Influence of Masonry Infill Walls on Seismic Performance of RC Framed Structures a Comparision of AAC and Conventional Brick Infill

Vikas P. Jadhao, Prakash S. Pajgade

Abstract—The construction of reinforced concrete buildings with unreinforced infill is common practice in India. Infill panels have traditionally 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 available in India to be used as masonry infill (MI) material in reinforced concrete (RC) framed buildings. The behavior of in-filled reinforced concrete (R/C) frames has been studied experimentally and analytically by a number of researchers. It has been recognized that infill materials give significant effect to the performance of the resulting in-filled frame structures. Most of the researches carried out in this area are focused on parameters such as the distribution of MI, variation of geometry, the strength of infill materials and the relative stiffness of infill to frame elements. The study of the effect of types of infill materials used (lightweight versus conventional brick masonry) on the behavior of in-filled R/C frames is however still limited. Previous experimental study has concluded that the R/C frame in-filled with AAC blocks exhibited better performance under lateral loads than that in-filled with conventional clay bricks. In the present paper an investigation has been made to study the behaviour of RC frames with both AAC block and conventional clay bricks infill when subjected to seismic loads.

Index Terms— AAC (autoclaved aerated light weight concrete blocks), FEMA 273, FEMA 356, in-filled frames.

I. INTRODUCTION

Earthquake engineering has come a long way since its birth and it seems to grow rapidly as we gain experience. Each time an earthquake happens, something new is available to learn. Reinforced concrete buildings with masonry infill are most common type of construction in India. The ordinarily occurring vertical loads i.e. dead load and live load, do not pose much of a problem but the lateral loads due to earthquake tremors are a matter of great concern and need special consideration in the design of such buildings. For functional and architectural requirements Masonry walls are provided in RC structures. The term infilled frame is used to represent a composite structure formed by the combination of a moment resisting RC frame & Infill walls. The Infill walls can be of conventional clay brick (CB), concrete block or AAC block.

The behavior of in-filled RC frames has been studied experimentally and analytically by a number of researchers. It has been recognized that infill materials significantly affect the seismic performance of the resulting in-filled frame structures. Most of the research work carried out in this area is focused on parameters such as the variation of distribution of MI and the stiffness of frame elements. The study of the effect of types of infill materials used (i.e. AAC block versus conventional brick masonry) on the seismic performance of in-filled RC frames is however still limited. In the present study seismic performance of ALC blocks & conventional bricks infill panel in RC frames are compared using SAP2000.

II. AAC BLOCKS

AAC was developed by an architect Dr. Johan Eriksson in 1923 at the Royal Technical Institute in Stockholm, Sweden, and was patented for manufacturing in 1924. Today, AAC is used in 135 countries of 6 continents worldwide.

Fig.1. AAC block Masonry

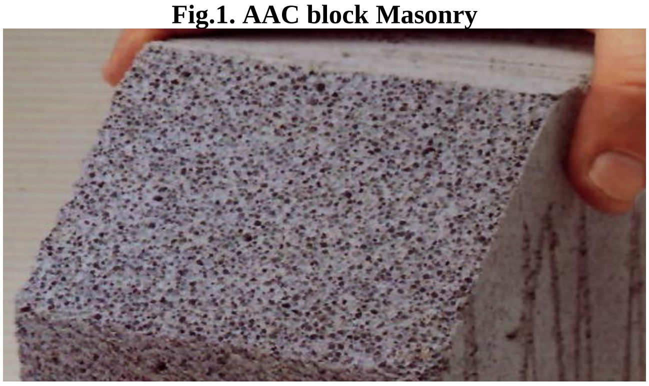

Fig.2-Porous structure of AAC block

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Autoclaved aerated concrete (AAC) block is a lightweight MI material and has been introduced in Indian construction market recently. AAC block is a light weight materials used as an infill material. The density of AAC is approximately 1/3rd to 1/4th of conventional clay brick unit. It is well known that the lesser the weight of infill material used the less will be the earthquake forces generated in the structure. The experimental result shows that the RC frame infilled with AAC blocks exhibited better performance under in plane lateral loads than that of infilled with conventional clay bricks.

