

# Comparison of Structure Having Different Infill Material (Bricks, AAC Blocks and Hollow Concrete Blocks) Using E-Tabs

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**ABSTRACT:** Due to recent development in structural analysis and design, high rise structures have become a popular one. The functional requirements and structural safety of a structure can be obtained from building laws, building codes and by adopting appropriate design methods. But in a developing country like India, the economy of construction is also of major importance. A frame system becomes structurally less efficient when subjected to large lateral loads such as a strong wind, earthquake or explosion. The situation becomes worse when the structural height is increased. In the current study the focus is on the investigation of the effect of infill in building and their behaviour in structure. There are different types of infill materials used in buildings, like brick infill, AAC block infill, Hollow concrete blocks infill etc. In this study focus is on behaviour of structure with different types of infill materials used. In this study four different types of model used- (1) RCC frame taking infill masonry weight, neglecting effect of stiffness. (2) Effect of stiffness is considered in addition to taking weight of infill (3) (Effect of stiffness is considered in addition to weight of infill excluding soft ground storey (4) (Effect of stiffness is considered in addition to weight of infill including soft ground storey effect. For each infill four cases studied. In this study three types of infill material used first is brick infill, second is AAC block infill and third is Hollow concrete block infill. So there for three types of infill material in which 12 models have been prepared in ETABS. In this study 15 storey building is considered for analysis which is located in zone 4 earth quake region. Static analysis is done using ETABS software, soil conditions are to be medium and importance factor is to be taken as 1.2. Various parameters studied like lateral displacement of building, axial load in column, storey drift, storey shear, base shear, and moment's diagrams for a particular beam for all three types of material and for all four cases. Results are represented in graphical as well as in tabular form. The structural members are modelled with the ETABS software package. Rigid end conditions are assumed for the frame members and the floor slab is assumed to act as diaphragms which ensure integral action of all the lateral load-resisting elements. The floor finish is taken to be 1.5 kN/m<sup>2</sup> on the floors. The live load on floor is taken as 2 kN/m<sup>2</sup>. In the analysis, 25% of the floor live load is considered in seismic weight calculations as per code IS 1893:2002.

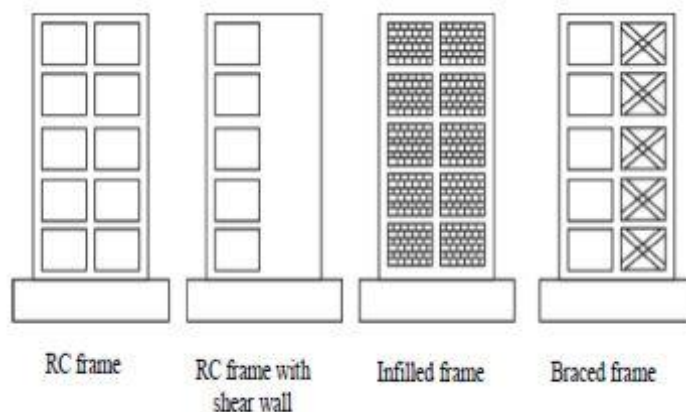
**KEYWORDS:** Soft storey, masonry infill, RC frame, earthquake, displacement, drift, base shear AAC blocks, Hollow concrete blocks.

## I. INTRODUCTION

Reinforced concrete structures with masonry infill's are very common type of construction in India. Masonry walls provide good architectural finish as well as it is quite useful with functional point of view. They are considered to be nonstructural elements. It is considered that these in fills do not have bonding with the frames in the design. Although an infill panel interacts with the frame when it is subjected to the lateral forces. As per now a days designs for the calculations of the seismic behavior of the RC frames the infill are not considered as their structural part and only as a load providing element but this leads to an inaccurate results and hence actual seismic behavior of structure is not guessed properly.

### 1.1 Introduction

Lateral Load Resisting System Lateral force resisting elements must be provided in every structure to brace it against wind and seismic forces. The principal types of resisting elements are as follows and the details are shown in Figure 1.1→ Moment frames → Shear walls → Braced frames Infilled frames



**Figure 1.1 Lateral load resisting system**

Present IS code IS 1893(Part-I): 2000 doesn't provide provisions for considering the effect of infill, hence the strength and stiffness of the infill walls are not considered in the general design practices in India. As we are neglecting the structural strength of the infill walls, it can cause inadequate information and can lead to the failure of the structure. The failure can take place due to excessive stiffening of the infill walls and hence unequal transfer of lateral forces at various storey's. Further failure modes can be due to i) short columns column effect ii) torsional forces iii) cracking of the infill walls.

