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Seismic Behaviour of open Ground Storey RC Framed Building with infill Walls

Comparison of Frames with AAC Blocks and Brick infill Walls with Varying Horizontal Aspect Ratio

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***Abstract*—Infill walls in framed buildings provide lateral stiffness to the structure. AAC (Autoclaved Aerated light weight Concrete) blocks are one of the available light weight and flexible infill materials. In this study, response spectrum analysis has been carried out using STAAD.Pro software to understand the seismic behaviour of open ground storey RC framed building with AAC infill walls. Models of varying horizontal aspect ratio were considered for the analysis. A comparison of the results such as base shear, displacement and storey drift of these models was made with that of the brick infilled framed models.**

Keywords—Infill Walls; AAC Blocks; Horizontal Aspect Ratio

I. INTRODUCTION

Open ground storey is adopted in many framed building constructions as it provides parking facilities. Inadequate lateral strength and stiffness of the soft storey tends the building to collapse during earthquake. Infill wall panels are used in framed buildings to subdivide the internal spaces of the building or to create an envelope or facade for the building. The IS code provisions do not give any guidelines for the analysis of RC frames with infill walls. The masonry infill panels in buildings are generally not considered for the design process and may be treated as non structural or architectural components. But, the presence of masonry infill panels has a significant impact on the seismic response of RC framed buildings. The presence of infill walls reduces lateral deflections and hence reduces the probability of collapse.

AAC (Autoclaved Aerated light weight Concrete) was developed in 1923 by an architect, Dr. Johan Eriksson, at the Royal Technical Institute in Stockholm, Sweden. In 1924, he was patented for manufacturing AAC blocks. The approximate size of AAC block is 600 / 625 mm × 200 / 240 mm × 100-300 mm. The density is approximately 1/3 rd of conventional clay brick unit. One of the major advantages of AAC over other cementacious construction materials is its lower impact on environment. It has less efflorescence emission. It possess high thermal insulation. It is easy and quick to install since the material can be routed, and cut to size on site using standard carbon steel band saws, hand saws, and drills. Today, AAC is used in many countries across worldwide. The important aspects affecting seismic configuration of buildings are overall geometry, structural systems, and load paths. This paper focuses on the effect of Horizontal or Plan Aspect Ratio (L/B ratio) on open ground storey RC framed building with AAC and brick infill walls, where B is the Base width and L is the Length of the building frame.

II. DETAILS OF THE STRUCTURE

A. Modelling and Analysis

In the present study, four building models having different horizontal aspect ratios of 1, 2, 3 & 4 have been considered and the influence of these varying horizontal aspect ratios on the seismic performance of the open ground storey RC framed buildings is demonstrated, by providing infill walls of two materials, namely, brick and AAC, using the parameters for the design as per IS-1893- 2002-Part-1 for the seismic zone V. The models are analyzed by Linear Elastic Dynamic Analysis (Response Spectrum analysis) with the help of STAAD.Pro software and the results obtained are summarized and compared. The models used for the analysis are as follows.

1) 12 storey 2 bay frame with AAC and brick infill walls.

   (*L/B* =12/12 = 1) (Fig.1)

2) 12 storey 4 bay frame with AAC and brick infill walls.

   (*L/B* =24/12 = 2) (Fig.2)

3) 12 storey 6 bay frame with AAC and brick infill walls.

   (*L/B* =36 /12 =3) (Fig.3)

4) 12 storey 8 bay frame with AAC and brick infill walls.

   (*L/B* =48/12 = 4) (Fig.4)

