



Study on “Seismic performance of asymmetric high rise RC buildings with & without infill walls”

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ABSTRACT

This study evaluates the seismic performance of an asymmetric 20-storey reinforced concrete building with and without infill walls. Three configurations—bare frame, AAC block infill, and burnt clay brick infill—are analyzed using ETABS as per IS 1893 (Part 1): 2016. Key parameters such as displacement, drift, stiffness, and overturning moment are compared. Results show that infill walls significantly improve seismic performance by reducing displacement and drift, with AAC blocks performing better in displacement control and burnt clay bricks providing higher stiffness. However, infill walls increase overturning moments, requiring stronger foundation design.

1. INTRODUCTION

The rapid growth of urbanization has led to an increase in the construction of high-rise buildings, especially in metropolitan cities. These structures are highly susceptible to seismic forces due to their height, mass distribution, and slender geometry. Ensuring the seismic safety of such buildings is therefore a major concern in structural engineering.

Traditionally, infill walls made of materials like brick or concrete blocks are treated as non-structural components and are often neglected in structural analysis. However, several studies have shown that infill walls play a significant role in influencing the seismic behavior of buildings. They contribute to increased lateral stiffness, improved strength, and enhanced energy dissipation capacity, thereby reducing lateral displacement and inter-storey drift during earthquakes.

Ignoring the effect of infill walls may lead to inaccurate predictions of structural behavior, resulting in either unsafe designs or overly conservative solutions. Therefore, it is essential to evaluate their impact on the overall seismic performance of buildings.

In this study, the seismic performance of a 20-storey asymmetric RC building located in Seismic Zone III is analyzed using ETABS software. The building is modeled as a Special Moment Resisting Frame (SMRF) and is evaluated under three different conditions: without infill walls (bare frame), with AAC block infill walls, and with burnt clay brick infill walls. The analysis is carried out as per IS 1893 (Part 1): 2016 using the Equivalent Static Method.

The objective of this study is to compare the behavior of these configurations in terms of key seismic parameters such as displacement, drift, stiffness, and overturning moment, and to provide insights for improving the seismic design of high-rise buildings.

2. METHODOLOGY

The seismic analysis of the 20-storey asymmetric RC building was carried out using **ETABS software** in accordance with IS 1893 (Part 1): 2016. The study involved modelling, loading, and analysis of the structure under different infill conditions.

Initially, the building geometry was created in ETABS based on the given plan dimensions (30 m × 24 m) and storey height of 3 m. Structural elements such as beams, columns, slabs, and shear walls were defined using specified dimensions and material properties (M60 concrete and Fe415 steel). The building was modelled as a Special Moment Resisting Frame (SMRF).

Three separate models were developed for comparison:

- Bare frame model (without infill walls)
- Model with AAC block infill walls
- Model with burnt clay brick infill walls

Infill walls were modelled using equivalent diagonal strut action to represent their stiffness contribution.

Load cases were then defined, including dead load, live load, and seismic load. Seismic loads were assigned as per IS 1893 (Part 1): 2016 using the Equivalent Static Method, considering Zone III parameters such as zone factor ($Z = 0.16$), importance factor ($I = 1.2$), response reduction factor ($R = 5$), soil type (Type I), and damping ratio (5%).

After assigning loads and combinations, the structural analysis was performed. The results obtained from ETABS included storey displacement, storey drift, stiffness, and overturning moment in both X and Y directions.

Finally, the results from all three models were compared to evaluate the effect of different infill materials on the seismic performance of the building.