III. MODELLING OF MASONRY INFILLS

The elastic in-plane stiffness of a solid unreinforced masonry infill panel prior to cracking shall be represented with an equivalent diagonal compression strut of width, a, given by equation 1.

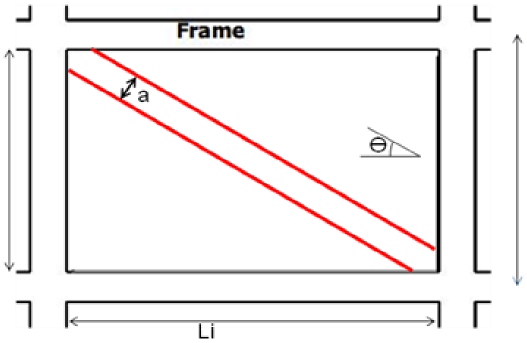

Fig. 3. Modeling MI walls as diagonal strut

Parameters are given below for finding out width of strut.

$$a = 0.175 \cdot (\lambda \cdot h)^{-0.4} d \qquad \text{Eq. 01}$$

$$\lambda = \sqrt[4]{\frac{E_i\, t\, \sin(2\theta)}{4\, E_f\, I_c\, h}} \qquad \text{Eq. 02}$$

And

$$\theta = \tan^{-1}(h_i / L_i)$$

Where:

Λ = Coefficient depending on properties of infill and frame,

H = Column height between centerlines of beam, in

hi = Height of infill panel, in,

Li = Length of brick infill panel, in

E_f = Expected modulus of elasticity of frame material, psi

E_i = Expected modulus of elasticity of infill materials, psi

I_c = Moment of inertia of column, in^4,

D = Diagonal length of infill panel, in

t = Thickness of infill panel and equivalent strut, in

Θ = Angle whose tangent is the infill height-to-length aspect ratio, radians.

The equivalent strut shall have the same thickness and modulus of elasticity as the infill panel it represents. The tensile strength of masonry is negligible and only compression diagonal strut is liable to resist the lateral load properties of brick masonry infill. The Strut is provided with hinges at ends to so that the strut doesn't carry any moment.

IV. LATERAL LOAD CALCULATION

The building under consideration is analyzed using seismic coefficient method. The following expression is used to calculate the lateral load pattern as per IS 1893 (Part-I): 2002.

$$V_B = A_h W \qquad \text{Eq. (03)}$$

$$Qi = VB \frac{Wihi^2}{\sum_{i=1}^{n} Wihi^2} \qquad \text{Eq. (04)}$$

Where,

VB = Design Base Shear as per IS 1893(Part-I): 2002 ,

Qi = Lateral Force at Floor i ,

Wi = Seismic weight of floor i ,

hi = Height of ith floor measured from base and

N = Number of storey in the building.

V. DATA TABULATION

In this study models of G+3 building is considered. A bare frame model and a model with full infill is considered for conventional brick masonry and AAC block masonry each. The dimensions of building are as shown in figure 4. The weight density of concrete is 25 KN/m^3, Grade of concrete used is M20, modulus of elasticity of concrete and steel are 22360.67x10^3 N/mm^2 and 2x10^{8}KN/m^2, grade of steel is fe-415 and Live load is 3 KN/m^2.

