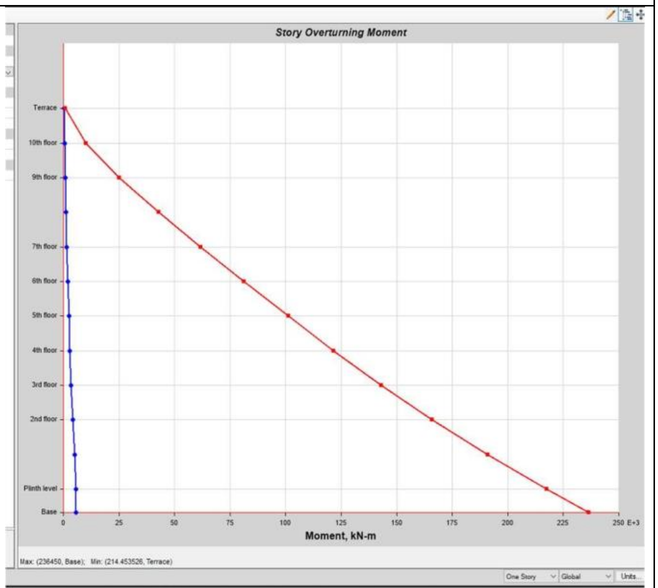


FIGURE6. 19OVERTURNING MOMENT IN X DIRECTION

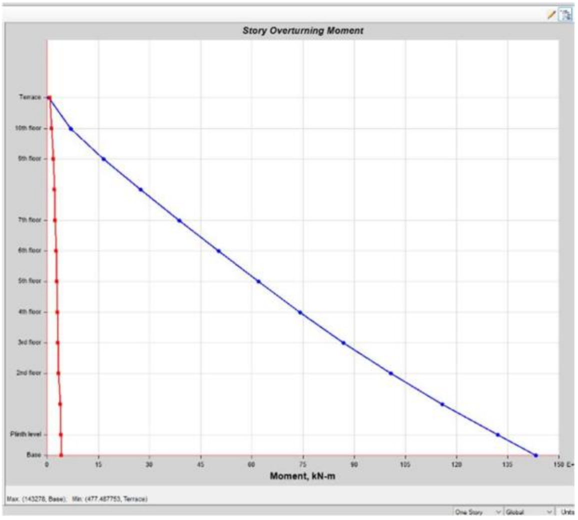
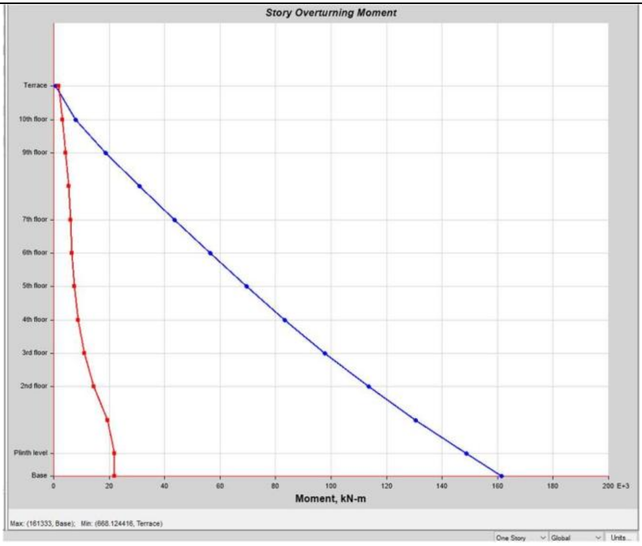
AAC BLOCK	BRICK
	