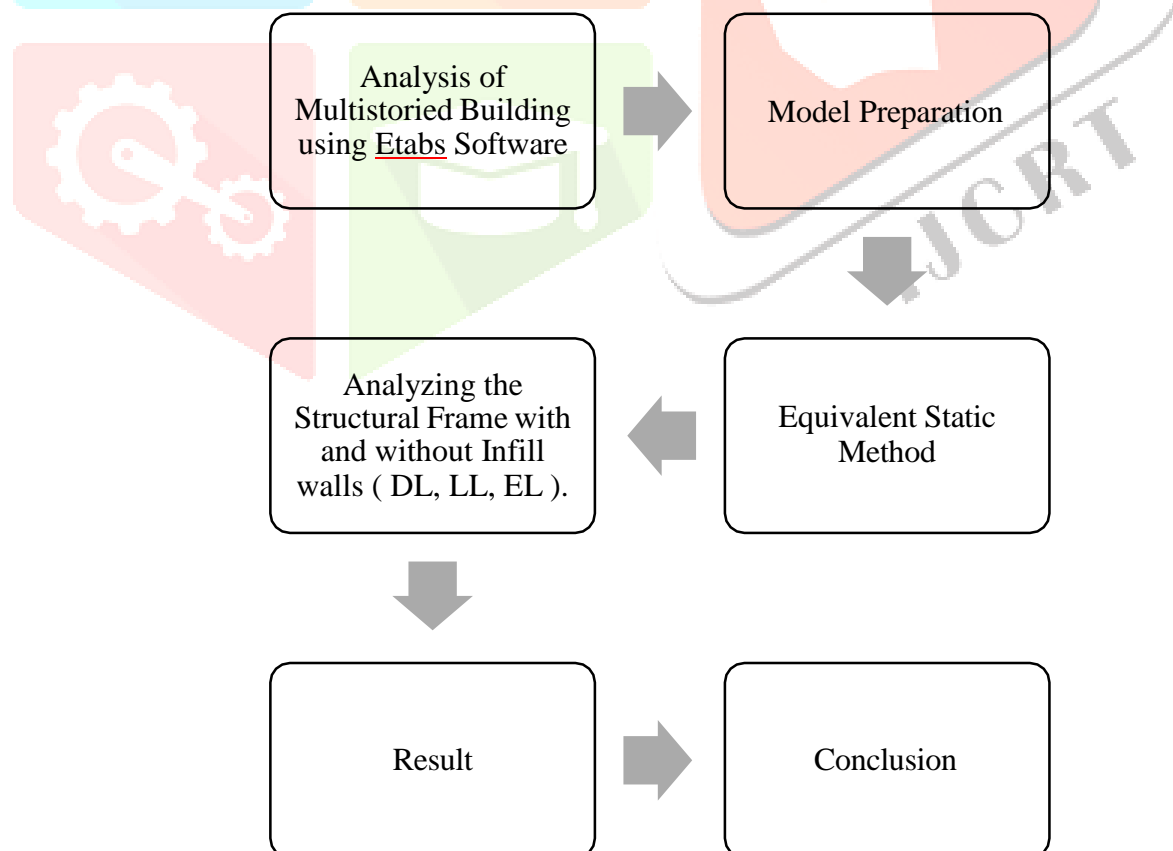


Fig 2.1. Methodology

3. MODELLING DETAILS

Analysis of 20 storey RC structure (30 x 24 m) located in Mumbai Zone (III) with and without infill walls using Etabs. The following are the fundamental data used in analysis, The table beside represents the structure under consideration is a multi-storey rigid jointed plane frame, specifically a Special Reinforced Concrete Moment Resisting Frame (SMRF), located in Mumbai, which falls under Seismic Zone III. The seismic zone factor (Z) for this region is 0.16, with an important factor (I) of 1.2 and a response reduction factor (R) of 5. The damping ratio used is 5%, and the soil type is classified as rock or hard soil (Type-I). The natural period of oscillation (Ta) is 1.616 seconds. The building consists of 20 storey's with a floor-to floor height of 3 meters. The live load considered is 3 KN/m². Structural dimensions include beams of size 350x550 mm, columns of size 300x700 mm, a slab thickness of 150 mm, and a shear wall thickness of 250 mm. The overall plan dimensions are 30 meters in the X-direction and 24 meters in the Y-direction.

