Study and Comparison of Structure having Different Infill Material 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 models have been prepared in ETABS. In this study 10 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/m2 on the floors. The live load on floor is taken as 2 kN/m2. In the analysis, 25% of the floor live load is considered in seismic weight calculations as per code IS 1893:2002.*

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

1. INTRODUCTION

1.1 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. The infill walls could be filled with various elements some of them are conventional bricks, AAC blocks, solid concrete blocks, hollow concrete blocks etc. Still this field has to go through a lot of study and research to understand properly the use of the various infill. In present study focus is about the response of various infill to the seismic activities. Hollow concrete, AAC blocks, and clay bricks have been used as the infill in the RC frames. AAC blocks are light- weight building material and provide insulation and fire resistance; they also have lower impact on the environment.

Hollow concrete blocks are also very light weight but not light as AAC blocks .Hollow concrete blocks provide much better insulation to the building and is a good material to construct a green structure. The experimental results have shown that the hollow concrete blocks infilled RC frame exhibits better performance subjected to lateral loads than that of AAC and conventional bricks infilled frames. Infill materials improve the performance of the RC frame structures as they somehow participate in frame structural part also. An infill wall decrease lateral deflections, storey drift, and the bending moment in the frames, and it also increase the axial loads in the columns hence the possibility of collapse of the structure decreases.

As infill leads to design of slender members in design and makes the building more economical. 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 stories. Further failure modes can be due to

1. short columns column effect
2. torsional forces
3. Cracking of the infill walls.

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.

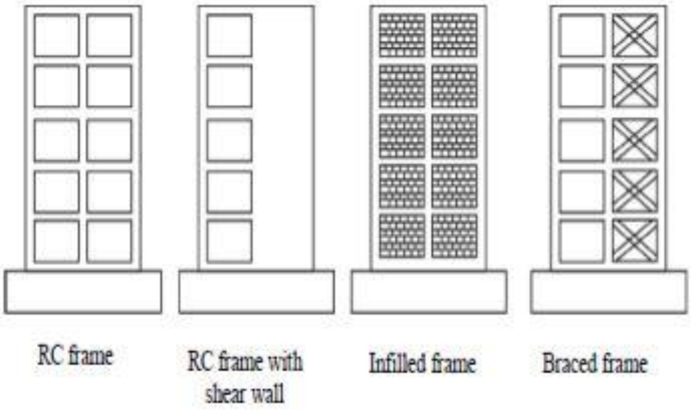


Fig. 1. Lateral load resisting system

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 story's . Further failure modes can be due to i) short columns column effect ii) torsional forces iii) cracking of the infill walls.

1.2 Drawbacks of Clay Bricks

1 Continuous use of clay bricks leads to extensive loss of fertile top soil in construction industry. This is not eco-friendly; a big loss to the environment takes place due to this.

2. We should use alternative building materials like Fly ash bricks, AAC blocks and hollow concrete blocks to keep the cost of building materials in reasonable range.

3. Use of alternative building materials like Fly ash bricks, AAC and hollow concrete blocks will decrease the rate of deforestation. Vast area of land is going under deforestation only in the search of top soil.

4. Old technology is used for manufacturing of Burnt clay bricks; quality testing facilities are not available at manufacturing sites. Most of bricks are inferior in quality with low compressive strength, manufactured using old technology. They are not recommended for use in multistory buildings.

1.3 AAC Blocks:

1.3.1 Overview:

India is having a tropical climate and most of the time during the year the temperature remains quite high and hence we require materials which are highly insulating in nature. Hence the designers go for green and ecofriendly material .One of the widely use material is AAC blocks

Dr. Johan Eriksson developed Autoclaved Aerated Concrete block in 1923 and was patented for manufacturing in 1924. These blocks lower the environmental impact. It is very new to Indian markets. The density of AAC is around 1/3rd of conventional clay bricks hence reduces the seismic forces on the structure. Experiments show that much lesser deflections takes in the structure when AAC blocks are used instead of clay bricks. Fly ashes are used as the raw material for manufacturing of the AAC blocks. Fly ashes are the waste generated from the thermal power plants and their disposal is a major issue these days, hence the AAC blocks could help significantly in this direction. AAC blocks are far more durable when compared to clay bricks.

1.3.2 Advantages of Using Autoclaved Aerated Concrete Blocks

(A) Lightweight: AAC Blocks are about 3 times lighter than conventional bricks resulting less dead weight of buildings and therefore reduces the amount of concrete and steel uses in the building. As a result it has following advantages

1. Saving the cost of handling and transportation.
2. Better earthquake resistance due to light weight of the structure.
3. Savings in foundation and structural costs due to less dead load. .