### 1.2 Structural analysis and modelling

Various literatures and previous studies were conducted to obtain the idea about the modelling process and the representation of infill in particular. Modelling of structures as a 3-Dimensional computer model generally creates no additional problems due to the irregularities in structure and soft storey effect (E L Wilson 2002). Strength, stability and rigidity are the important factors that are to be considered while modelling the distinct structural system to resist gravity and lateral loading. The building is considered to be a vertical cantilever as far as seismic loading is concerned and hence the influence of horizontal loading caused by the earthquake is more effective as the height of the structure increases, (Smith and Coull, 1991). Moment resisting rigid frame system that mainly comprises of beam and columns connected by a moment resisting system is extensively used for the modelling of low rise building. In this modelling the joints created by each beam and column carries 6 degree of freedom.

### 1.3 Problem Statement

The high rise buildings now-a-days are provided with soft storey's for parking purpose. When such building is located in the earthquake prone area, can be subjected to heavy lateral forces. Due to the presence of soft storey in a building, the lateral load resisting capacity of building decreases, thereby the stiffness of building decreases. This leads to sudden failure of structure. To increase the lateral strength and stiffness of a structure, AAC BLOCK is introduced in a structure, such that the building can sustain under the seismic loads and decrease the overall cost of building.

### 1.4 Objectives

The brick masonry is a brittle material and it has been found to fail prematurely by shearing along the bedding panels or by diagonal splitting. Structural limitations of brick masonry like poor shear and tensile strength, brittle characteristics, potential damages from debris and vulnerability to out of plane loads restrict their role as an effective infill in resisting lateral loads. To overcome the above limitations, traditional brick infill has been changed by using hollow blocks and aero on blocks masonry infill as well as by using reinforced masonry infill to find the effectiveness of reinforced masonry in resisting lateral loads. The aim of the present work is

1. Study Various Parameters - Lateral Displacement of Building, Axial Load in Column, Storey Drift, Storey Shear, Base Shear and Moment's
2. Create Analytical Model Using Equivalent Strut Concept Using ETAB Software.
3. Compare The Analytical Results Value.

## II. LITERATURE REVIEW

**Sachin Surendran and Hemant B. Kaushik et.al.(1)** Reinforced concrete (RC) frames in-filled with unreinforced masonry walls are quite commonly constructed all across the globe since many decades. Past researchers have tried to find out experimentally and analytically the influence of several parameters, like opening size and location, aspect ratio

of openings, connection between frame and infill wall, ductile detailing in frame members, material properties, failure modes, etc. on behaviour of masonry infill RC frames. Accordingly, several analytical models have been proposed in the literature and seismic codes of some countries to model the stiffness and strength properties of infill walls.

**Prof. P.B Kulkarni<sup>1</sup>, PoojaRaut<sup>2</sup>, Nikhil Agrawal et.al (2)** Many urban multistorey buildings in India today have open first story as an unavoidable feature. This leave the open first storey of masonry in-filled reinforced concrete frame building primarily to generate parking or reception lobbies in the first storeys. Masonry infill walls are mainly used to increase initial stiffness and strength of reinforced concrete (RC) frame buildings .It is mainly considered as a non-structural element. In many cities of India, it is very common to leave the first storey of masonry infilled reinforcement concrete (RC) frame building open preliminary to generate parking space or any other purposes (Ex-Reception lobbies) in the first storey. This Open First storey is also termed as “Soft Storey”. The upper storeys have brick in-filled wall panels with various opening percentage in it.

**Ms.Rajashri A. Deshmukh et.al (3)** Earthquakes represent the largest potential source of casualties and damage for inhabited areas due to natural hazard. The construction of RC buildings with unreinforced infill wall is a regular practice in India. Infill panels have usually been made of heavy rigid materials, such as clay bricks or concrete blocks. However, more lightweight and flexible infill options such as AAC (aerated light weight concrete) blocks are now obtainable in India to be used as masonry infill (MI) material in reinforced concrete (RC) framed buildings. It has been accepted that infillmaterials considerably influence the seismic performance of the infilled framed structures. Number of researchers studied the behaviour of infilled RC frames experimentally and analytically.