Table no.1 Modelling Details

Title	Description
Type of Structure	Multi storey rigid jointed plane frame (special RC moment resisting frame SMRF)
Region	Mumbai (Zone-III)
Seismic zone factor (Z)	0.16
Importance factor (I)	1.2
Response reduction factor (R)	5
Damping ratio	5%
Soil type	Rock or hard soil (Type-I)
Natural period of oscillation (T) (sec)	1.616
Number of storeys	20
Live load (kN/m) ²	3
F-F height (m)	3
Beam size (mm)	350x550
Column size (mm)	300x700
Slab thickness (mm)	150
Shear wall thickness (mm)	250
Length in X-direction (m)	30
Length in Y-direction (m)	24
Bay length (m)	6

The below Table represents material properties, the grade of concrete used is M60 with a compressive strength of 60 N/mm², and the steel used is of grade Fe415 with a yield strength of 415 N/mm². The density of AAC blocks is 9.81 KN/m³, while the density of burnt clay bricks is 20 KN/m³. The density of concrete is 25 KN/m³, and that of steel is 78.5 KN/m³. The Young's Modulus of Steel is 2×10^5 N/mm², and for concrete, it is 38729.63 N/mm².

Table no.2 Input Data for modelling

Description	Value
Grade of Concrete (M60) (N/mm ²)	60
Grade of Steel (Fe415) (N/mm ²)	415
Density of AAC blocks (kN/m ³)	9.81
Density of Burnt clay bricks	20
Density of Concrete (kN/m ³)	25
Density of Steel (kN/m ³)	78.5

Young's Modulus of Steel (N/mm ²)	2 x 10 ⁵
Young's Modulus of Concrete (N/mm ²)	38729.63

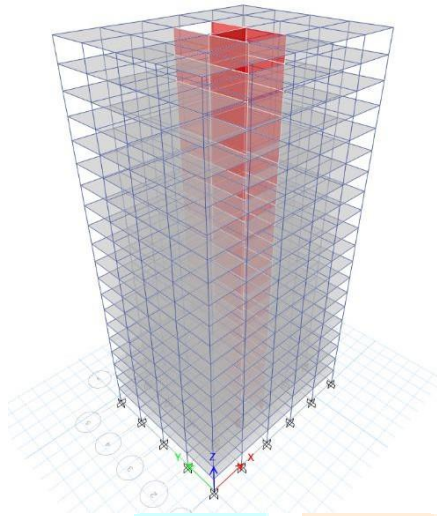


Fig 3.1. Structural Model (3D view)

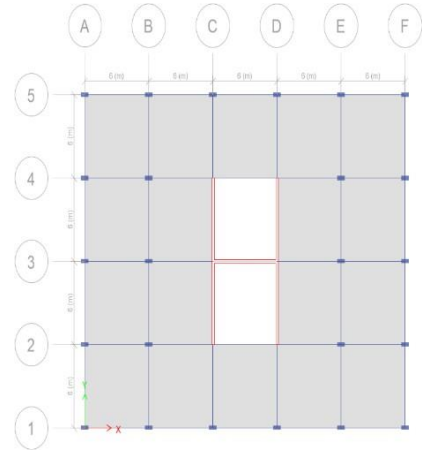


Fig 3.2. Structural Model (Plan)