(B) Economical:

1. AAC blocks are bigger in size of conventional bricks which results fewer joints thus savings in cement and mortar.
2. AAC blocks are factory made with finished edges & shapes which results reduction in cost of plaster.
3. Reduced dead load due to low density results saving in consumption of structural steel.
4. Greater area is covered for the same mass of brick by AAC block, results saving in transportation costs.

(C) Thermal Insulation: AAC has got a lot of air bubbles in between them hence they do not conduct the heat much and hence provides better thermal insulation, it results in reduction of cost for cooling and heating. 1. It keeps interior cool in summer and warm in winters. 2. It reduces air conditioning loads by 25-30% and hence save energy.

(D) Fire Resistance: 1. AAC block is noncombustible and has a melting point of approx. 1500 degrees Centigrade which is much higher than other building materials. 2. During a fire, No toxic fumes are generated, thus saves precious lives during a fire.

(E) Sound Insulation: AAC blocks have better sound insulation properties than conventional brick.

(F) Easy Workability: The workability of AAC blocks better than wood. Hence it is easy to cut, reducing the amount of waste generated from cutting.

(G) Environment Friendly: Due to light weight of AAC, energy is saved in transportation which reduces the CO2 emissions by transport vehicles. AAC uses Fly ash waste and solve the problem of disposal. Thus it is Environment Friendly material in construction industry.

(H) Earthquake Resistance: AAC blocks provides less dead load on the structure and hence reducing earthquake forces as it is function of mass.

(I) Less Maintenance: AAC blocks doesn’t suffer from the salt efflorescence while there is a lot of problem in the clay bricks regarding this hence it is good to use the AAC blocks where there is lot of slats present in the top soil .

(J) Easy Transportation: As the density of clay bricks is higher they suffer a lot of breakage during transportation while this is not a major issue in transportation of AAC blocks.

(K) Long Term Use: AAC does not deteriorate over time and thus routine repairs are not required.

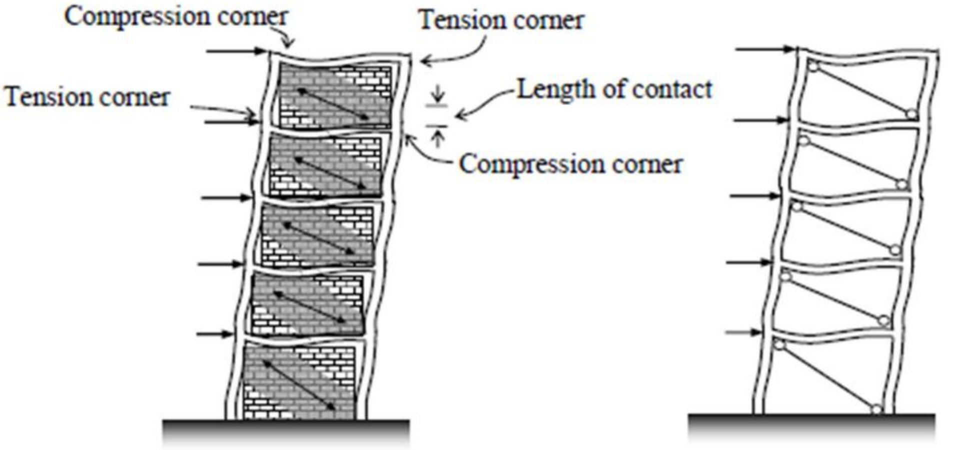
(**L) Shorter Project Duration:** Due to bigger size of AAC blocks, construction is fast compared to clay brick which leads shorter project duration.

(M) Precision: Precise architectural design dimension are attained in AAC blocks due to machine finished precast AAC elements.

1.4 Concrete Hollow Blocks: Hollow concrete blocks are good substitutes for conventional bricks and stones in building construction. These are made of concrete but these are kept hollow in between to reduce the material and make the block lightweight. They are lighter than bricks, easier to place and also economical in foundation cost and consumption of cement. In comparison to conventional bricks, they offer the advantages of uniform quality, faster speed of construction, lower labor involvement and longer durability. In view of these advantages, hollow concrete blocks are being increasingly used in construction activities.