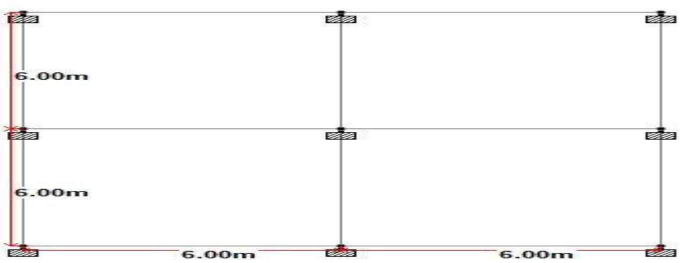

Fig. 1. Plan of the building with horizontal aspect ratio 1

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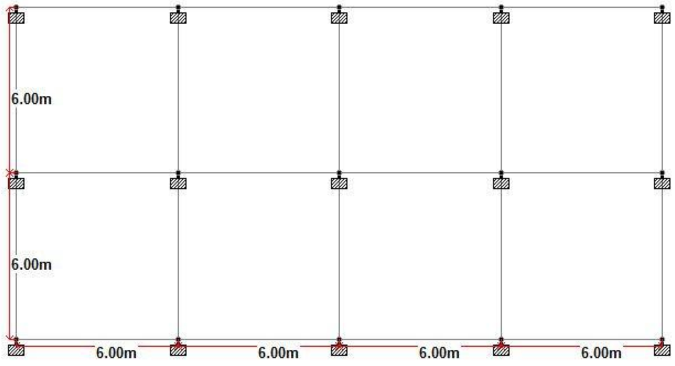

Fig. 2. Plan of the building with horizontal aspect ratio 2

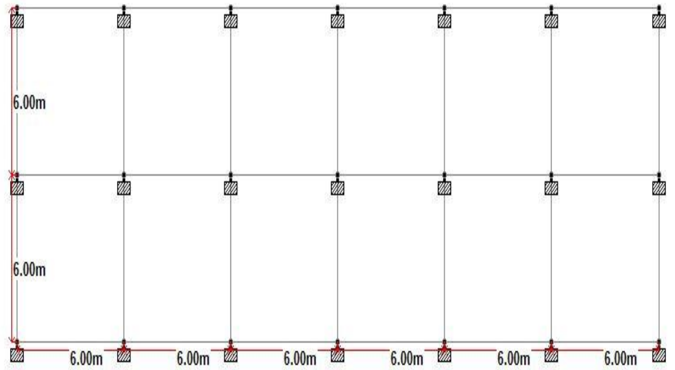

Fig. 3. Plan of the building with horizontal aspect ratio 3

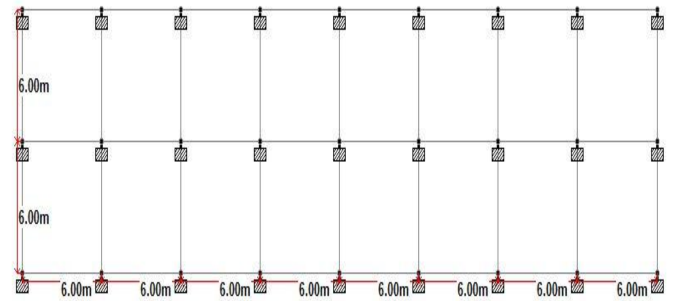

Fig. 4. Plan of the building with horizontal aspect ratio 4

B. Assumptions

In the analysis, the height of all the building models is kept as 36 m. From the ground, these buildings are of 12 storey's. The height of each floor is 3 m. The foundation depth is 2 m. Fig.5, Fig.6, Fig.7 and Fig.8 shows the 3-D rendered view of the building for various horizontal aspect ratios. Door and window openings are not considered while modelling.

C. Group Properties

The properties assigned to different components of the buildings are as follows.

Type of frame: Special RC moment resisting frame fixed at the base

Depth of Slab: 125 mm

Size of beam: 300 × 600 mm

Size of column: 800 × 800 mm

Spacing between frames:

6 m along X direction

6 m along Z direction

Materials: M 25 concrete, Fe 415 steel

Density of concrete: 25 kN/m^3

Poisson's Ratio of concrete: 0.2

Modulus of Elasticity of concrete: 25 kN/mm^2

D. Data for Infilled Frame

Thickness of infill wall: 230 mm

Density of brick infill: 18 kN/m^3

Density of AAC block infill: 7 kN/m^3

Poisson's Ratio of brick masonry: 0.16

Poisson's Ratio of AAC masonry: 0.25

Modulus of Elasticity of brick masonry: 3 kN/mm^2

Modulus of Elasticity of AAC: 3.5 kN/mm^2

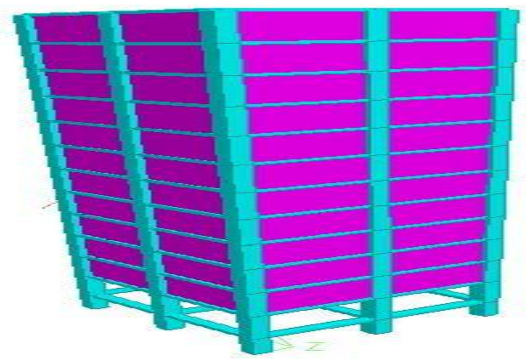

Fig. 5. 3-D rendered view of the building with horizontal aspect ratio 1

Fig. 6. 3-D rendered view of the building with horizontal aspect ratio 2

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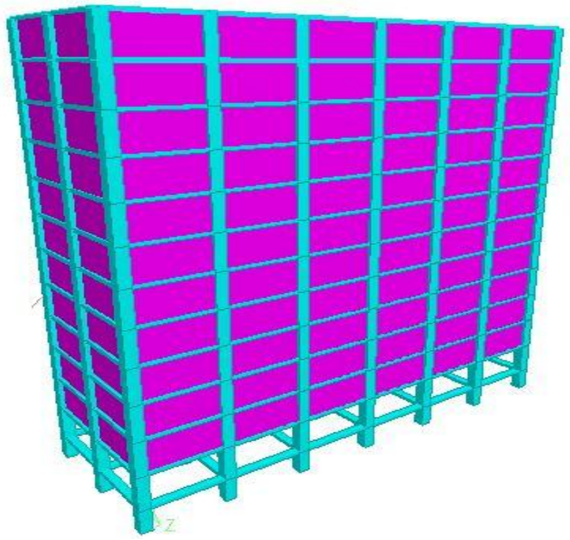

Fig. 7. 3-D rendered view of the building with horizontal aspect ratio 3

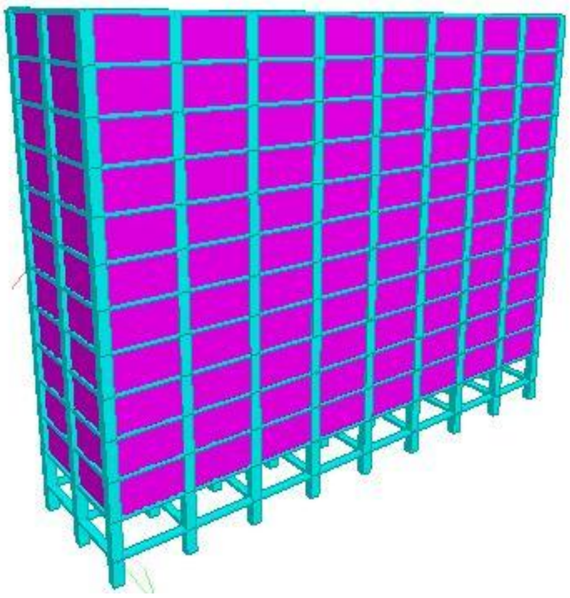

Fig. 8. 3-D rendered view of the building with horizontal aspect ratio 4

E. Description for Loading

The loading on the buildings are considered as given below.

1)*Dead Loads*

i)Floor finish: 1 kN/m^2

ii)Terrace water proofing: 2.5 kN/m^2

iii)Self weight of the building is automatically considered by the STAAD.Pro software.

2)*Live Load*

Live load on floor: 4 kN/ m^2

3)*Earthquake Forces Data*

Response spectra: As per IS 1893(Part-1):2002

Type of soil: Medium

Seismic zone: V

Zone factor, Z = 0.36

Response reduction factor, R = 5

Importance factor, I = 1

Damping of structure: 5 percent

III. RESULTS AND DISCUSSIONS

The response spectrum analysis of models with varying horizontal aspect ratios was done for earthquake zone V using STAAD.Pro software and the results obtained were tabulated. In table I, table II, table III and table IV, the displacement and storey drift for 2 bay frame, 4 bay frame, 6 bay frame and 8 bay frame are tabulated respectively. Base shear for different horizontal aspect ratios are given in table V.

The four building models are analyzed by providing infill walls of the two materials. Graphs are plotted for comparing the performance of buildings with AAC blocks and brick infill walls. Fig.9, fig.11, fig.13 and fig.15 shows the graph for displacement along X direction for 2 bay frame, 4 bay frame, 6 bay frame and 8 bay frame respectively. Fig.10, fig.12, fig.14 and fig.16 shows the graph for storey drift along X direction for 2 bay frame, 4 bay frame, 6 bay frame and 8 bay frame respectively. Base shear in X direction for various horizontal aspect ratios are plotted in fig.17.