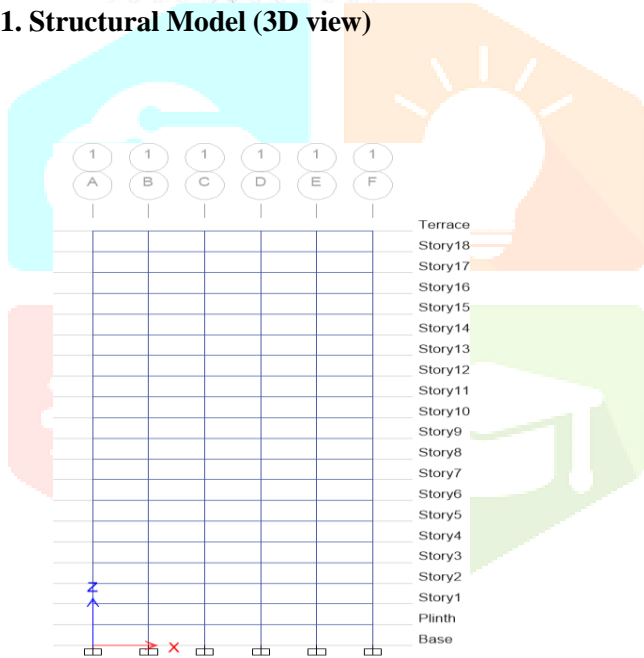


Fig 3.3. Structural Model (Elevation Along X) without Infill Walls

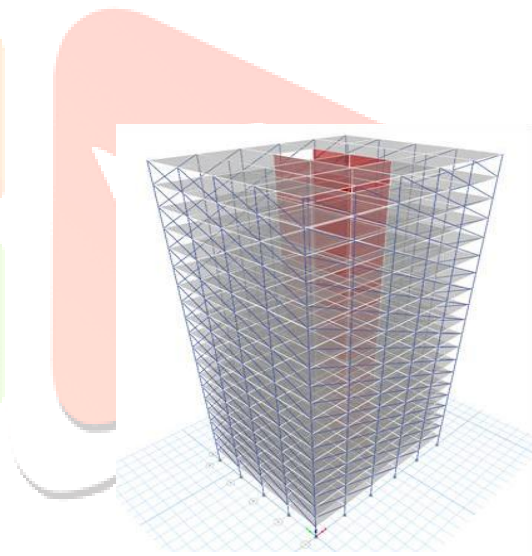


Fig 3.4. Structural Model (3Dview) Infill walls