1.5 Behavior in the Presence of Infill Wall

Under lateral load condition the frame and the infill wall tends to stay intact initially. As the lateral load is increased the infill wall gets separated from the surrounding frame at the unloaded (tension) corner, but at the compression corners the infill walls remaining still intact in position as previously. The length over which the infill wall and the frame are intact in position is called the length of contact. Load transfer in the wall occurs through an imaginary diagonal which acts like a compression strut member. Due to this behaviour of the infill wall, they can be modelled as an equivalent diagonal strut by connecting the two compressive corners diagonally. The property of the stiffness should be such that the strut is active only when subjected to compression. Thus, only under lateral loading one diagonal will be operating at a time.



(a) Deformed shape (b) Equivalent strut model

Fig.2 Showing the behavior of infill frame

1.6 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 . For most of the buildings the stiffness of the frame members are generally considered low as compared to in-plane stiffness of the floor systems. Because of this the in-plane deformations of all the beams are neglected and the walls and columns are constrained to move as an isolated single unit in lateral directions. By using this property in the modelling we can reduce the dimension of the system of the equations of the building.

1.7 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.

1.8 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. The main objectives of this project is to overcome the above limitations, traditional brick infill has been changed by using hollow blocks and aerocon 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. To Study Various Parameters - Lateral Displacement of Building, Axial Load in Column, Storey Drift, Storey Shear, Base Shear and Moment's
2. To Create Analytical Model using Equivalent Strut Concept Using ETAB Software.
3. To Compare the Analytical Results Value.

2. 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. Most of the past studies and seismic codes recommend modelling the in-fills as equivalent diagonal struts, and cross sectional area of the struts are reduced appropriately to account for openings in the walls.

Prof. P.B Kulkarni1, Pooja Raut , Nikhil Agrawal et.al (2) Many urban multi-storey 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 in-filled 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 causalities 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 infill materials considerably influence the seismic performance of the in-filled framed structures. Number of researchers studied the behaviour of in-filled RC frames experimentally and analytically.

Nusfa Karuvattil1, Priyanka Dilip P. et.al(4) Many urban multi-storey buildings in India today have open first storey 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 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). 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.

István Haris1, Gyorgy Farkas 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, one third scale, one-bay, two-storey reinforced concrete (RC) frame specimens in-filled with masonries with different stiffness. The aim of the complete research experiment was to analyse, in accordance with the international scientific research trend, the behaviour of masonry in-filled concrete frames for earthquake action, particularly for cyclic lateral loading under and over the appearance of the main continuous diagonal, corner- to-corner cracks. In the first step the in-filled frames were loaded in one direction with monotonic increasing lateral loads. In the second step of the research the in-filled frames were investigated in two lateral directions in cases of cyclic top loading with different load histories. This paper shows the conclusions of the experimental programme.

Ugur Albayrak, Eşref Unluogl, and Mizam Dogan 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 behaviour of the buildings. Although infill walls are not considered structural members, they are acting together with the frame when subjected to seismic loads. Analyse and calculation models including infill wall contribution are difficult and complex especially on major construction projects. Behaviour of masonry in-filled R.C. frames under seismic loads should be modelled 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.

3. 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, Fe 415 grade of steel is used for all the model cases considered in this study. The unit weight of concrete is taken as 25kN/m3. The unit weight for brick masonry infill and AAC/HCB block masonry infill are taken as $20 kN/m^3$ and $6.5\ kN/m^3$ respectively. The modulus of elasticity for concrete is taken as $[5000\,(fck)^{0.5}]$ which is equal to 25000MPa (as per IS: 456- 2000) and poison ratio is 0.2. The modulus of elasticity for brick masonry infill and AAC/HCB block masonry infill are taken as 2640MPa and 2040MPa respectively. The poison ratio for brick masonry is 0.16 and that of AAC block masonry is 0.25. The live load on floors is taken to be $3\ kN/m^2$ and $1kN/m^2$ 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 $3\ kN/m^2$ 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

Ei = modulus of elasticity of infill material
Ef = 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 Ic = moment of inertia of column
t = thickness of infill wall d = diagonal length of strut
θ = angle between diagonal of infill wall and the horizontal in radian

The RC Framed structure is modeled by using ETABS software for the following cases.

Currently only single strut model suggested by Main stone and week is used in linear static analysis of RC frames with infill walls.Contact length parameter which is given by Stafford Smith and his associates has been used.

The infills are modeled by single equivalent diagonal strut approach and its thickness is equal to infill 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 week 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.