As per clause 7.11.1 of IS-1893(Part – I): 2002, the storey drift in any storey due to the minimum specified design lateral force with partial load factor of 1 shall not exceed 0.004 times the storey height. Here, the maximum storey drift for the building of 3m storey height is 1.2 cm.

TABLE I. Displacement And Storey Drift For 2 Bay Frame

Storey Level	Displacement(cm)				Storey Drift(cm)			
	X Direction		*Z Direction*		*X Direction*		*Z Direction*	
	AAC	*Brick*	*AAC*	*Brick*	*AAC*	*Brick*	*AAC*	*Brick*
1	0.0676	0.0813	0.0676	0.0813	0.0676	0.0813	0.0676	0.0813
2	0.2555	0.309	0.2555	0.309	0.1879	0.2276	0.1879	0.2276
3	0.3462	0.4216	0.3462	0.4216	0.0907	0.1126	0.0907	0.1126
4	0.4204	0.5137	0.4204	0.5137	0.0742	0.0921	0.0742	0.0921
5	0.4901	0.6007	0.4901	0.6007	0.0698	0.087	0.0698	0.087
6	0.5575	0.6847	0.5575	0.6847	0.0674	0.0841	0.0674	0.0841
7	0.6242	0.7677	0.6242	0.7677	0.0666	0.0829	0.0666	0.0829
8	0.6904	0.8498	0.6904	0.8498	0.0662	0.0822	0.0662	0.0822
9	0.7554	0.9302	0.7554	0.9302	0.065	0.0804	0.065	0.0804
10	0.8175	1.0067	0.8175	1.0067	0.0621	0.0765	0.0621	0.0765
11	0.8744	1.0767	0.8744	1.0767	0.057	0.07	0.057	0.07
12	0.9242	1.1376	0.9242	1.1376	0.0498	0.0609	0.0498	0.0609
13	0.9669	1.1896	0.9669	1.1896	0.0427	0.052	0.0427	0.052

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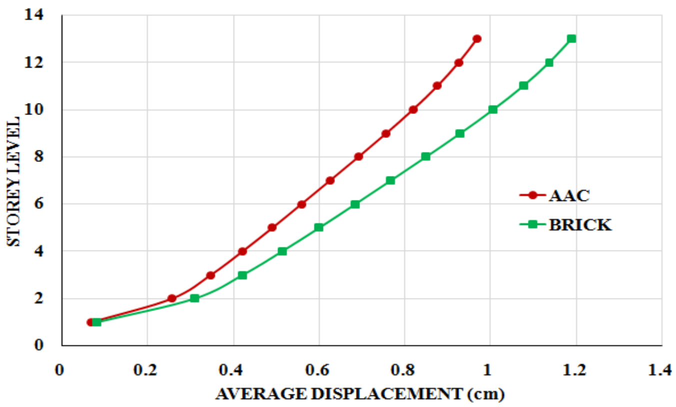

Fig. 9. Displacement along X direction for 2 bay frame (cm)

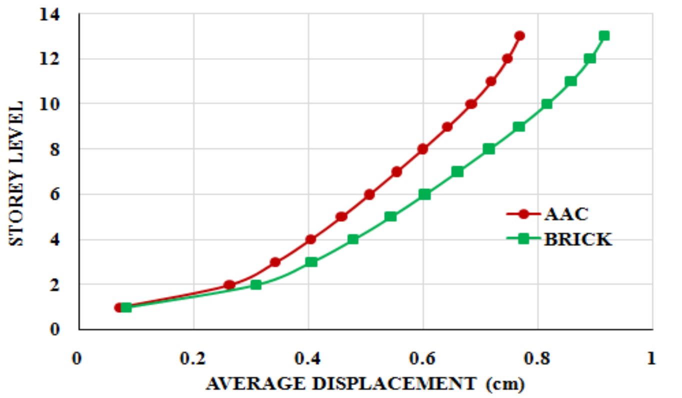

Fig. 11. Displacement along X direction for 4 bay frame (cm)