**NusfaKaruvattil\*<sup>1</sup>, PriyankaDilip P. et.al(4)** Many urban multistorey buildings in India today have open first storey as an unavoidable feature. This leave the open first storey of masonry infilled reinforced concrete frame building primarily to generate parking or reception lobbies in the first storey . Masonry infill walls are mainly used to increase initial stiffness and strength of reinforced concrete (RC) frame buildings .It is mainly considered as a non-structural element. In many cities of India, it is very common to leave the first storey of masonry infilled reinforcement concrete (RC) frame building open preliminary to generate parking space or any other purposes (ExReception lobbies).

**István Haris<sup>1</sup>\*, GyörgyFarkas et.al. (5)** In many countries it is a common practice to infill some of the bays of the steel and/or concrete frame. Traditionally infill walls are usually considered as non-loadbearing, non-primary structural elements The main goal of this paper is to present an executed research experiment, planned to include a group of 15, onethird scale, one-bay, two-storey reinforced concrete (RC) frame specimens infilled with masonries with different stiffness.

**UğurAlbayrak, EşrefÜnlüoğlu, and MizamDoğan et.al.(6)** Infill walls are considered to non-bearing structural members but affect not only structure masses also lateral rigidities which may cause free vibration behavior of the buildings. Although infill walls are not considered structural members, they are acting together with the frame when subjected to seismic loads. Analyze and calculation models including infill wall contribution are difficult and complex especially on major construction projects. Behavior of masonry infilled R.C. frames under seismic loads should be modeled to consider the effect of the infill walls on the seismic performance of the structure. In this study an overview of the modelling methods of infill walls in reinforced concrete frames is presented. The advantages or disadvantages of the presented methods are discussed and an easy and effective procedure is suggested for using in practice design.

**P.G. Asteris et.al.(7)** The main objective of this paper is to present a general classification scheme of the failure modes of in-filled frames, both with and without openings. For the former, the existing classification is summarized based on a literature review. For the latter, recent experimental results on frames in-filled with unreinforced masonry walls with openings and subjected to slowly applied cyclic lateral loads are used, and a number of different failure modes (crack patterns) of masonry in-filled frames are identified and classified into distinct categories. Such a classification of failure modes improves substantially the understanding of the earthquake resistant behaviour of in-filled frames and leads to better methodological approaches regarding their modelling, analysis and design

**Mehmet Baran<sup>1</sup>\* and TugceSevil at.al.(8)** Although hollow brick infills, widely used as partition walls, are considered as non-structural members, experimental studies revealed that hollow brick infills have favourable effects on strength and stiffness of structures. In this work, analytical studies were conducted to investigate the hollow brick infill behaviour, in which infills were modeled by diagonal compression struts. Results were compared with experimental ones obtained from tests of one-bay, one or two story reinforced concrete (RC) frames, tested under both vertical and reversed-cyclic lateral loads simulating earthquake.

**BhargaviSattar, Pradeep Kumar Ramancharla et.al.(9)** Improperly designed brick masonry walls cause undesirable effects under seismic loading in both brick masonry in-filled reinforced concrete (RC) frames and masonry load bearing wall structures. Doors and windows (openings) are unavoidable components in brick masonry in-filled RC structures and masonry load bearing wall structures because of its functional and ventilation requirements.

**Sreekeshava K.S, A.S Arunkumar et.al.(10)** The brick masonry is used in a wide range as an infill material in reinforced concrete (RC) frames. In general masonry infill (MI) are treated as non-structural elements and ignored in many structural designs, But the contribution of infill under lateral loads shows the better performance and contribution to strength and stiffness of RC frames. The stiffness of masonry controls the failure of MI and plays a significant role under lateral loads. Masonry is a brittle material and exhibits poor performance under shear and flexure.

### III. RESEARCH METHODOLOGY

#### 3.1 Geometry

In the present study, A typical Ten storey RC framed type of building with five bays in longitudinal X direction and three bays in transverse Y direction have been considered with the plan dimension as 25 m × 15 m. All stories including ground storey having 3.2m floor to floor height is considered for the analysis. The width of bay is taken as 5m along X as well as Y direction. The thickness of masonry wall is taken as 300mm. The building is kept symmetric in both orthogonal directions in plan to avoid torsional response under lateral force. The column is kept square having size 500x500mm and size of the column is taken to be same throughout the height of the structure. The size of beam is taken as 300x450mm having 150mm thick Floor and roof slab for all the spans. The base is considered to be fixed. The building is located in zone III and Medium Type of soil is considered. A response spectrum is considered as per IS 1893(Part-1):2002. Response reduction factor for the special moment resisting frame is taken as 5.0 (assuming ductile detailing). Damping of structure is taken as 5 percent and Importance factor is taken as 1. Superimposed dead and live loads are applied on slab and beams as per IS 875 and Earthquake loads are applied as per IS 1893(Part-1)2002.