FIGURE6. 20OVERTURNING MOMENT IN Y DIRECTION

<u>Overturning Moment</u>

Story: G+20. R=5

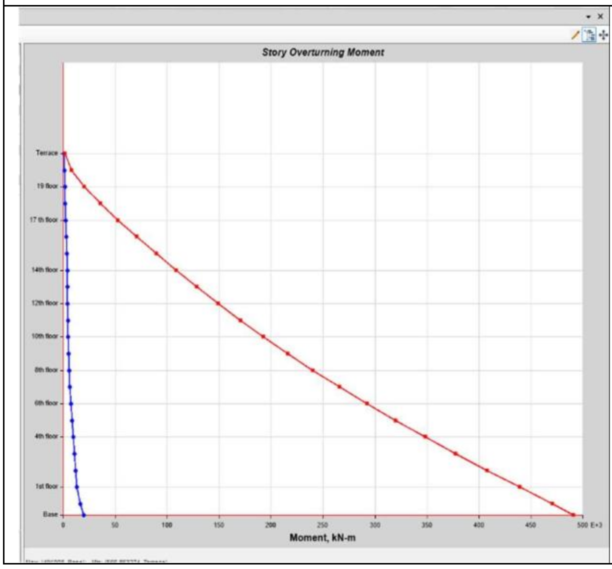
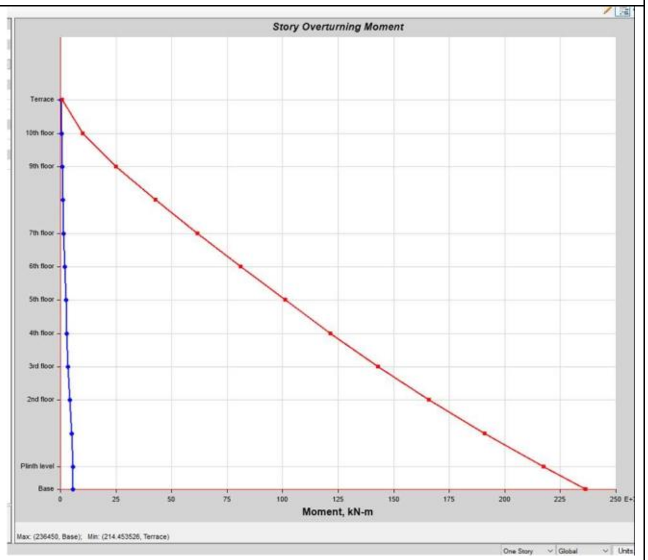
AAC BLOCK	BRICK
	

FIGURE6. 21OVERTURNING MOMENT IN X DIRECTION

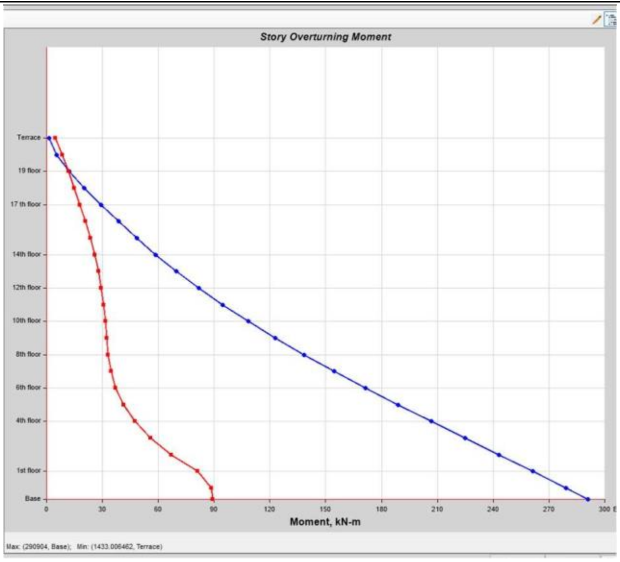
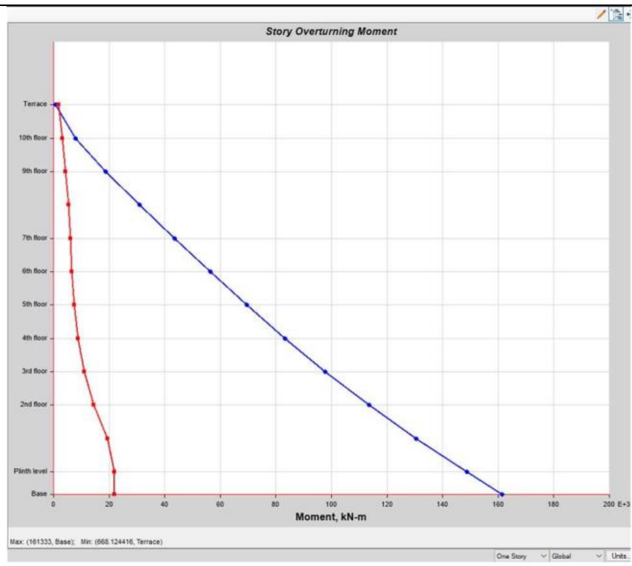
AAC BLOCK	BRICK
	