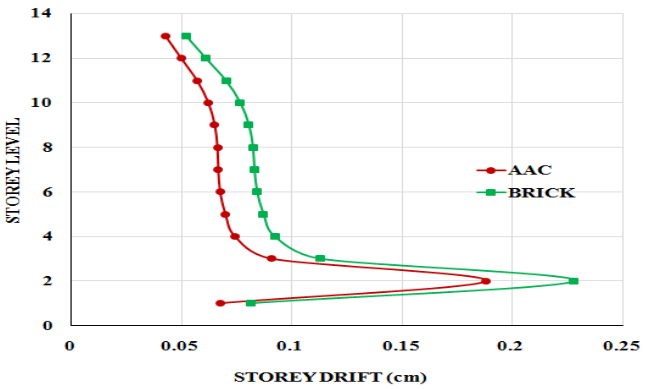

Fig. 10. Storey drift along X direction for 2 bay frame (cm)

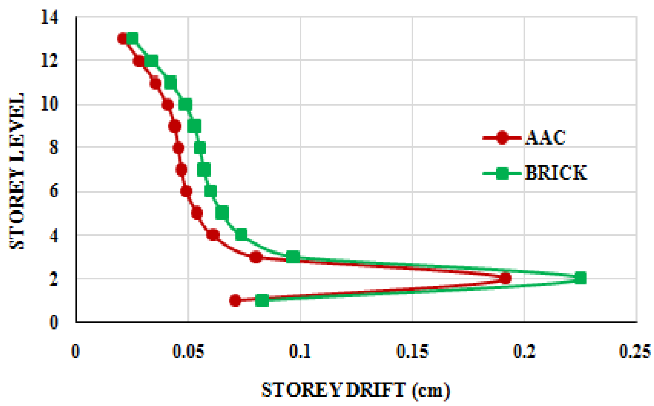

Fig. 12. Storey drift along X direction for 4 bay frame (cm)

TABLE II. Displacement And Storey Drift For 4 Bay Frame

Storey Level	Displacement(cm)				Storey Drift(cm)			
	X Direction		*Z Direction*		*X Direction*		*Z Direction*	
	AAC	*Brick*	*AAC*	*Brick*	*AAC*	*Brick*	*AAC*	*Brick*
1	0.0709	0.0828	0.0392	0.0956	0.0709	0.0828	0.0392	0.0956
2	0.2624	0.3081	0.1587	0.3878	0.1915	0.2253	0.1195	0.2922
3	0.3423	0.4046	0.2455	0.6002	0.08	0.0966	0.0868	0.2124
4	0.4031	0.4779	0.3313	0.8087	0.0608	0.0733	0.0858	0.2085
5	0.4567	0.5428	0.4175	1.0173	0.0536	0.0649	0.0862	0.2086
6	0.5058	0.6024	0.5023	1.2217	0.0491	0.0596	0.0848	0.2043
7	0.5527	0.6591	0.5849	1.4202	0.0469	0.0567	0.0827	0.1985
8	0.5983	0.714	0.6646	1.6111	0.0455	0.0548	0.0796	0.191
9	0.642	0.7664	0.7397	1.7917	0.0438	0.0524	0.0751	0.1806
10	0.6826	0.8148	0.8081	1.9576	0.0406	0.0484	0.0684	0.1659
11	0.7179	0.8568	0.8674	2.104	0.0353	0.042	0.0593	0.1464
12	0.746	0.8901	0.9161	2.2277	0.0281	0.0333	0.0487	0.1238
13	0.767	0.9149	0.9558	2.3318	0.0209	0.0248	0.0397	0.1041

TABLE III. Displacement And Storey Drift For 6 Bay Frame

Storey Level	Displacement(cm)				Storey Drift(cm)			
	X Direction		*Z Direction*		*X Direction*		*Z Direction*	
	AAC	*Brick*	*AAC*	*Brick*	*AAC*	*Brick*	*AAC*	*Brick*
1	0.0724	0.0836	0.0935	0.108	0.0724	0.0836	0.0935	0.108
2	0.2662	0.309	0.3989	0.4623	0.1938	0.2254	0.3054	0.3543
3	0.3431	0.4008	0.6727	0.7822	0.0769	0.0918	0.2738	0.32
4	0.4002	0.4689	0.9663	1.1247	0.0571	0.0681	0.2937	0.3425
5	0.4494	0.5278	1.2733	1.4827	0.0491	0.0589	0.3069	0.358
6	0.4935	0.5806	1.583	1.8437	0.0441	0.0529	0.3098	0.361
7	0.535	0.6302	1.8887	2.1995	0.0415	0.0495	0.3056	0.3557
8	0.5749	0.6775	2.184	2.5427	0.0399	0.0474	0.2953	0.3432
9	0.6128	0.7224	2.4624	2.8655	0.038	0.0448	0.2784	0.3229
10	0.6476	0.7632	2.7169	3.1599	0.0347	0.0408	0.2545	0.2944
11	0.677	0.7977	2.941	3.4185	0.0294	0.0345	0.2241	0.2586
12	0.6992	0.8237	3.1319	3.6379	0.0222	0.026	0.1908	0.2194
13	0.7141	0.8412	3.2947	3.8244	0.015	0.0176	0.1629	0.1865