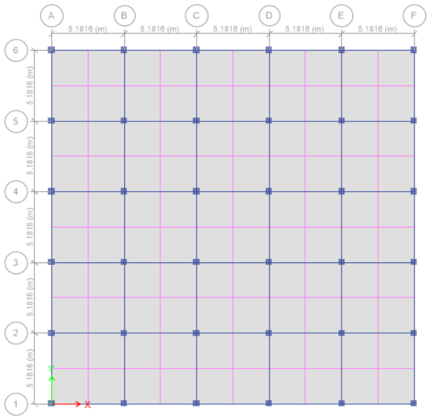


Fig. 3.1 RCC building with Conventional Clay bricks as infill material. (Plan of building with Conventional Clay Bricks as infill material)

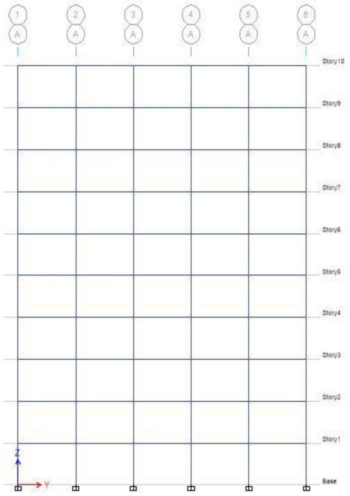


Fig3.2. Elevation 3D render view of building with Conventional bricks as inclined struts

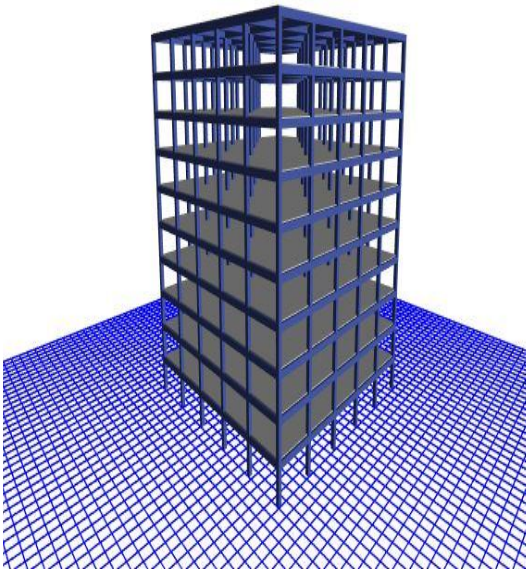


Fig. 3.3 3D Render view

Model 2: RCC building with AAC block as infill material (plan of AAC block)

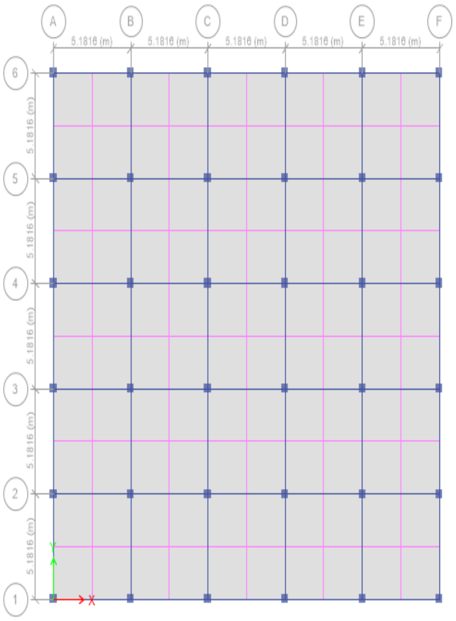


Fig. 3.4 RCC building with AAC bricks as infill material. (Plan of building with AAC Bricks as infill material)

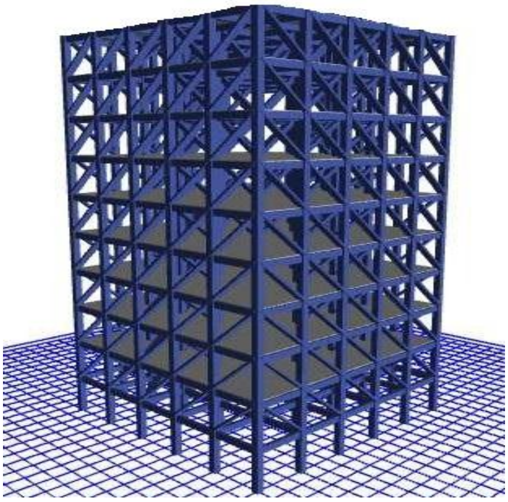


Fig.3.6 3D Render view

NO OF STORIES	G+10
EACH STOREY HEIGHT	3 m
THICKNESS OF SLAB	150 mm
GRAD OF CONCRETE	M20
GRAD OF STEEL	Fe415
SIZE OF BEAM	0.23mX0.35m
SIZE OF COLUMN	0.3mX0.3m
SIZE OF COLUMN	0.150mm
DENSITY OF BRICK INFILL	20 kN/m3
DENSITY OF ACC INFILL	6.5 kN/M3