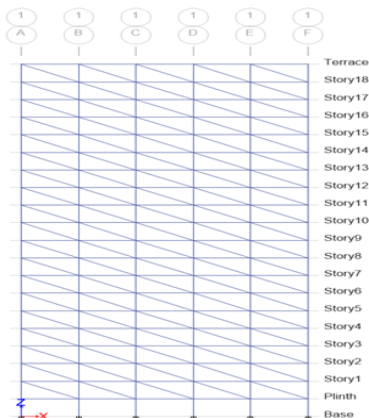


Fig 3.5. Structural Model (Elevation along X) With Infill Walls

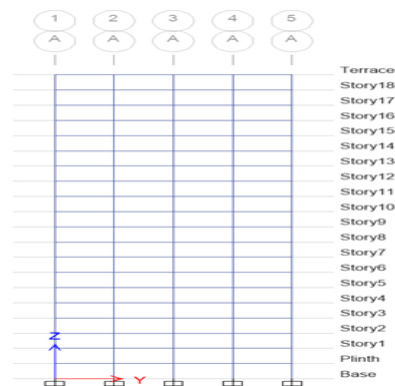
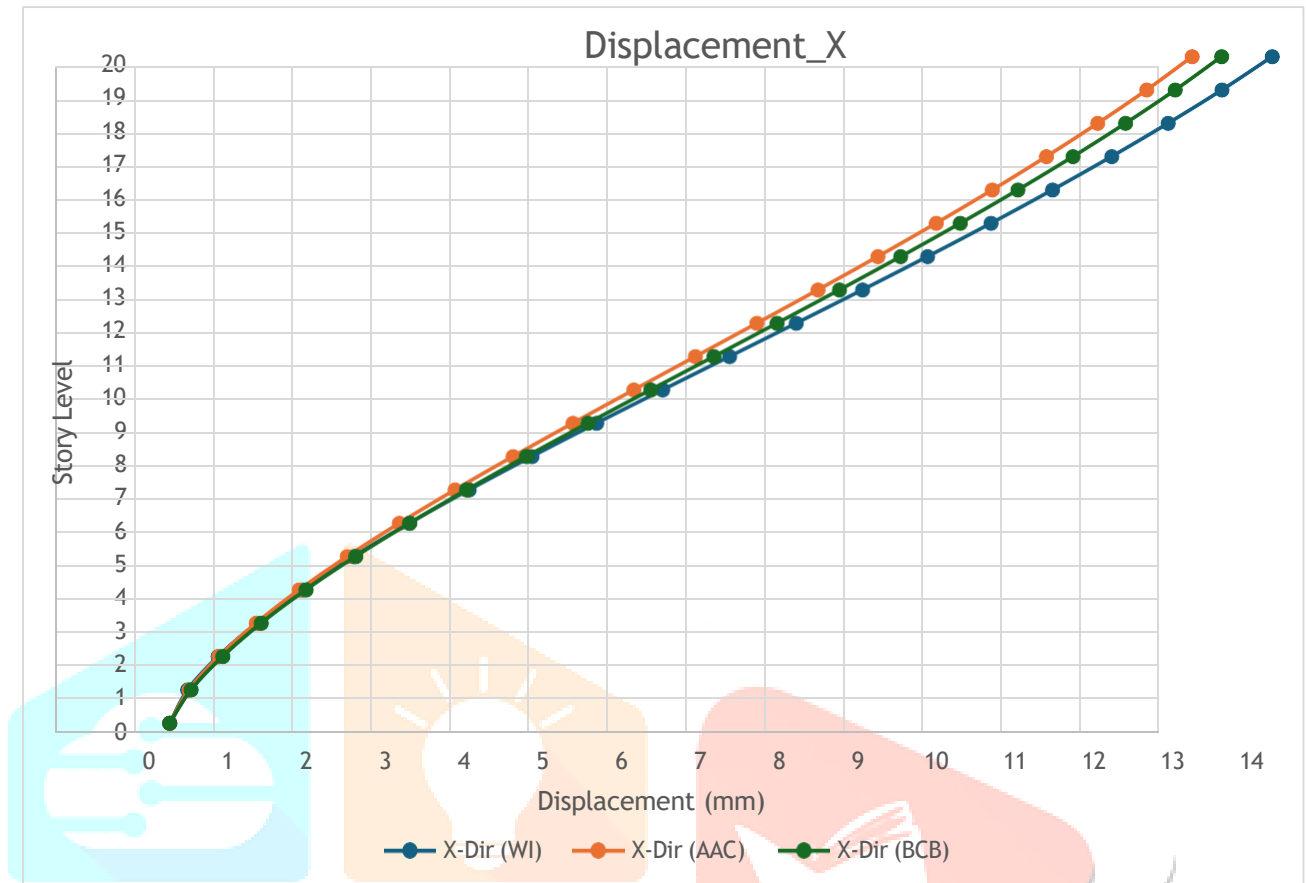