#### 3.2 Material properties

Grade of concrete is taken as M-25 and for reinforcing steel, Fe415 grade of steel is used for all the model cases considered in this study. The unit weight of concrete is taken as 25 kN/m<sup>3</sup>. The unit weight for brick masonry infill and AAC/HCB block masonry infill are taken as 20 kN/m<sup>3</sup> and 6.5 kN/m<sup>3</sup> respectively. The modulus of elasticity for concrete is taken as  $[5000(f_{ck})^{0.5}]$  which is equal to 25000 MPa (as per IS: 456- 2000) and poisson ratio is 0.2. The modulus of elasticity for brick masonry infill and AAC/HCB block masonry infill are taken as 2640 MPa and 2040 MPa respectively. The poisson ratio for brick masonry is 0.1 and that of AAC block masonry is 0.25. The live load on floors is taken to be 3 kN/m<sup>2</sup> and 1 kN/m<sup>2</sup> live load is taken as floor finishes respectively. In seismic weight calculations, 25 % of the floor live loads are considered because live load on floor is equal to 3 kN/m<sup>2</sup> as given in IS code 1893:2002.

#### 3.3 Modelling of Infill Walls

As FEMA 356(2000) stated that the elastic in plane stiffness of a masonry infill panel shall be denoted with an equivalent diagonal compression strut prior to cracking. The width of equivalent diagonal strut is computed as

$$W = 0.175(hh)^{-0.4}d$$

Where

$E_i$  = modulus of elasticity of infill material

$E_f$  = modulus of elasticity of frame material

$L$  = beam length between center lines of columns

$L'$  = length of infill wall

$h$  = column height between center lines of beams

$s$  = height of infill wall  $I_c$  = moment of inertia of column

$t$  = thickness of infill wall  $d$  = diagonal length of strut

$\theta$  = angle between diagonal of infill wall and the horizontal in radian

The infills are modeled by single equivalent diagonal strut approach and its thickness is equal to in fill wall thickness. The ends of strut are pin jointed which are connected to frame and releases moments at ends. A pin jointed end of strut avoids transfer of moment from frame to strut. Considering Main stone and weak diagonal strut width expressions for modeling the infill, width of strut for brick infill and AAC block and HCB BLOCK

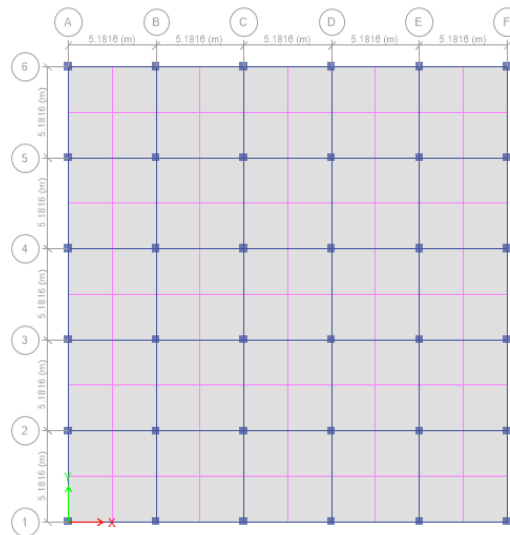
infill is calculated which has been represented in following table. Contact length parameter is based on Stafford Smith.

**Table-3.1:** Width equivalent of strut

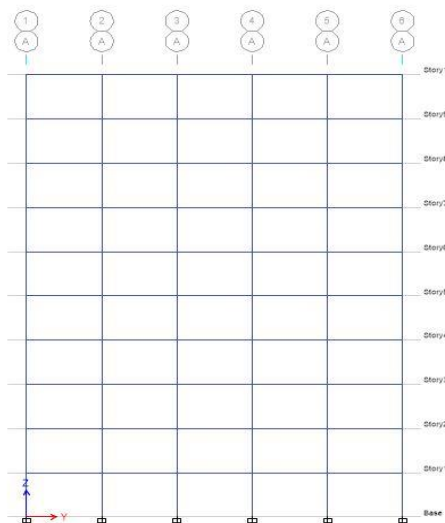
Strut	Brick infill	AAC block infill
Width (mm)	700	750
Thickness(mm)	300	300