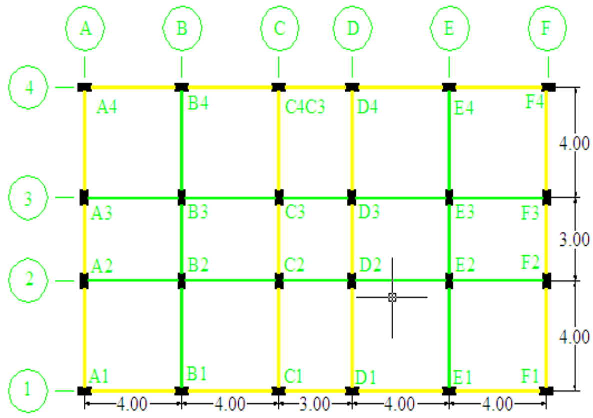

Fig.4. Plan of Building

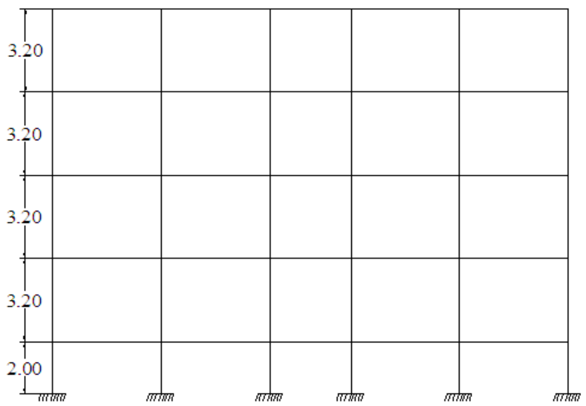

Fig.5. Elevation of Building

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The thickness of infill used is 230mm and 115 mm thick for conventional clay brick and 200 mm and 100 mm thick for AAC blocks. The building is situated in zone IV thus zone factor is 0.24. Response reduction factor is 5 and importance factor is 1. For conventional clay brick masonry the unit weight is 20 KN/m^3, modulus of elasticity is 3500 N/mm^2 and poisons ratio is 0.16. The details of RC building considered in present study are as below. For AAC block masonry the unit weight is 7 KN/m^3, modulus of elasticity is 2600 N/mm^2 and poisons ratio is 0.25.

VI. RESULTS AND DISCUSSION

A. Base Shear

It has been also observed that the base shear for model with conventional clay bricks was 744.88 KN whereas for model with AAC blocks it was 483.9 KN. Thus the lateral forces experienced by model with AAC blocks are less as compare with model with conventional bricks. Also the dead load on building with AAC blocks is less as compared to model with clay bricks. Thus Lesser the lateral forces and lesser dead load will results in lesser member forces which ultimately results economical design.

Table I. Base shear for various models with Conventional clay brick masonry

BASE SHEAR	With Conventional Bricks	With AAC BLOCKS
VBx	744.88	483.9
VBy	744.88	483.9

B. Axial Force

The comparison of axial force in column B1 and B2 for Bare frame models is as shown in table 2.

Table II. The comparison of axial force in column B1 and B2 for Bare frame models

STORY LEVEL	Column No.	P (KN) (Bare frame with CB)	P (KN) (Bare frame with AAC)	% Difference
4	B1 (25)	121.64	102.59	18.57
3	B1 (24)	333.45	245.68	35.72
2	B1 (23)	545.50	388.80	40.31
1	B1 (22)	757.32	531.56	42.47
0	B1 (21)	883.28	587.04	50.46
4	**B2 (55)**	156.10	155.67	0.28
3	**B2 (54)**	418.98	363.38	15.30
2	**B2 (53)**	682.03	571.89	19.26
1	**B2 (52)**	947.24	782.70	21.02
0	**B2 (51)**	1052.39	833.83	26.21

C. Column Moments

The comparison of column moments in column B1, B2 for Bare frame model and model with full infill is as shown in Figure 6, Figure 7.