Fig 3.6. Structural Model (Elevation Along Y) without Infill Walls

4. RESULTS AND OBSERVATION

4.1. Displacement due to vibrations in X-direction



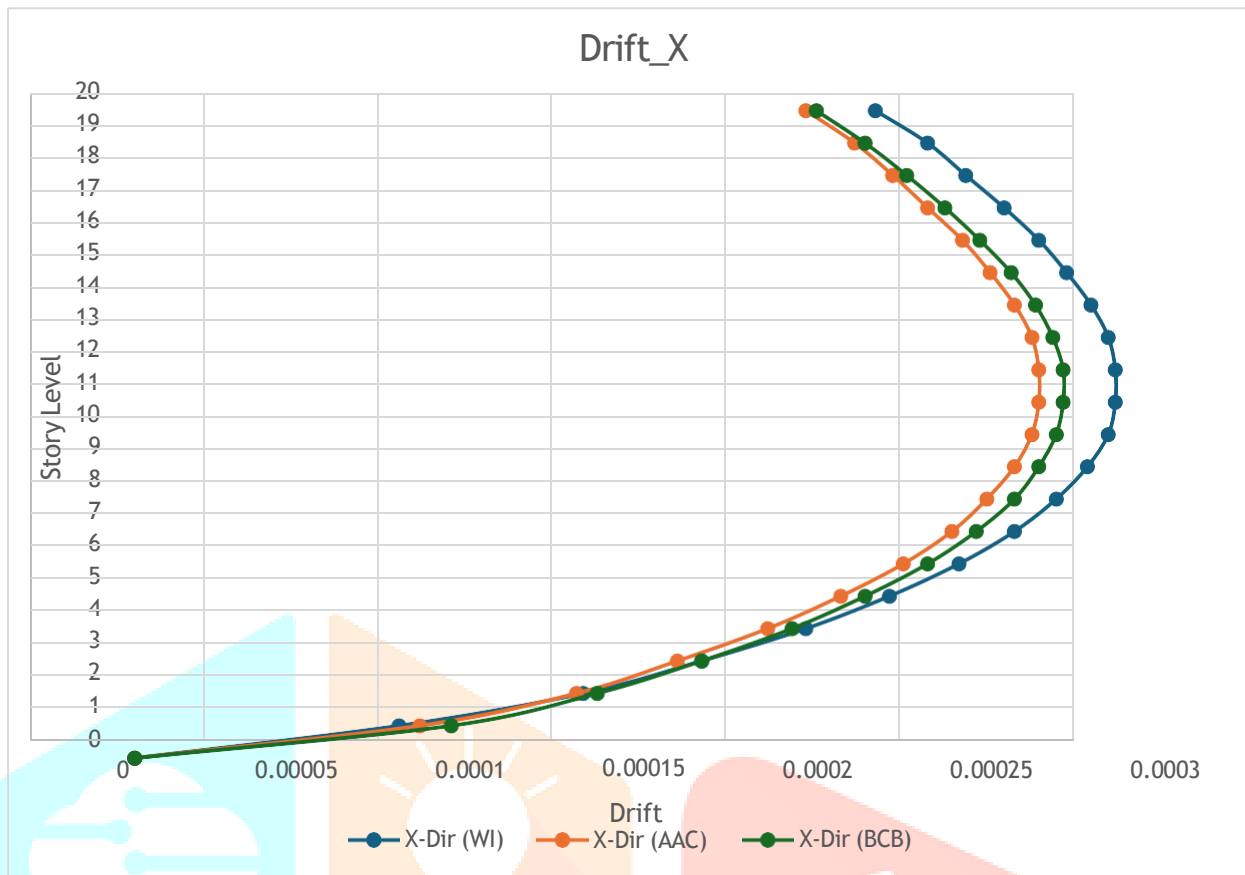
Results: Max. Displacement

- Bare Frame (WI): 13.988 mm
- With AAC Block: 12.973 mm
- With Burnt Clay Brick: 13.345 mm

Observations:

- Top story:
 - AAC: 7.26 % reduction
 - BCB: 4.60% reduction
- Middle story:
 - AAC: 5.85 % reduction
 - BCB: 2.44% reduction
- Bottom story:
 - AAC: 8.37 % increase
 - BCB: 19.82% increase