### 3.4 Building plans

**Model 1:** Conventional brick infill frame without opening.



**Fig. 3.1** RCC building with Conventional Clay bricks as infill material. (Plan of building with Conventional Clay Bricks as infill material)



**Fig3.2.** Elevation of RCC Building showing Conventional Clay Bricks modelled as inclined STRUT



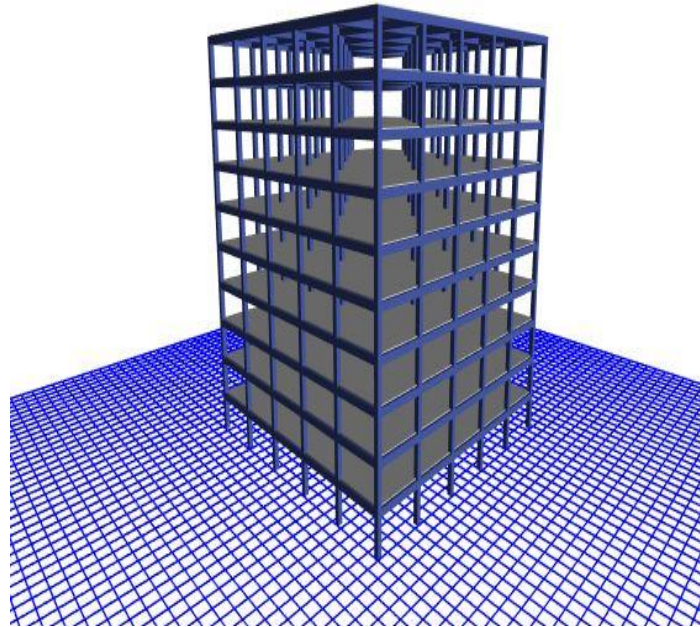


Fig.3.3 3D Render view

**IV. RESULT AND DISCUSSION**

TheseismicanalysisfortheallRCframemodelsareconsist ofbrickinfill(M-1),modelwithfullinfill(modelinginfillasa AAC block infill element) (M-2) and full infill with has been doneforboththeinfillmaterialsie.forbrickmasonryinfill and AAC block masonry infill by using software ETABS and theresultsarepresentedbelow.Theparameterswhichhave to be studied are Base Shear, Displacement, Beam Forces, Column Forces, Storey Shear and Storey drift by changing the material of infill as Brick infill and AAC blockinfill.

**Lateral Displacement**

**Model 1:- Brick infill**

TABLE 1 :Diaphragm center of mass Displacement			
Storey	Diaphragm	Load Case/Combo	UX
Storey11	D1	EQX	32.727
Storey10	D1	EQX	31.337
Storey9	D1	EQX	29.541
Storey8	D1	EQX	27.419
Storey7	D1	EQX	25.053
Storey6	D1	EQX	22.52
Storey5	D1	EQX	19.892
Storey4	D1	EQX	17.237
Storey3	D1	EQX	14.615
Storey2	D1	EQX	12.083



**Model 2 AAC block infill**

TABLE 2 :Diaphragm center of mass Displacement			
storey	Diaphragm	loadCase /combo	UX
Storey11	D1	EQX	23.81
Storey10	D1	EQX	22.839
Storey9	D1	EQX	21.567
Storey8	D1	EQX	20.054
Storey7	D1	EQX	18.359
Storey6	D1	EQX	16.537
Storey5	D1	EQX	14.641
Storey4	D1	EQX	12.718
Storey3	D1	EQX	10.812
Storey2	D1	EQX	8.958

**Model 3 HCB block infill**

TABLE 3 :Diaphragm center of mass Displacement			
storey	Diaphragm	load Case/combo	UX
Storey11	D1	EQX	20.11
Storey10	D1	EQX	19.35
Storey9	D1	EQX	18.52
Storey8	D1	EQX	18.22
Storey7	D1	EQX	17.535
Storey6	D1	EQX	15.537
Storey5	D1	EQX	14.641
Storey4	D1	EQX	12.718
Storey3	D1	EQX	11.542
Storey2	D1	EQX	9.32

Lateral displacement in X or Y direction for all model in all zones are as in graph

**Graph: story’s wise of lateral displacement**

Therefore, The AAC block material can basically be used to replace conventional bricks as infill material for RC frames built in the earthquake prone region. The results show that, the minimum cost of building and maximum strength of AAC brick wall in a building can help to reduce the deflection and story drift in a building. Some studies deal with the evaluation of steel and cost of building required for the building provided with AAC BLOCK masonry wall.