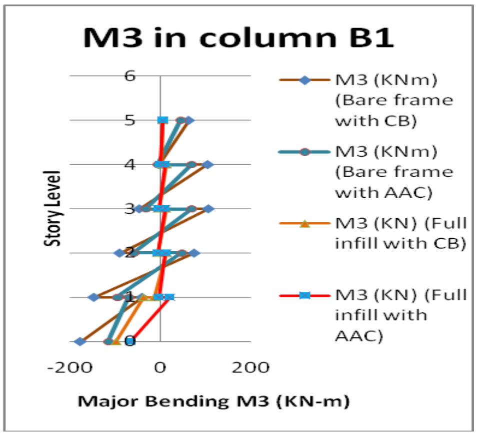

Fig.6. The comparison of major bending B1

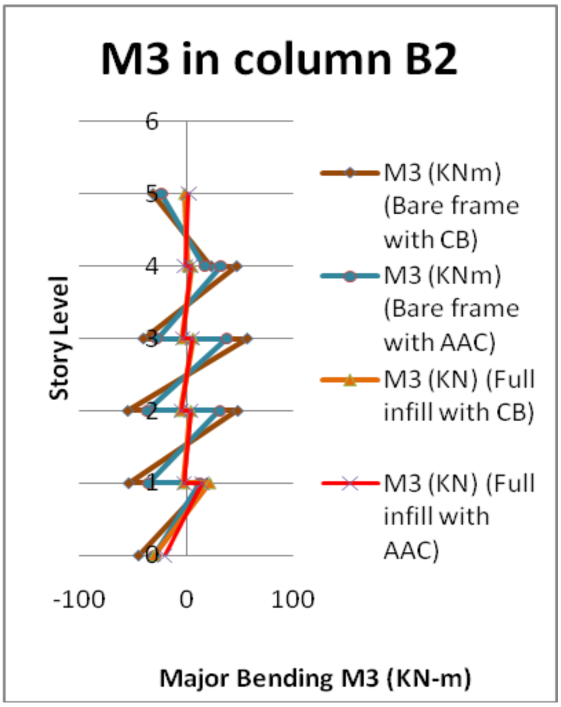

Fig.7. The comparison of major bending M3 in column M3 in column B2

D. Lateral Displacement

Next, the effect of infill on the lateral displacement is studied for bare frame model and model with full infill (i.e. modeling infill as a strut element). The floor displacements are presented in Figure 8.

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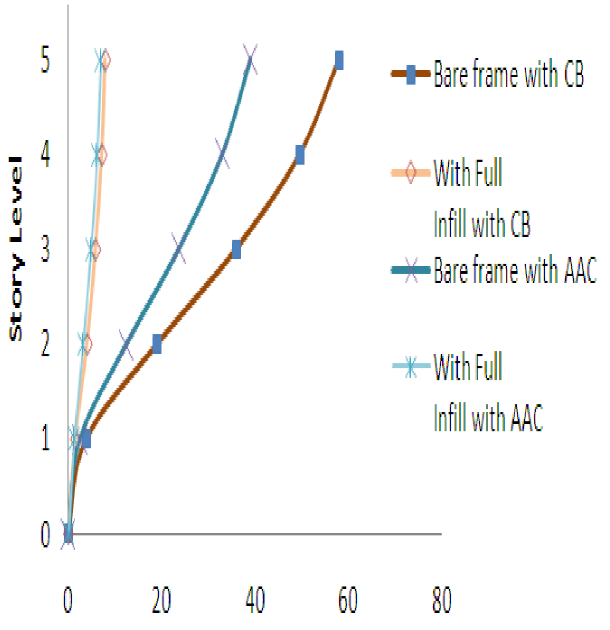

Fig.8. Floor Displacement in X- direction

E. Ast Comparison

It is well known that the lesser the weight of infill material used the less will be the earthquake forces generated in the structure. The density of AAC is approximately 1/3rd to 1/4th of conventional clay brick unit which results in reduction in Ast required to resist the loads. Also lesser weight will results in reduction in cross sectional dimensions of structural members.

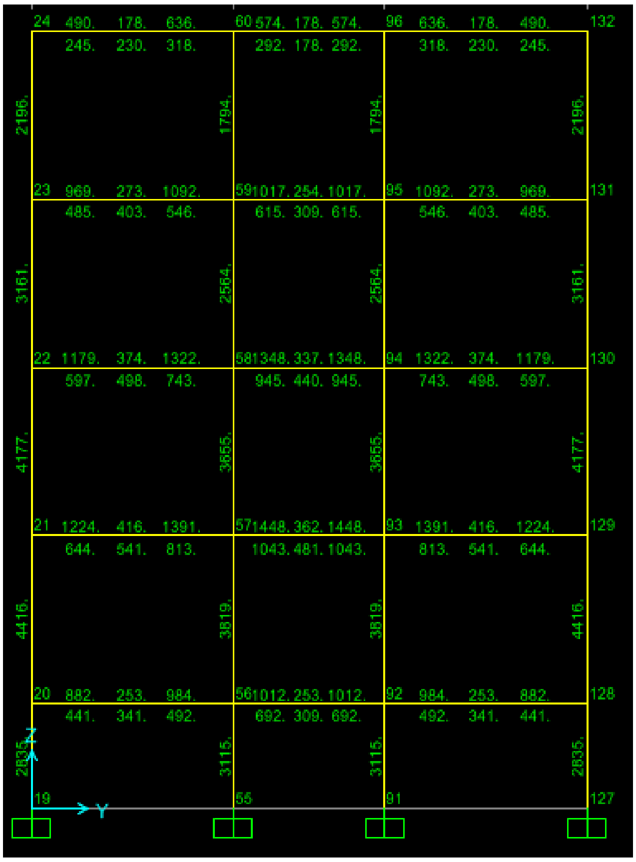

Fig.9. Ast for frame A and frame F with Conventional clay bricks (in mm2)

In this study a comparison has been made required amount of Ast when infill material is conventional clay bricks and AAC clocks keeping cross sectional dimensions of structural members same for both cases. Figure 9 to 14 shows the comparison of Ast for model with conventional clay bricks and AAC blocks.