FIGURE6. 22OVERTURNING MOMENT IN Y DIRECTION

<u>Overturning Moment</u>
Story: G+30. R=5

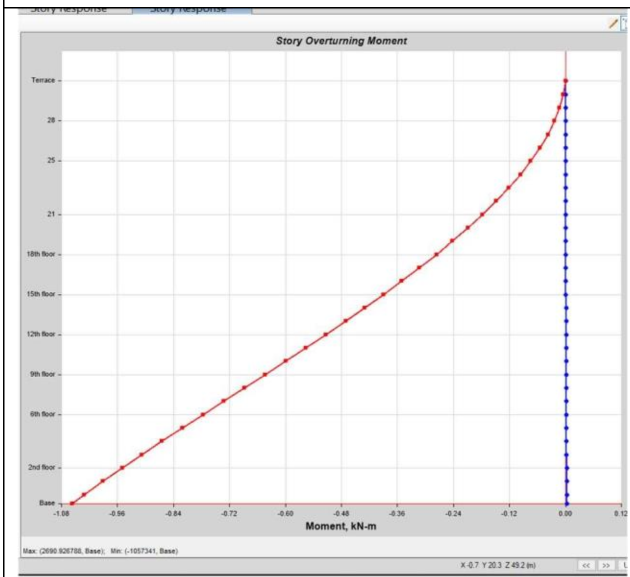
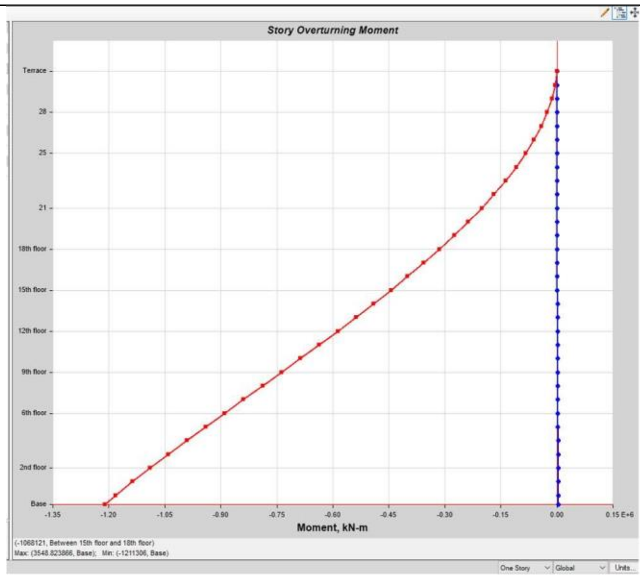
AAC BLOCK	BRICK
	

FIGURE6. 23OVERTURNING MOMENT IN X DIRECTION

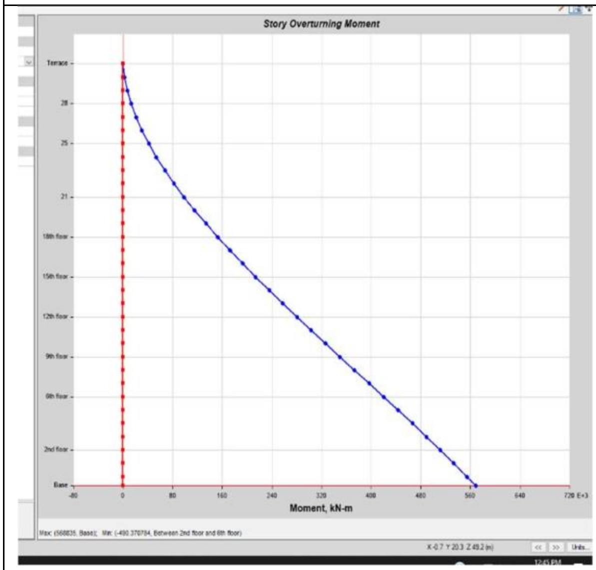
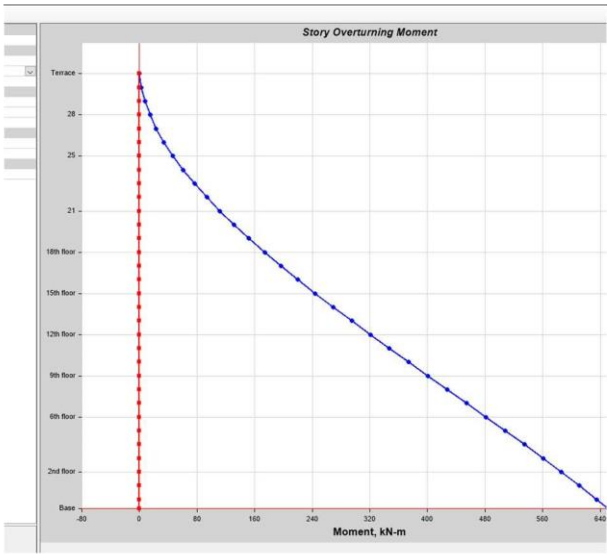
AAC BLOCK	BRICK
	