4.2 Drift due to vibrations in X-direction:



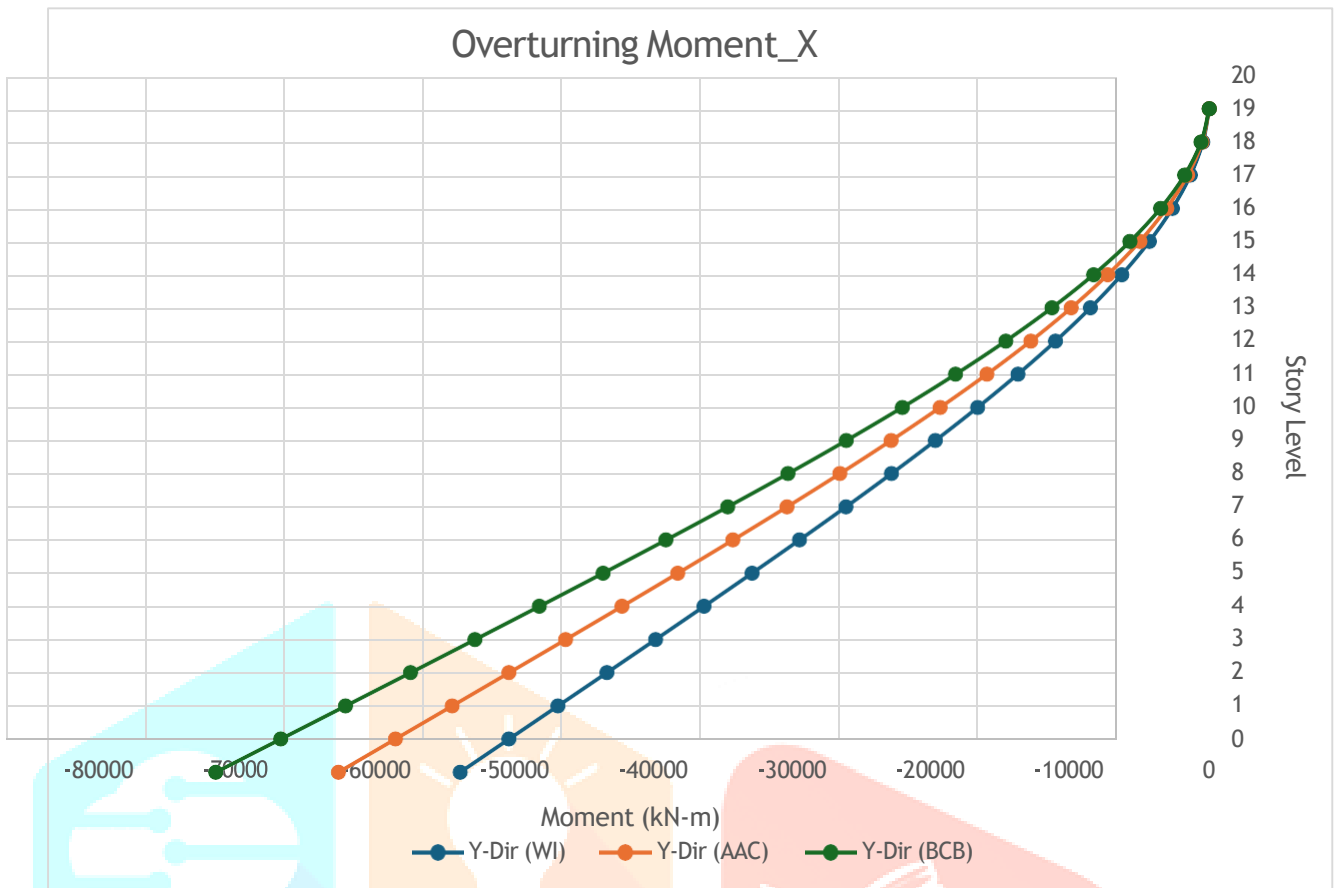
Results: Max. Drift

- Bare Frame (WI): 0.000213
- With AAC Block: 0.000193
- With Burnt Clay Brick: 0.000196

Observations:

- Top story:
 - AC: 9.39 % reduction
 - BCB: 7.98% reduction
- Middle story:
 - AAC: 7.86% reduction
 - BCB: 5.36% reduction
- Bottom story:
 - AAC: 7.89% increase
 - BCB: 19.74% increase
 - AAC: 0 %
 - BCB: 4.76% increase