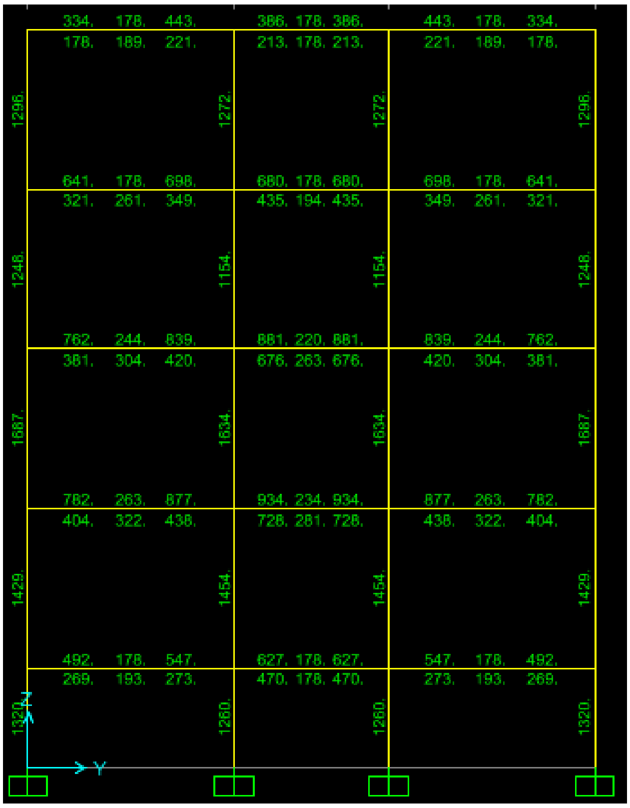

Fig.10. Ast for frame A and frame F with AAC Blocks (in mm2)

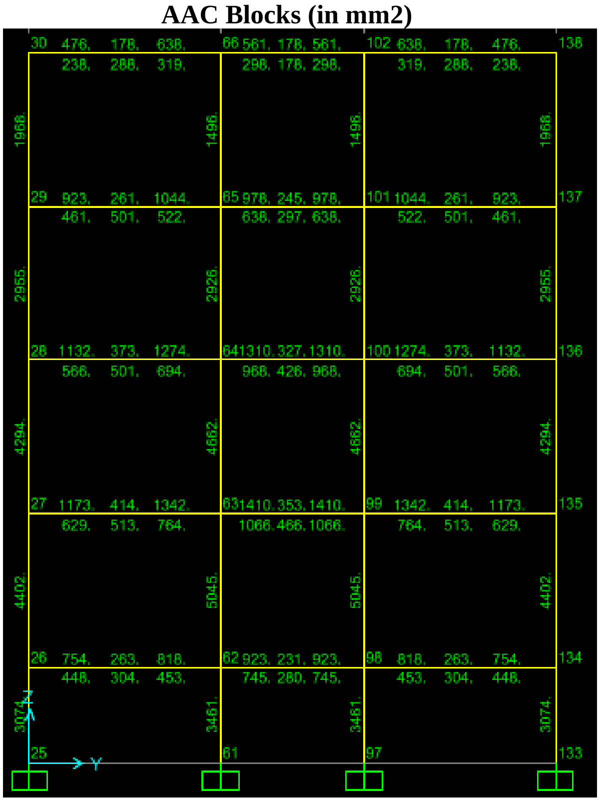

Fig.11. Ast for frame B and frame E with Conventional clay bricks (in mm^2)