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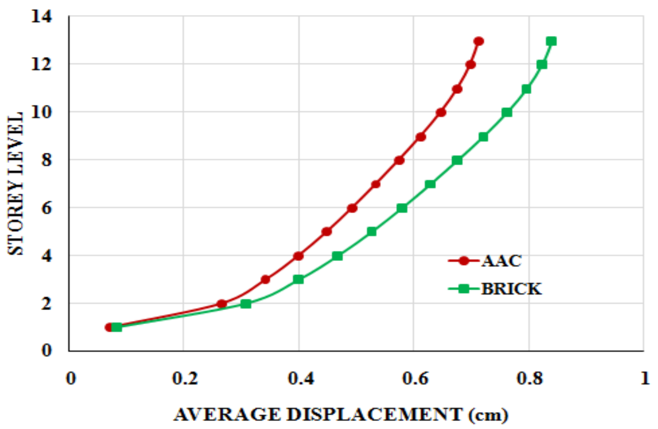

Fig. 13. Displacement along X direction for 6 bay frame (cm)

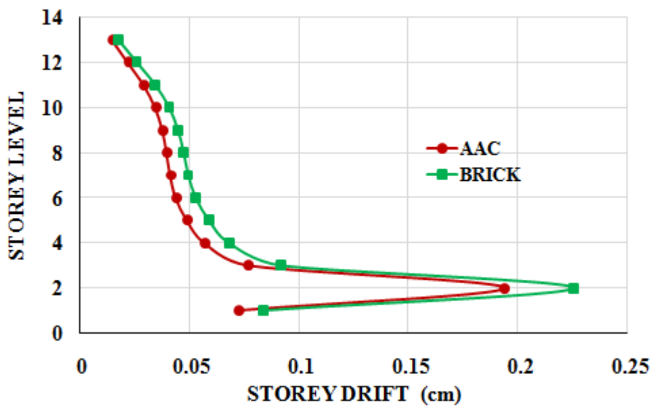

Fig. 14. Storey drift along X direction for 6 bay frame (cm)

TABLE IV. Displacement And Storey Drift For 8 Bay Frame

Storey Level	Displacement(cm)				Storey Drift(cm)			
	X Direction		*Z Direction*		*X Direction*		*Z Direction*	
	AAC	*Brick*	*AAC*	*Brick*	*AAC*	*Brick*	*AAC*	*Brick*
1	0.0733	0.0841	0.1049	0.1203	0.0733	0.0841	0.1049	0.1203
2	0.2685	0.3098	0.4687	0.5389	0.1952	0.2257	0.3638	0.4186
3	0.3439	0.3993	0.8456	0.9744	0.0755	0.0895	0.3769	0.4354
4	0.3995	0.4651	1.268	1.4616	0.0556	0.0658	0.4224	0.4872
5	0.4467	0.5213	1.7187	1.9813	0.0472	0.0562	0.4506	0.5197
6	0.4887	0.5712	2.1793	2.5121	0.042	0.0499	0.4606	0.5308
7	0.5279	0.6177	2.6364	3.0383	0.0392	0.0464	0.4571	0.5262
8	0.5653	0.6618	3.0784	3.5464	0.0374	0.0441	0.442	0.5081
9	0.6008	0.7034	3.494	4.0236	0.0355	0.0416	0.4157	0.4771
10	0.633	0.741	3.8728	4.4575	0.0322	0.0376	0.3787	0.4339
11	0.66	0.7723	4.206	4.8385	0.027	0.0313	0.3333	0.381
12	0.6797	0.7952	4.4908	5.1631	0.0197	0.0229	0.2848	0.3246
13	0.6921	0.8097	4.7355	5.4411	0.0124	0.0145	0.2447	0.2781