FIGURE6. 24OVERTURNING MOMENT IN Y DIRECTION

<u>Maximum Story Displacement</u>

Story: G+10. R=5

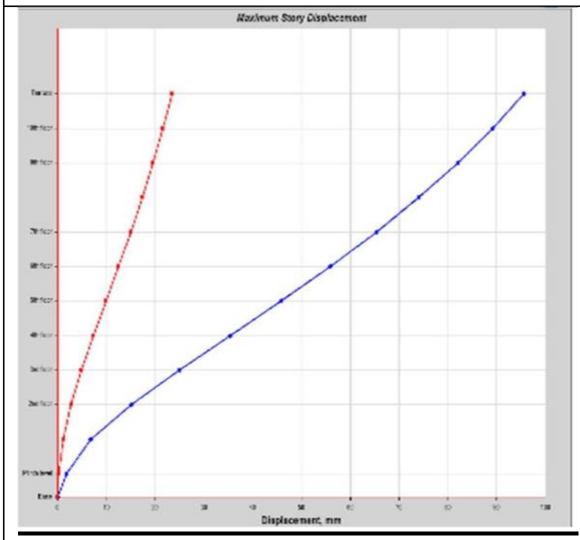
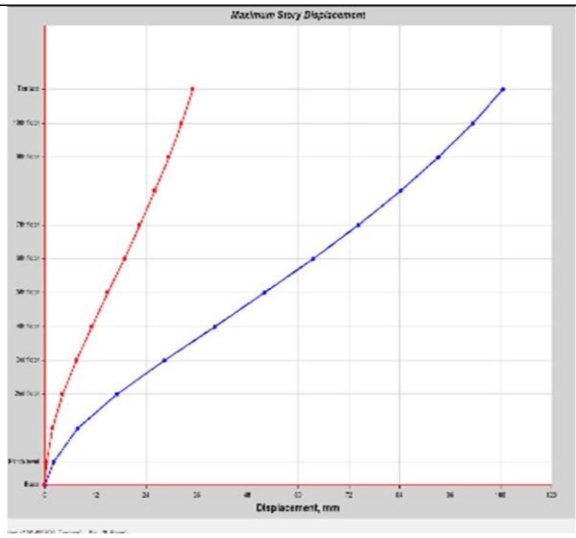
AAC BLOCK	BRICK
	

FIGURE6. 25MAXIMUM STORY DISPLACEMENT IN X DIRECTION

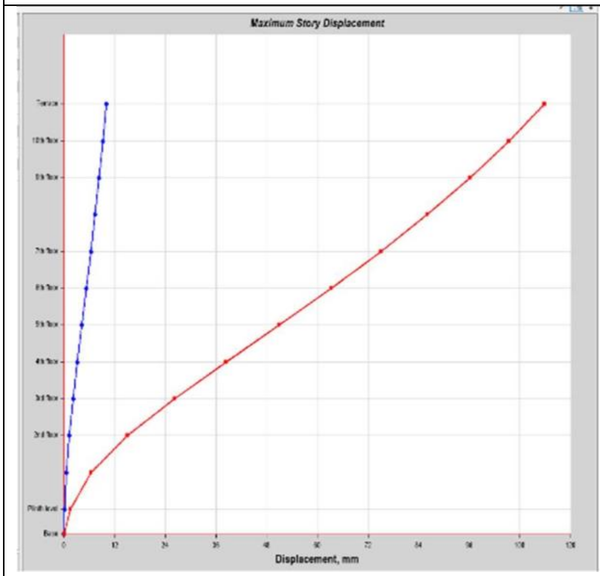
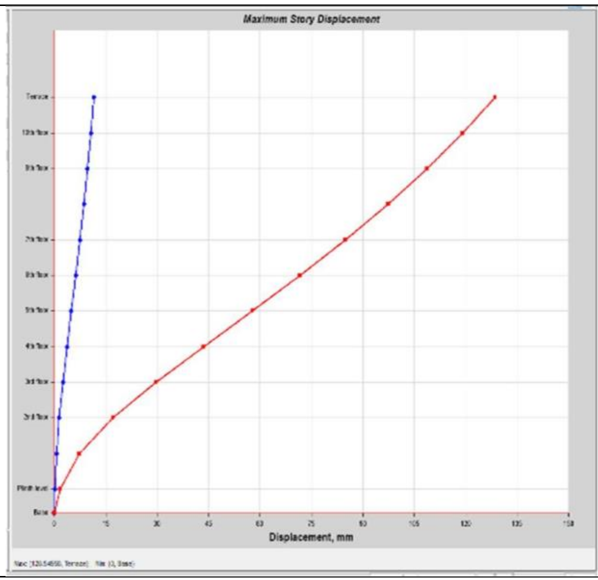
AAC BLOCK	BRICK
	