In this chapter, The seismic analysis for all the RC frame models which consist of bare frame (M-1), model with full infill (modeling infill as a strut element) (M-2) and full infill with soft ground storey (M-3) has been done for both the infill materials i.e. for brick masonry infill and AAC block masonry infill by using software ETABS and the results are represented below. The parameters which are to be studied are Base Shear, Displacement, Beam Forces, Column Forces, Storey Shear and Storey drift by changing the material of infill as Brick infill and AAC block infill.

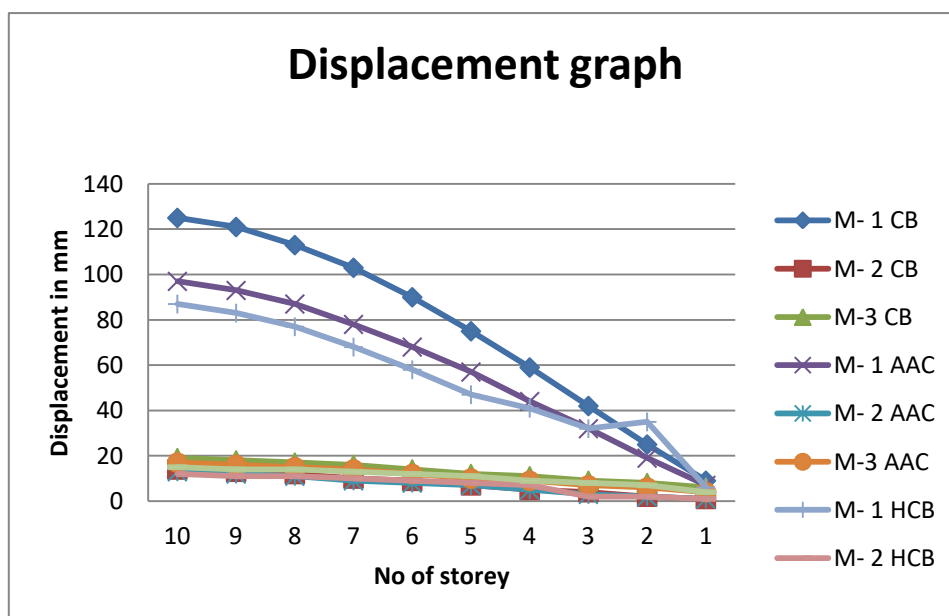


**Displacement(mm)**

The decrease in the displacement in AAC block masonry is found 31% in case 1 for bare frame model, 8% in case 2 for full infill masonry and 22% in case 3 for full infill ground soft storey. Thus Displacement in AAC block is less than that of Brick infill in every case due to its light weight. From the results it is found that the lateral displacement is very large for bare frame model compared to other models while masonry infill have least displacement.

**Table-3:** Displacement (mm) at Various Storey Level

Storey	Brick masonry			AAC block masonry			Hollow Concrete Block		
	Bare frame	Infill frame	Infill with ground soft storey	Bare frame	Infill frame	Infill with ground soft storey	Bare frame	Infill frame	Infill with ground soft storey
			y			y			
	M- 1 CB	M- 2 CB	M-3 CB	M- 1 AAC	M- 2 AAC	M-3 AAC	M- 1 HCB	M- 2 HCB	M-3 HCB
10	125	14	19	97	13	17	87	12	15
9	121	13	18	93	12	16	83	11	14
8	113	12	17	87	11	15	77	11	14
7	103	10	16	78	9	14	68	10	13
6	90	9	14	68	8	12	58	9	12
5	75	7	12	57	7	10	47	8	11
4	59	5	11	44	5	9	41	7	9
3	42	4	9	32	3	7	32	2	8
2	25	2	8	19	2	6	35	2	7
1	9	1	6	7	1	4	6	1	4