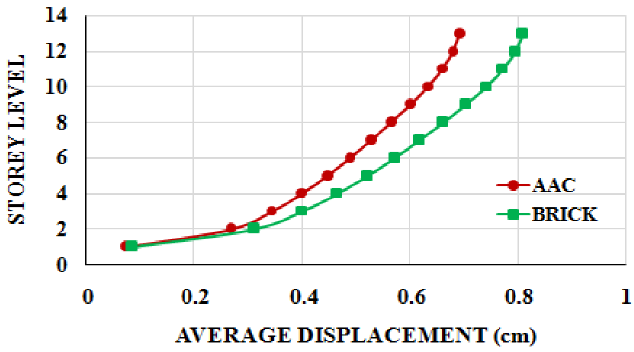

Fig. 15. Displacement along X direction for 8 bay frame (cm)

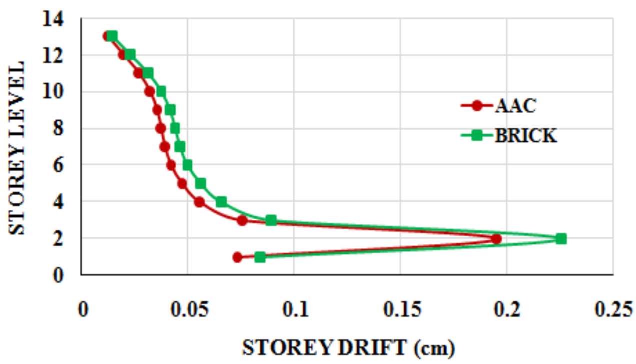

Fig. 16. Storey drift along X direction for 8 bay frame (cm)

TABLE V. Base Shear For Different Horizontal Aspect Ratios

Number of Bays	Base Shear in X Direction (kN)		Base Shear in Z Direction (kN)	
	AAC	*Brick*	*AAC*	*Brick*
2	911.15	1075.67	911.15	1075.67
4	2419.48	2593.08	1457.72	1573.37
6	3595.53	3839.81	1566.10	1690.41
8	4757.97	5072.46	1673.66	1797.6

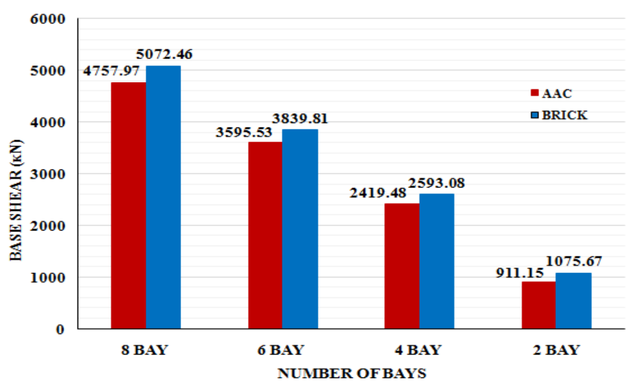

Fig. 17. Base shear in X direction for various horizontal aspect ratios (kN)

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IV. CONCLUSION

While considering the models with varying horizontal aspect ratio, the displacement, storey drift and base shear was found to be less for building with AAC infill walls than that with brick infill walls in all the cases. With the increase in number of bays in X direction, the top storey displacement and storey drift decreases in that direction. Therefore displacement and storey drift decreases with increase in horizontal aspect ratio.

The base shear increases with increase in number of bays which means that the base shear of the building increases with increase in horizontal aspect ratio. The base shear experienced by models with AAC blocks was significantly smaller than that with conventional clay bricks in all the cases which results in reduction in member forces which leads to reduction in required amount of A_{st} to resist member forces. So economy in construction can be achieved by using AAC blocks instead of conventional clay bricks.

V. FUTURE SCOPE AND RECOMMENDATIONS

The future scope and recommendations of the work are:

1)The effectiveness of some other innovative materials which can be used for infill walls in resisting the seismic forces can be studied.
2)The effect of various geometrical properties of beams, columns and infills can be analyzed.
3)The variation in horizontal aspect ratio can be made by changing bay numbers in both horizontal directions.

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