FIGURE6. 26 MAXIMUM STORY DISPLACEMENT IN Y DIRECTION

Maximum Story Displacement
Story: G+20. R=5

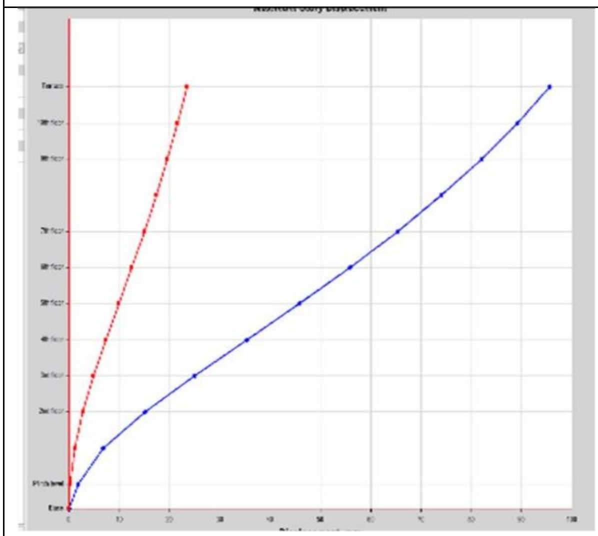
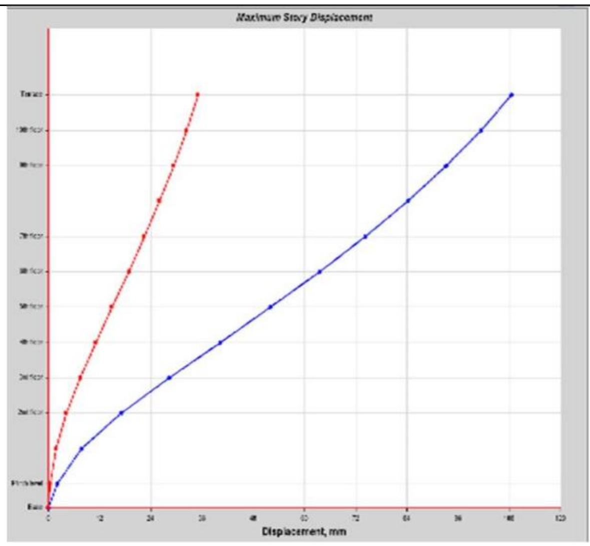
AAC BLOCK	BRICK
	

FIGURE6. 27MAXIMUM STORY DISPLACEMENT IN X DIRECTION

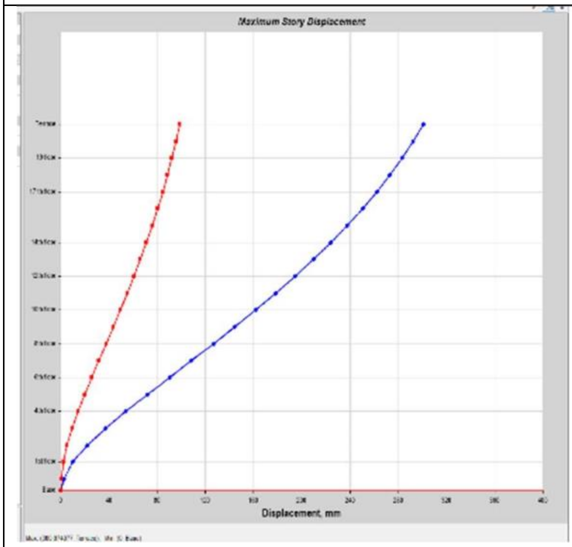
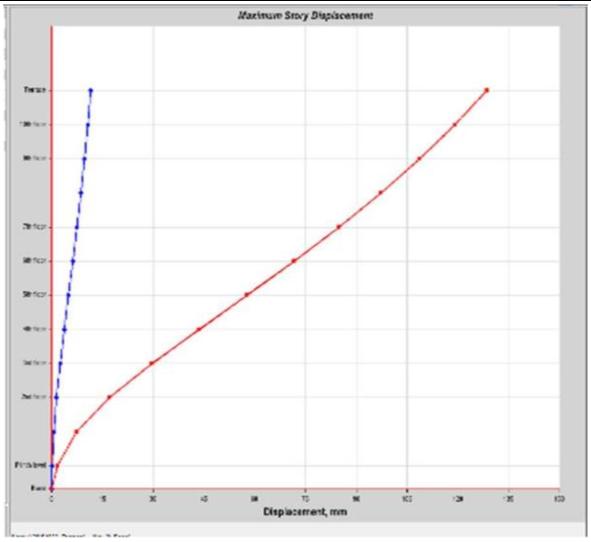
AAC BLOCK	BRICK
	