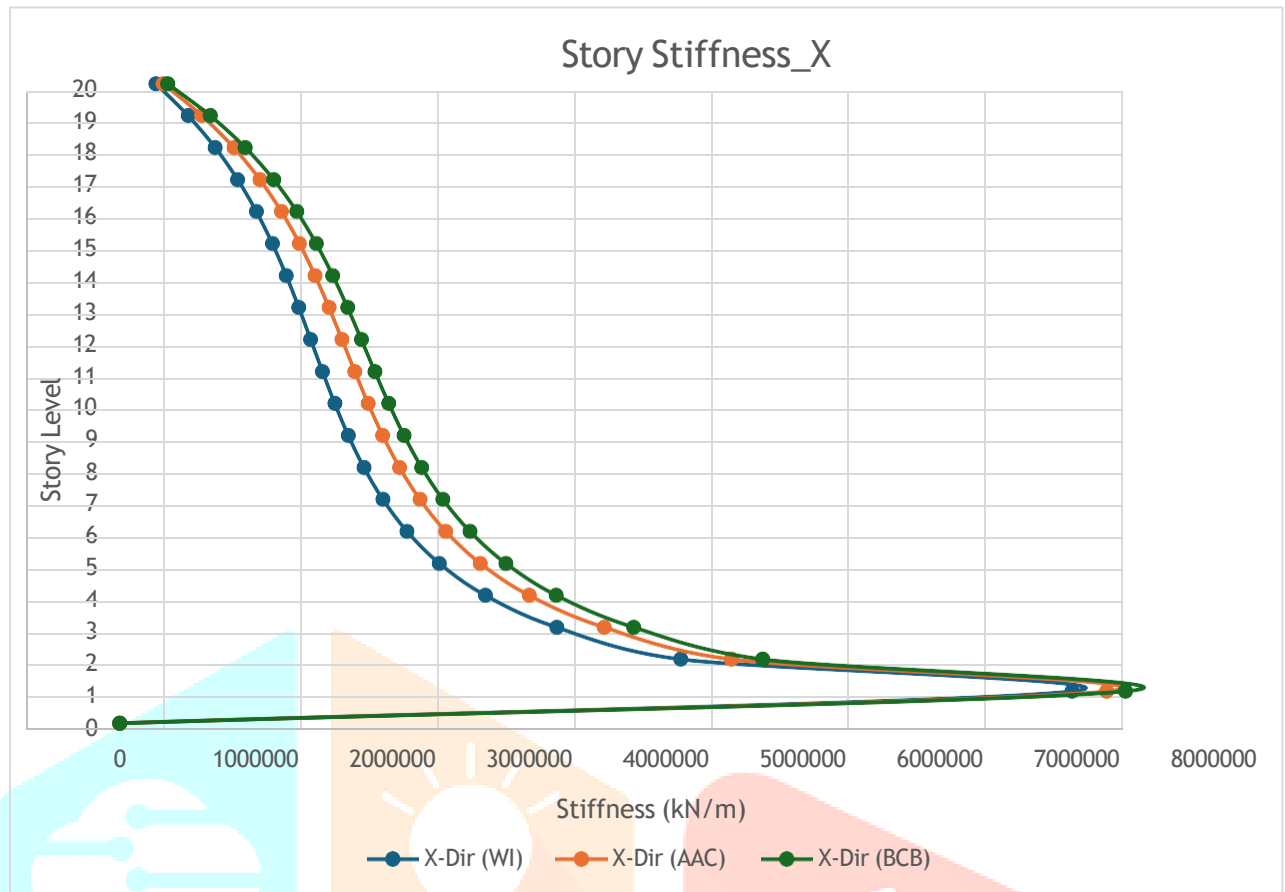
4.3 Overturning moment due to vibrations in X-direction:



Results: Max. Overturning moment

- Bare Frame (WI): 54020.51 kN-m
 - With AAC Block: 62792.14 kN-m
 - With Burnt Clay Brick: 71633.23 kN-m
- Observations:
- Top story:
 - AAC: 0 %
 - BCB: 0 %
 - Middle story:
 - AAC: 16.17 % increase
 - BCB: 32.50% increase
 - Bottom story (At base):
 - AAC: 16.27% increase
 - BCB: 32.58 % increase

4.4 Stiffness due to vibrations in X-direction:



Results: Max. Stiffness

- Bare Frame (WI): 69547799.92 kN/m
- With AAC Block: 7206983.04 kN/m
- With Burnt Clay Brick: 7346281.65 kN/m Observations:
- Top story:
 - AAC: 20.03 % increase
 - BCB: 32.48% increase
- Middle story:
 - AAC: 15.51% increase
 - BCB: 25.07% increase
- Bottom story:
 - AAC: 3.62 % increase
 - BCB: 5.63% increase

5. CONCLUSIONS

- Infill walls play a crucial role in enhancing seismic performance by effectively reducing lateral displacements, with the impact being most significant in the upper and middle zones of the structure.
- Among the options, AAC blocks demonstrate superior performance compared to BCB, particularly at higher elevations.

However, attention must be given to lower stories, where minor increases in displacement may occur. The use of AAC or BCB as infill significantly boosts seismic resilience, with AAC emerging as the more effective choice for minimizing displacements under X-direction seismic loads. Infill walls play a crucial role in improving seismic performance, as evidenced by the consistent reduction in inter-story drifts across all four drift analyses.

- Both AAC and BCB infill walls significantly enhance the building's lateral stiffness, making the structure more resilient during seismic events. Infill walls increase overturning moments due to added stiffness and mass, raising seismic demand on the structure.
- While they improve drift and displacement performance, they require stronger foundation design— especially with BCB, which shows the highest moment values. Infill walls significantly improve the seismic performance of asymmetric high-rise RC buildings by increasing stiffness.
- Burnt clay brick infill provides the highest stiffness, followed by AAC blocks, with bare frames performing the weakest.

6. REFERENCES

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