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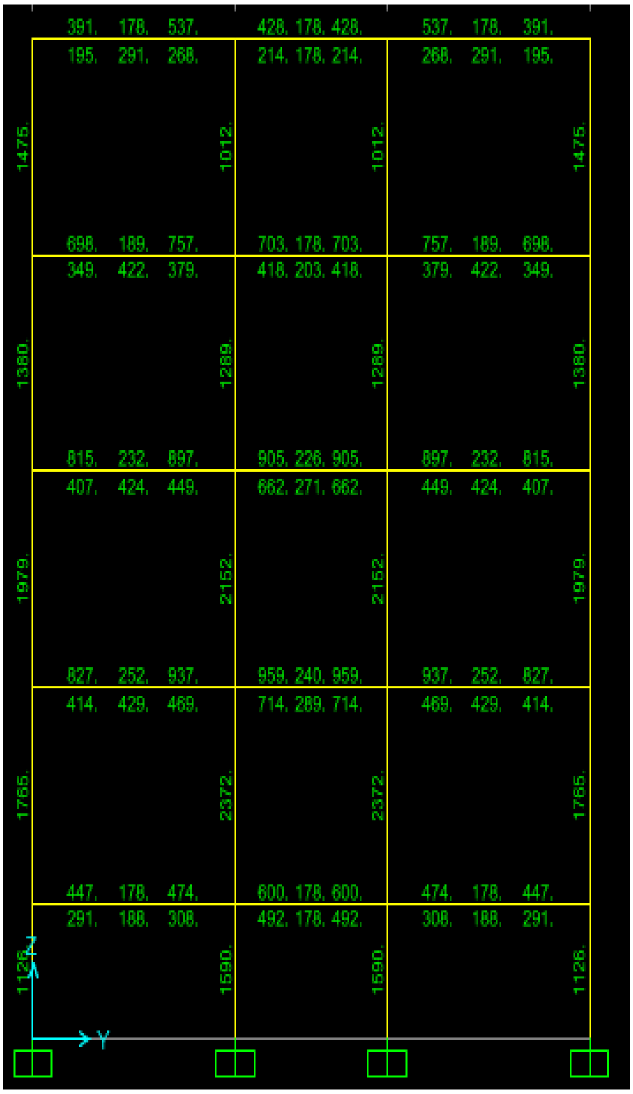

Fig.12. Ast for frame B and E Frame with AAC blocks (in mm^2)

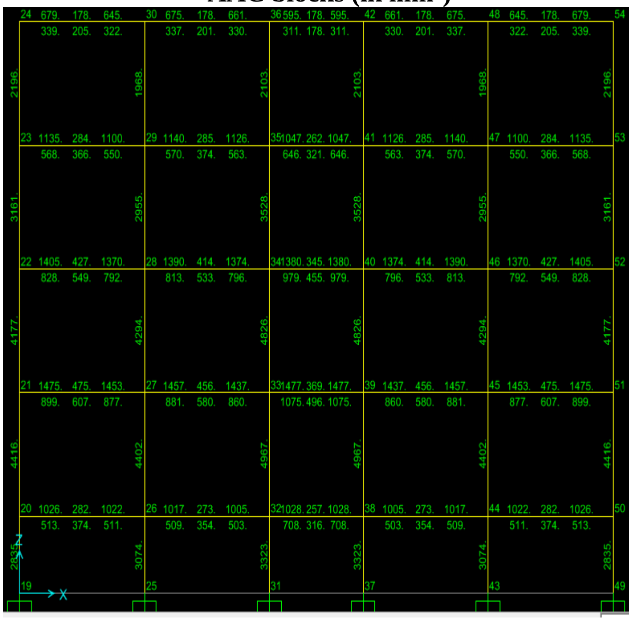

Fig.13. Ast for frame 1 and frame 4 with Conventional clay bricks (in mm^2)