**Chart-1:** Displacement in X direction for all models





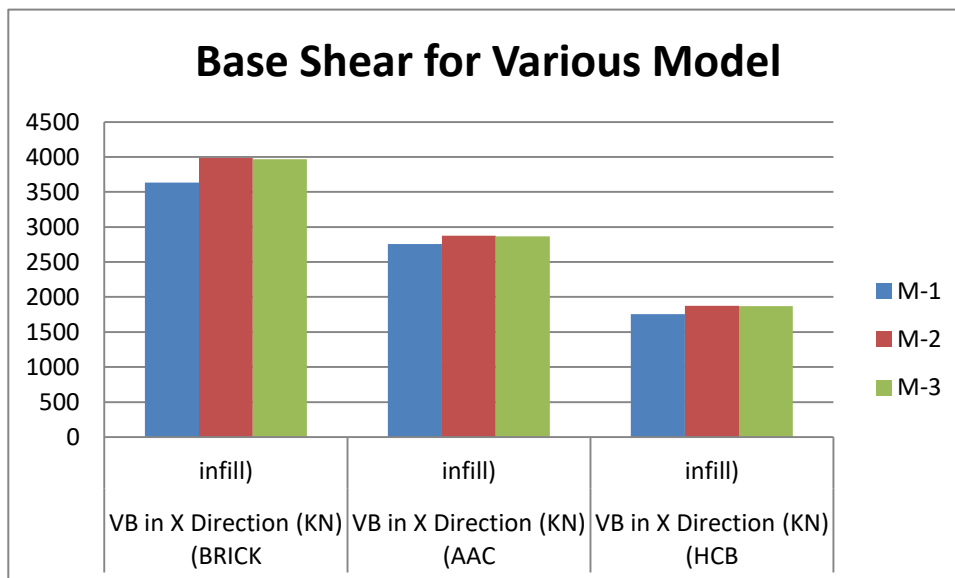
**Storey drift(mm)**

Storey drift in AAC block is in every case is lower than Brick masonry. Model 1 shows highest storey drift then the other models. The decrease in the storey drift in AAC block masonry is found 29% in case 1 for bare frame model, 6% in case 2 for full infill masonry and 10% in case 3 for full infill ground soft storey.

**Base shear(KN)**

**Table-6:** Base shear for various models

MODEL	VB in X Direction (KN) (BRICK infill)	VB in X Direction (KN) (AAC infill)	VB in X Direction (KN) (HCB infill)
M-1	3635.66	2754.95	1754.95
M-2	3988.2	2873.95	1873.95
M-3	3969.65	2867.37	1867.37



**Fig Base shear for various models**

**V. CONCLUSION**

The following conclusions can be enumerated point wise as follows:

1. From the results, it has been noticed that displacement of the structure with AAC block in all the three Model cases is found less than that of conventional brick masonry.
2. When displacement results of Model 1 and Model 2 and Model 3 in the both type of masonry infill as AAC blocks and brick infill hollow concrete block are compared,
3. Model 2 is preferred than Model 1 because displacement is least in case of Model -2. This is because, In Model 2 strength and stiffness of the masonry panel is considered by modeling infill panel as equivalent diagonal strut which reduces the lateral deflection of the structure.
4. The results of Model 2 and Model 3 are comparable with very less increase in displacement in Model 3 compared to Model 2 because of soft ground storey.
5. From the results, it can be observed that storey drift of the structure is found less in AAC block masonry infill in all the three model cases with the corresponding model cases of brick masonry. Model 1 shows highest storey drift then the other models in both types of masonry infill panels.
6. Storey drift in model 2 is less than model 1 and 3 because stiffness is taken into consideration in model M-2. The

- results of model 2 and model 3 are comparable expect ground storey. The storey drift of first storey in model M-3 is very large than the upper stories due to absence of infill walls in the first storey.
7. It is observed from the results that storey shear with AAC is significantly less as compared to brick masonry infill panel. It is because of light weight of AAC blocks.
  8. Model M-2 has more storey shear than M-1 and M-3 because Storey shear is 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 both type of infill materials because stiffness has not been considered in case M-1.
  9. Base shear in case of AAC block masonry is also less in all the three models compared to brick masonry panels. This is because of light weight of AAC blocks. Less base shear results lesser lateral forces. Due to reduced base shear, member forces are also reduced which leads to reduction in amount of area of steel in various members
  10. Base shear in model 2 is more than model 1 and model 3 because of increased mass of structure.
  11. From the results it is observed that axial forces in columns are reduced with AAC block masonry than that of conventional brick masonry. Axial Force is found maximum at the foundation level.

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