FIGURE6. 28MAXIMUM STORY DISPLACEMENT IN Y DIRECTION

<u>Maximum Story Displacement</u>

Story: G+30. R=5

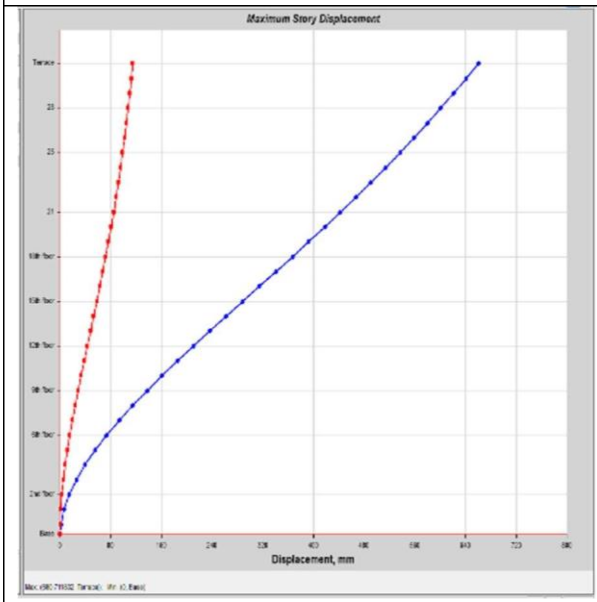
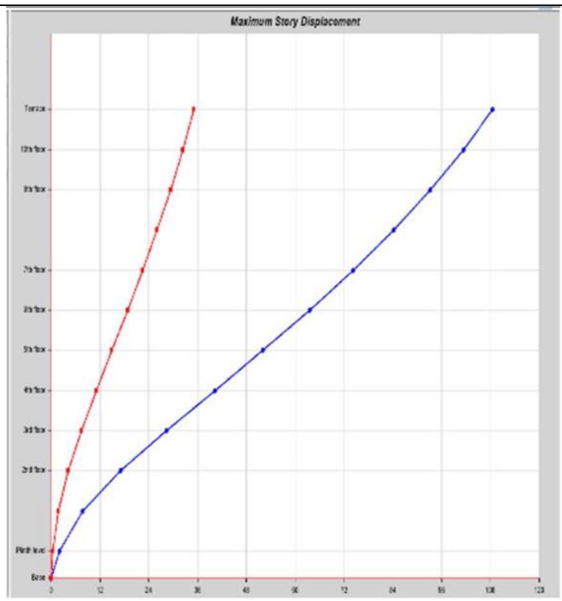
AAC BLOCK	BRICK
	

FIGURE6. 29MAXIMUM STORY DISPLACEMENT IN X DIRECTION

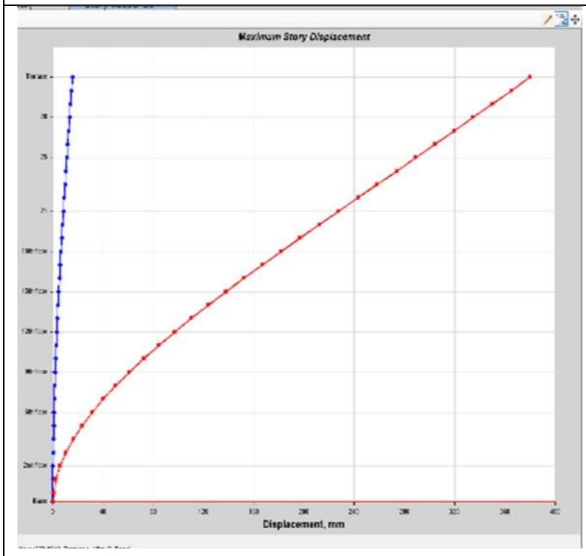
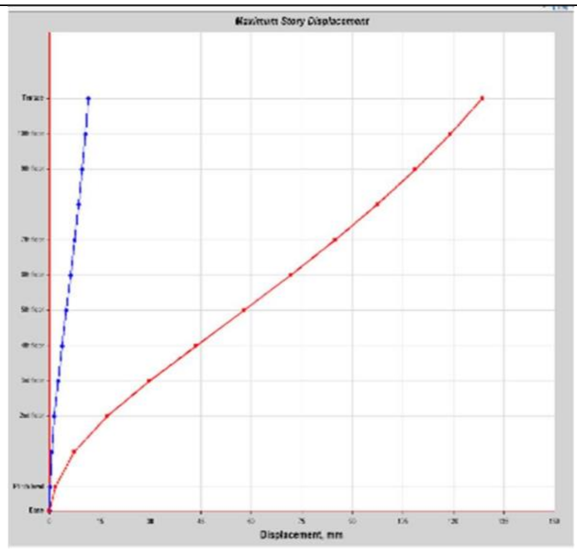
AAC BLOCK	BRICK
	