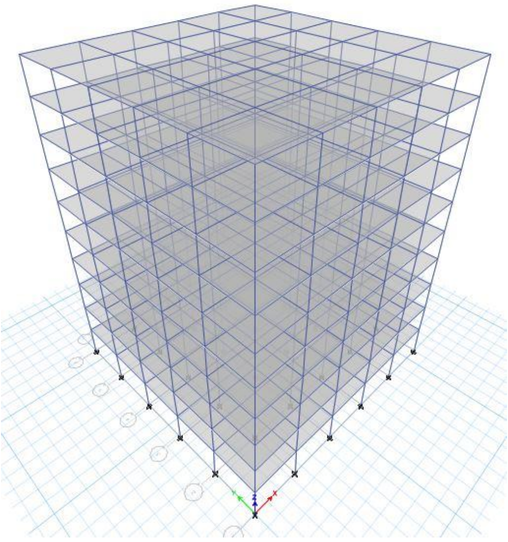


Fig.3.7 3d view

4. RESULT AND DISCUSSION

The seismic analysis for the all RC frame models are consist of brick infill (M-1), model with full infill (modeling infill as a AAC block infill element) (M-2) and full infill with 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 presented below. The parameters which have 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.

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	load Case/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 shows that, the minimum cost of building and maximum strength of AAC brick wall in a building can helps to reduce the deflection and story drift in a building. Some studies deals 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 presented 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 cases 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

	Brick masonry			**AAC block masonry**			**Hollow Concrete Block**		
Storey	**Bare frame**	**Infill frame**	**Infill with ground soft store**	**Bare frame**	**Infill frame**	**Infill with ground soft store**	**Bare frame**	**Infill frame**	**Infill with ground soft store**
			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

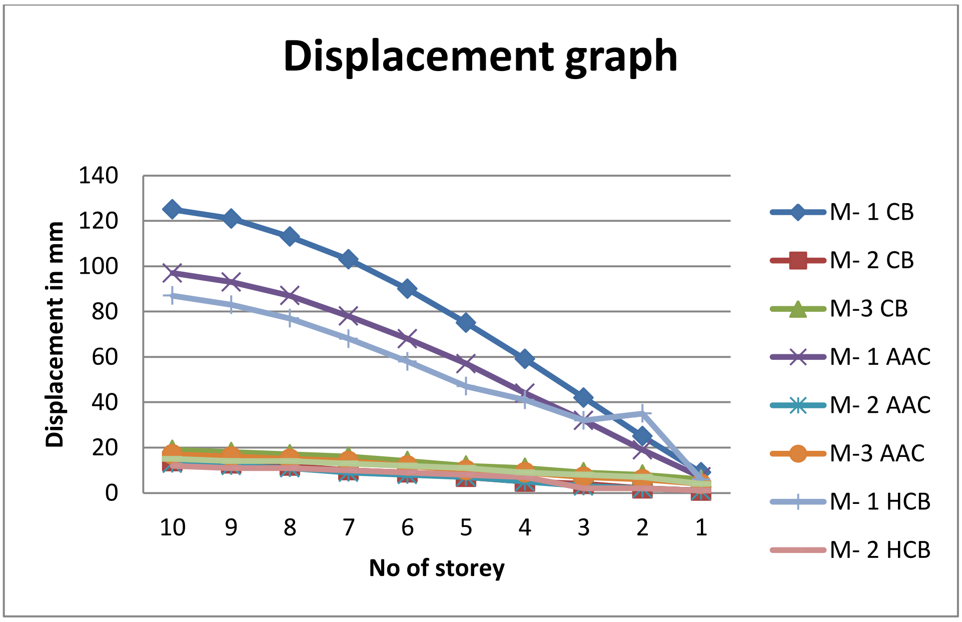


Chart-1: Displacement in X direction for all models

Storey drift (mm)

Storey drift in AAC block 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.