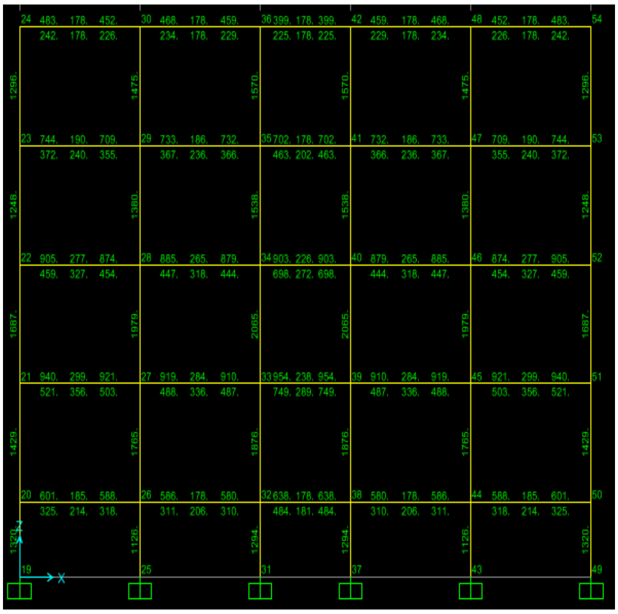

Fig.14. Ast for frame 1 and Frame 4 with AAC blocks (in mm^2)

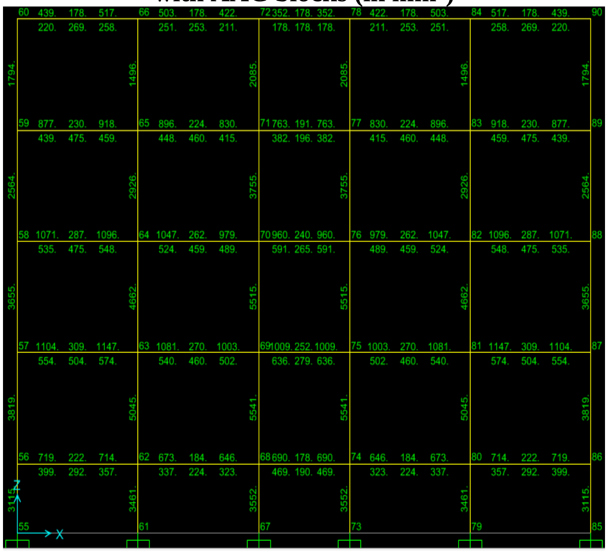

Fig.15. Ast for frame 2 and frame 3 with Conventional clay bricks (in mm^2)

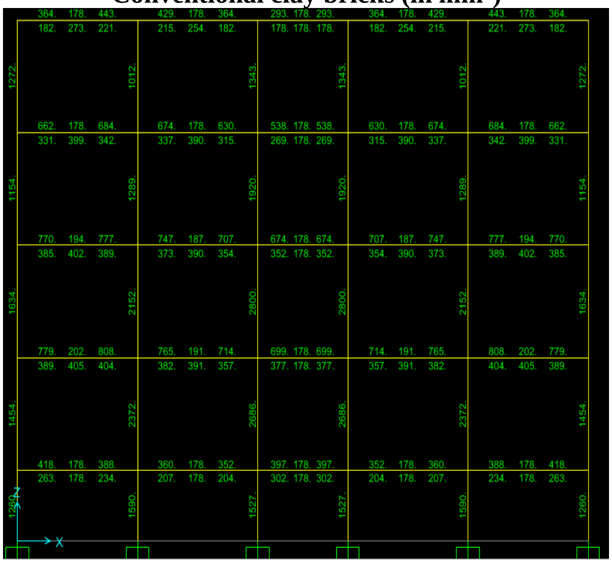

Figure b. Ast for frame 2 and Frame 3 with AAC blocks (in mm^2)

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VII. CONCLUSIONS

In this study the influence of masonry infill on the seismic response of multi-storeyed building under seismic loading is illustrated through typical examples. It has been found that the Indian standard codal provisions do not provide any guidelines for the analysis and design of RC frames with infill panels. It has been also found that the presence of infill reduces the displacement capacity of structure and modifies the structural force distribution significantly. The base shear experienced by models with AAC blocks was significantly smaller than with conventional clay bricks which results in reduction in member forces which leading to reduction in required amount of Ast to resist member forces. So economy in construction can be achieved by using AAC blocks instead of conventional clay bricks. The performance of AAC block infill was superior to that of Conventional brick infill in RC frame. Therefore, the ALC block material can basically be used to replace conventional bricks as infill material for RC frames built in the earthquake prone region. If we compare the performance of frame with full infill as conventional clay bricks and AAC blocks was significantly superior to that of bare frame.

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