FIGURE6. 30MAXIMUM STORY DISPLACEMENT IN Y DIRECTION

Comparison of Seismic Forces on Different Infill

Seismic forces are influenced by a building's mass. We conducted various tests in order to compare the forces that are directly acting on buildings as lowering self-weight will also lower seismic force.

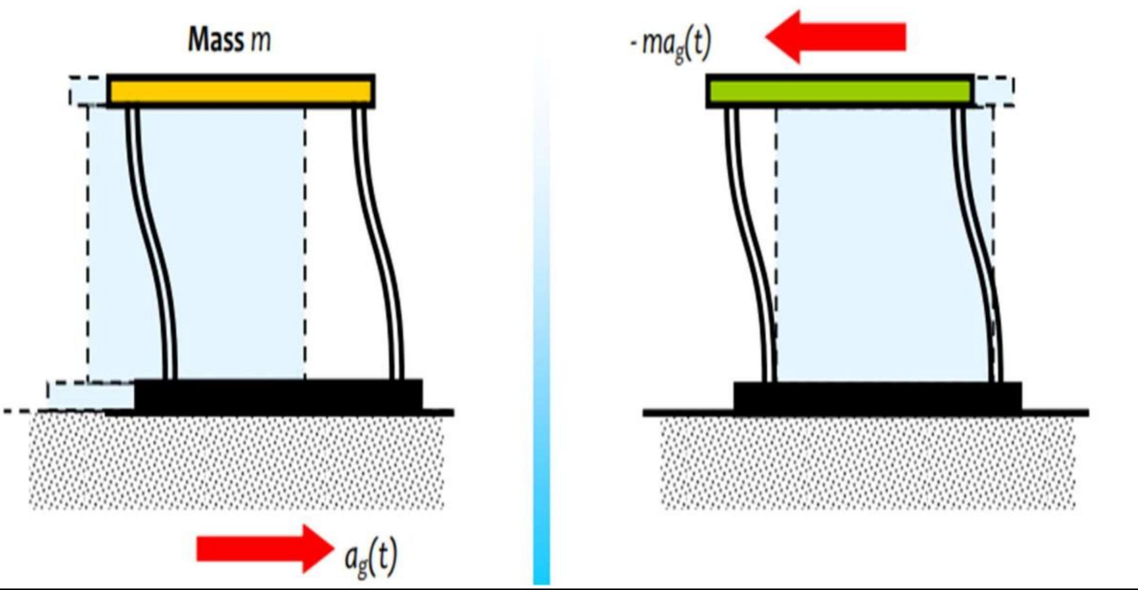


FIGURE6. 31COMPARISON OF SEISMIC FORCES ON DIFFERENT INFILL

The following graphs demonstrate the comparison of forces using various materials on various stories.