Table-4: Storey drifts (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
	M-1 CB	M-2 CB	M-3 CB	M-1 ACC	M-2 ACC	M-3 ACC	M-1 HCB	M-2 HCB	M-3 HCB
10	0.001 377	0 239	0 239	0.001 165	0 222	0 222	0.001 145	0 202	0 212
9	0.002 383	0 369	0 368	0.001 92	0 336	0 335	0.001 72	0 326	0 325
8	0.003 339	0 47	0 468	0.002 616	0 425	0 425	0.002 616	0 415	0 415
7	0.004 104	0 533	0 531	0.003 168	0 483	0 482	0.003 108	0 483	0 465
6	0.004 672	0 563	0 56	0.003 577	0 514	0 513	0.003 577	0 510	0 483
5	0.005 61	0 563	0 56	0.003 857	0 52	0 519	0.003 857	0 42	0 519
4	0.005 287	0 538	0 536	0.004 17	0 505	0 505	0.004 17	0 495	0 505
3	0.005 316	0 491	0 474	0.004 34	0 474	0 464	0.004 134	0 474	0 434
2	0.004 899	0 432	0 624	0.003 714	0 433	0 587	0.003 714	0 413	0 577
1	0.002 794	0 3	0.001 796	0.002 117	0 308	0.001 336	0.002 97	0 298	0.001 336

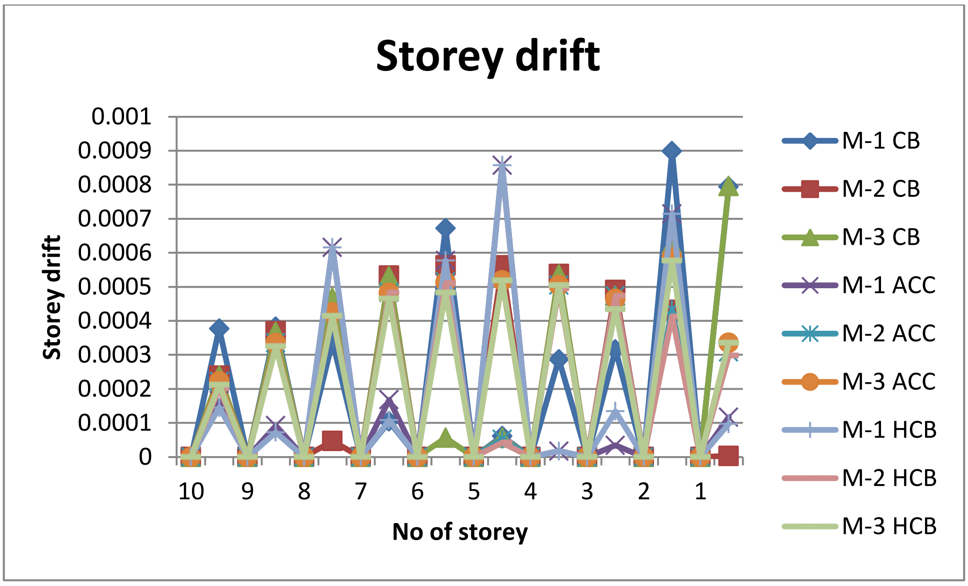


Chart-2: Storey drift in all models

Storey shear (KN)

The decrease in the storey shear in AAC block masonry is found 28% in case 1 for bare frame model ,35% in case 2 for full infill masonry and 34% in case 3 for full infill ground soft storey.

Table-5: Storey shear 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
	M-1	M-2	M-3	M-1	M-2	M-3	M-1	M-2	M-3
10	672 85	725 79	722 5	618 22	636 42	635 8	618 22	636 42	635 8
9	672 85	725 79	722 5	618 22	636 42	635 8	618 22	636 42	635 8
9	1514 0.92	1653	1645 0.52	1225 0.5	1272 0.26	1269 0.56	1225 0.5	1272 0.26	1269 0.56
8	1514 0.92	1653	1645 0.52	1225 0.5	1272 0.26	1269 0.56	1225 0.5	1272 0.26	1269 0.56
8	2180 0.25	2385 0.61	2374 0.82	1705 0.33	1774 0.64	1770 0.89	1705 0.33	1774 0.64	1770 0.89
7	2180 0.25	2385 0.61	2374 0.82	1705 0.33	1774 0.64	1770 0.89	1705 0.33	1774 0.64	1770 0.89
7	2689 0.64	2946 0.52	2933 0.19	2072 0.7	2159 0.28	2154 0.72	2072 0.7	2159 0.28	2154 0.72
6	2689 0.64	2946 0.52	2933 0.19	2072 0.7	2159 0.28	2154 0.72	2072 0.7	2159 0.28	2154 0.72

6	3063 0.89	3358 0.61	3343 0.42	2342 0.6	2441 0.88	2436 0.71	2342 0.6	2441 0.88	2436 0.71
5	3063 0.89	3358 0.61	3343 0.42	2342 0.6	2441 0.88	2436 0.71	2342 0.6	2441 0.88	2436 0.71
5	3323 0.79	3644 0.79	3628 0.3	2530 0.03	2638 0.12	2632 0.54	2530 0.03	2638 0.12	2632 0.54
4	3323 0.79	3644 0.79	3628 0.3	2530 0.03	2638 0.12	2632 0.54	2530 0.03	2638 0.12	2632 0.54
4	3490 0.12	3827 0.94	3810 0.62	2649 0.99	2763 0.72	2757 0.87	2649 0.99	2763 0.72	2757 0.87
3	3490 0.12	3827 0.94	3810 0.62	2649 0.99	2763 0.72	2757 0.87	2649 0.99	2763 0.72	2757 0.87
3	3583 0.69	3930 0.97	3913 0.18	2717 0.46	2834 0.37	2828 0.37	2717 0.46	2834 0.37	2828 0.37
2	3583 0.69	3930 0.97	3913 0.18	2717 0.46	2834 0.37	2828 0.37	2717 0.46	2834 0.37	2828 0.37
2	3625 0.27	3976 0.76	3958 0.76	2747 0.45	2865 0.77	2859 0.7	2747 0.45	2865 0.77	2859 0.7
1	3625 0.27	3976 0.76	3958 0.76	2747 0.45	2865 0.77	2859 0.7	2747 0.45	2865 0.77	2859 0.7
1	3635 0.66	3988 0.2	3969 0.65	2754 0.95	2873 0.62	2867 0.37	2754 0.95	2873 0.62	2867 0.37

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

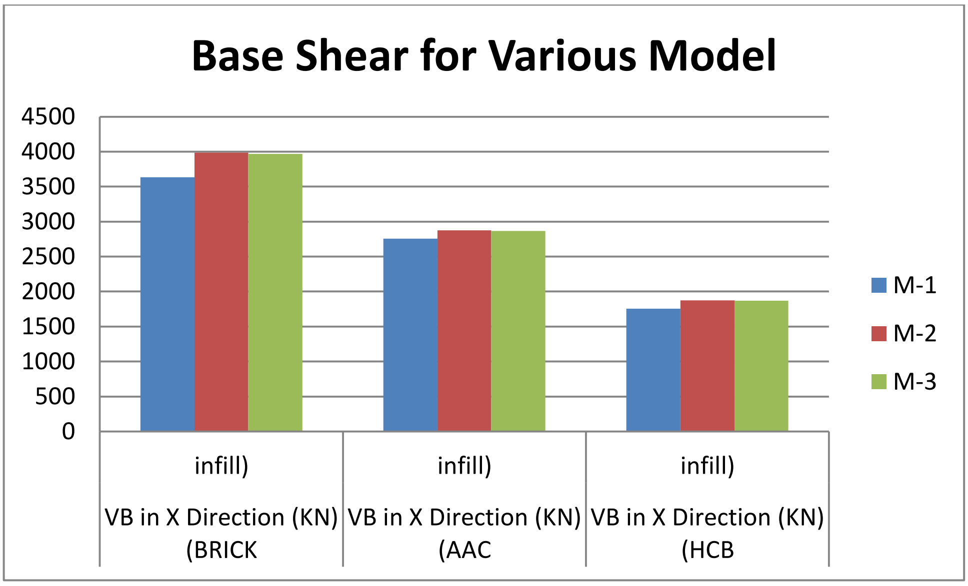


Fig Base shear for various models

Axial forces (KN)

For comparison column C1 has been chosen and the axial forces at the mid height of column C1 are found which are presented below