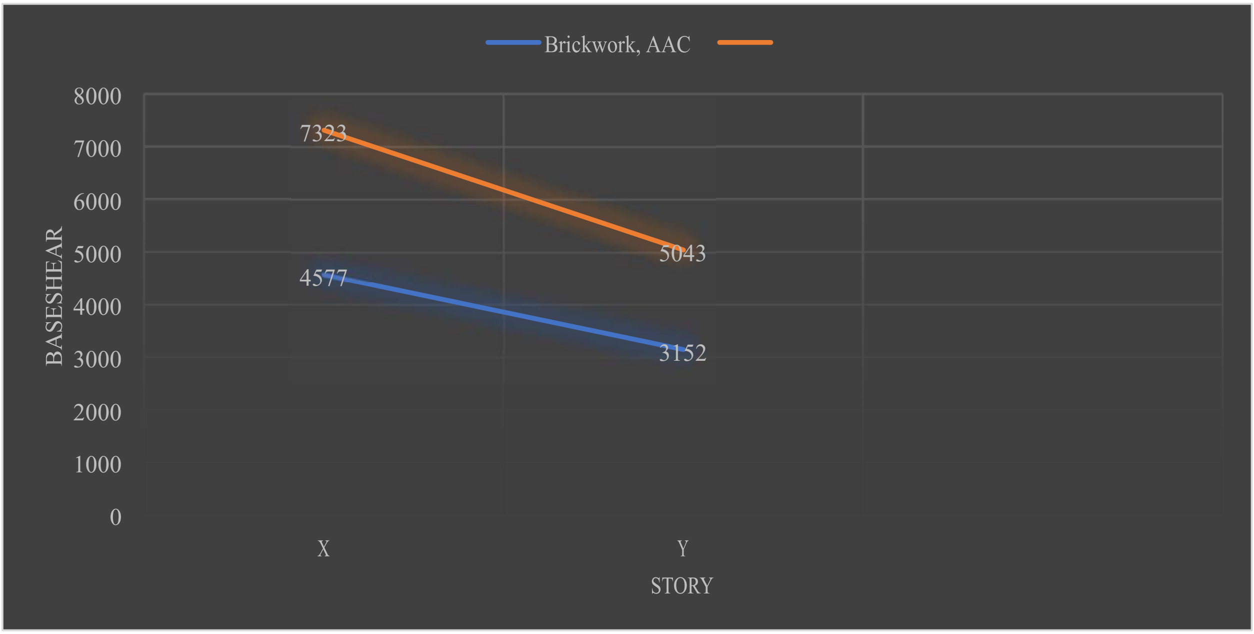


FIGURE6.32SEISMIC FORCES(X DIRECTION)

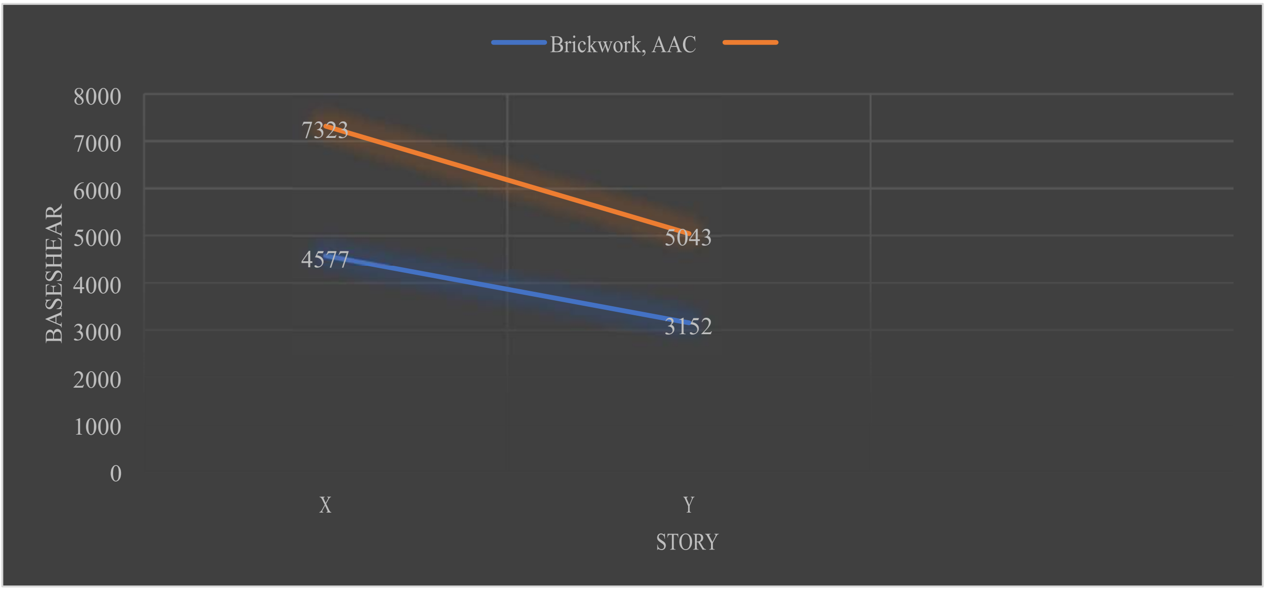


FIGURE6. 33SEISMIC FORCES (Y DIRECTION)

Conclusions

We have reached the following findings after several trials:

- When we studied the G+10 story building, we chose the column beam system since it was shown to be seismically resistant. When we examined the same structure for G+20, we discovered that the column beam system was insufficient to withstand seismic forces, so we added some shear walls. The same is true for G+30; we made the entire structure a shear wall structure. We discovered that the structural system plays a significant role in both combating pressures and making the structure economical by transmitting forces in a healthy manner.
- We compared buildings of the same configuration in different seismic zones and discovered that it mostly depends on the building configuration, as in our case, the building length is much longer in the X direction than in the Y direction, so we compared seismic forces in seismic zones and discovered a 50% to 60% increase in forces. As a result, we discovered that altering zones will raise overall construction costs. By 25% to 35%.

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