Table-6: Axial forces at Various Storey Level in column C1

Storey	Brick masonry			AAC block masonry			AAC block masonry		
	Bare frame	Infill frame	Infill with gro nd soft storey	Bare frame	Infill frame	Infill with ground soft storey	Bare frame	Infill frame	Infill with ground soft storey
	M-1	M-2	M-3	M-1	M-2	M-3	M-1	M-2	M-3
10	195	352	352	167	266	267	167	266	267
9	471	771	773	365	556	557	365	556	557
8	721	1162	1164	544	825	827	544	825	827
7	951	1529	1533	707	1077	1079	707	1077	1079
6	1162	1875	1880	857	1313	1315	857	1313	1315
5	1359	2200	2206	996	1533	1537	996	1533	1537
4	1544	2505	2513	1125	1739	1743	1125	1739	1743
3	1719	2790	2801	1248	1929	1935	1248	1929	1935
2	1890	2014	3035	1367	2102	2090	1367	2102	2090

1	2072	3280	3279	1493	2254	2263	1493	2254	2263

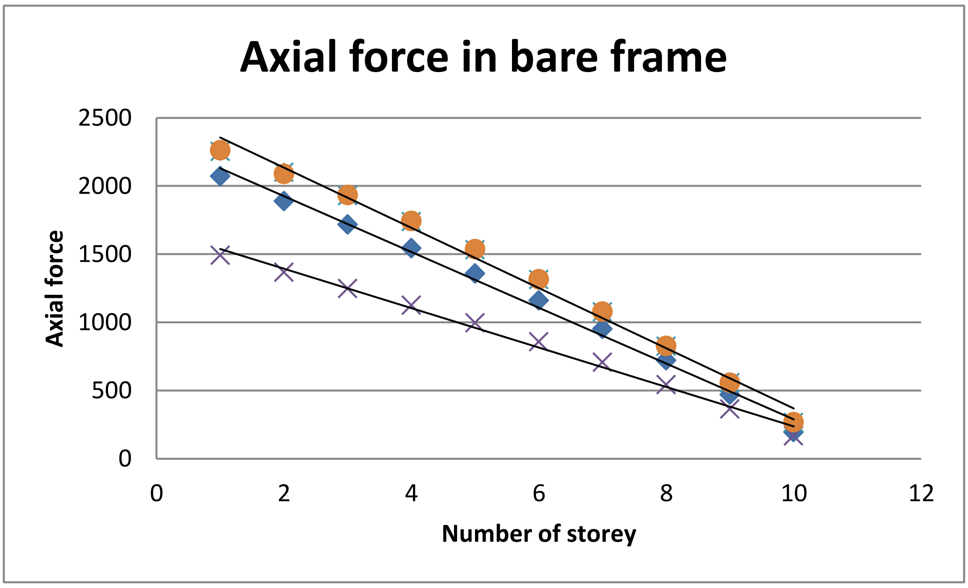


Chart-3: Axial force in bare frame

Bending moment (KN-m)

For comparison Beam B1at every floor has been selected and the Bending moment at a distance 0.25m from the end is found out and results are presented below in the form of bar chart. The all Bending moments are shown here in the table with (-) sign but for comparison point of view only amplitude is considered.

Table-7: BM (KN-m) at various storey level in Beam B1

Storey	Brick masonry			AAC block masonry			HCB block masonry		
	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
	M-1	M-2	M-3	M-1	M-2	M-3	M-1	M-2	M-3
10	86.7	71.9	71.9	73	63	63.1	75	75	55
9	123	106	107	95	83	83.3	95	55	62
8	119	106	106	91	81	81.6	85	71	85.2
7	117	107	107	89	82	82.6	89	86	76.32
6	114	108	108	86	82	82.5	76	72	71

	505								
5	110	108	108	83	82	82.2	873	70	81
4	105	108	108	79	81	81.5	63	81	79.5
3	99.6	107	107	74	80	80.3	65	80	80.3
2	93.4	106	107	69	78	79.4	69	66	79.4
1	83.2	103	93.1	61	76	68.5	61	76	68.5

CONCLUSION

The following conclusions can be enumerated point wise as follows:

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. 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, 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. 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. 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. 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. 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. 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. 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 Base shear in model 2 is more than model 1 and model 3 because of increased mass of structure. 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. Masonry infill increases the axial forces in columns and it can be seen from the results also that axial forces are min. in model M-1 because in this model stiffness is not considered; only load of the infill is considered. Due to presence of infill the stiffness also increases in frame with increase of axial forces in column. The bending moment and shear forces in beam members of AAC block masonry structure is found less as compared to brick masonry. As the density of AAC block masonry is less (1/3rd of brick) as compared to brick masonry, the dead load of the structure is reduced in AAC block masonry and hence economy may be achieved in design by replacing brick masonry with AAC block masonry. From all 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 perform superior to that of brick masonry therefore AAC blocks 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.

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