© 2018 IJSRSET | Volume 4 | Issue 4 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section : Engineering and Technology

Seismic Evaluation of AAC block and Brick Wall Fully Infilled Building and Building Having Soft Storey at Different Floor as Per IS 1893-2016

Hrituraj Singh Rathore*[1], Dr. Savita Maru[2]
*[1]M.E Student Department of Civil Engineering, Ujjain Engineering College, Ujjain, Madhya Pradesh, India
[2]Professor Department of Civil Engineering, Ujjain Engineering College, Ujjain, Madhya Pradesh, India

ABSTRACT

Autoclaved Aerated Concrete is not a "new" innovation. It has been around for over 80 years. Invented in 1924, AAC has been used extensively in Europe and Asia. It comprises over 40% of all construction in the United Kingdom and 60% in Germany and 16% in India. At present there are more than 80 manufacturing plants in India are working with heavy concentration in Gujarat, Madhya Pradesh, Maharashtra and other state. The development of tall building setup rapidly worldwide introducing the new challenges that need to be met through engineering judgment. In the past decades the seismic deficient is because of the lack of awareness regarding seismic behaviour of the structure. The widespread damage specially to the tall building structure with a heavy loading during earthquake exposed the construction practices being adopted around the world. Although various studies are carried out in past years but the advancement in technology and analysis procedure of structure gives us more precise result. Therefore, there is a need of performing structural analysis with some advance tools. Therefore, the present research work is to analyze a 3D numerical model of 10 stories AAC block and brick fully infill and having soft storey at different floor level of building subjected to earthquake and performed the analysis by using software SAP 2000 (ver.16.0) using static nonlinear method for comparing and investigating the changes in structural behaviour subjected to seismic load. The result of the analysis for displacement, base shear and storey drift have been studied and compared for all the structure models.

Keywords : AAC block, Brick Infill, Equivalent strut, Soft storey, Nonlinear Analysis.

I. INTRODUCTION

The Autoclaved Aerated Concrete (AAC) material was developed in 1924 in Sweden. It has become one of the most used building materials in Europe and is rapidly growing in many other countries around the world. AAC is produced from the common materials like lime, sand, cement and water, and a small amount of rising agent. After mixing and moulding, it is then autoclaved under heat and pressure to create its unique properties. AAC has excellent thermal insulation and acoustic absorption properties. AAC is fire and pest resistant and is economically and environmentally superior to the more traditional structural building materials such as concrete, wood, brick and stone.

AAC blocks manufacturing projects exist in more than 40 countries and used across more than 70 countries. Cumulative manufacturing capacity of AAC blocks manufacturing projects stands at over 75 million m3/year.

Now a day's large number of building are constructed using AAC block due to its lower cost than brick masonry, Easy to construct, light in weight, high thermal insulation, high fire protection, high sound insulation, lower water absorption, eco-friendly.

Therefore, it is essential to analysis the AAC block and brick fully infill and having soft storey at different level of building subjected to earthquake using SAP 2000 (ver. 16.0) and compare the response of structure in terms of base shear and displacement and storey drift.

II. MODELLING OF INFILL

Macro models are used to investigate the overall response of the infill wall. The behaviour of macro models is based on physical behaviour of infill walls. Mortar joints and units are recognized together considering collective mechanical and physical properties to obtain more simplified solution especially for large scaled models. Diagonal strut model for infilled frames is shown in

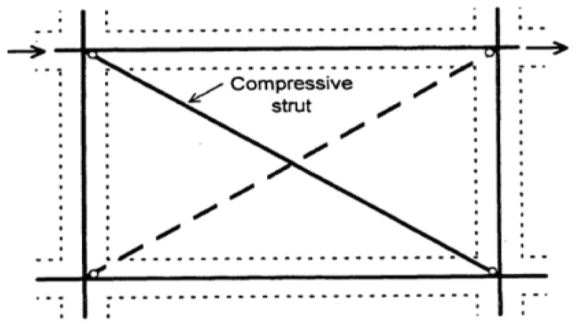


Figure 1. Diagonal strut model for infilled frames

[IS 1893-2016]

The Empirical equation developed by Mainstone and Weeks subsequently, included in FEMA 274, FEMA 306, FEMA 356, Turkish Seismic Code-2007 and widely used nowadays. The equivalent strut has the same thickness and modulus of elasticity as the infill panel it represents. The equivalent strut width w, can be determined by

$$w = 0.175.(\lambda_1.h_{col})^{-0.4}.r_{inf}$$

The expression of non-dimensional λ is given by

$$\lambda = \sqrt[4]{\frac{E_{inf.}\ t_{inf.}\ \sin 2\theta}{4.E_{fr.}\ I_{col.}\ h_{inf}}}$$

Where, h_{col} is column height between centrelines of beam, h_{inf} is height of infill panel, E_{fr} is expected modulus of elasticity of frame material, E_{inf} is expected modulus of elasticity of infill materials, I_{col} is moment of inertia of column, r_{inf} is diagonal length of infill panel, t_{inf} is thickness of infill panel and equivalent strut, θ is angle whose tangent is the infill height-to-length aspect ratio in radians.

III. NONLINEAR STATIC ANALYSIS

Nonlinear static analysis is a technique by which a computer model of the building is subjected to a lateral load of a certain shape (i.e., inverted triangular or uniform). The intensity of the lateral load is slowly increased and the sequence of cracks, yielding, plastic hinge formation, and failure of various structural components is recorded. Nonlinear static analysis can provide a significant insight into the weak links in seismic performance of a structure. A series of iterations are usually required during which, the structural deficiencies observed in one iteration, are rectified and followed by another. This iterative analysis and design process continues until the design satisfies a pre-established performance criterion. The performance criteria for pushover analysis is generally established as the desired state of the building given a roof-top or spectral displacement amplitude. Non-linear or pushover analysis option will allow engineers to perform pushover analysis as per FEMA-356 (2000) and ATC-40 (1996).

SOFT STOREY- It is one in which the lateral stiffness is less than that in the storey above. The storey lateral stiffness is the total stiffness of all seismic force resting element resting lateral earthquake shaking effect in the considered direction.

LOAD COMBINATION AS PER IS 1893-2016

1) 1.2[DL+LL+(ELx+.3ELy)]
2) 1.2[DL+LL+(ELx-.3ELy)]
3) 1.2[DL+LL-(ELx+.3ELy)]
4) 1.2[DL+LL-(ELx-.3ELy)]
5) 1.5[DL+(ELx+.3ELy)]
6) 1.5[DL+(ELx-.3ELy)]
7) 1.5[DL-(ELx+.3ELy)]
8) 1.5[DL-(ELx-.3ELy)]
9) .9DL+1.5(ELx+.3ELy)
10) .9DL+1.5(ELx-.3ELy)
11) .9DL-1.5(ELx+.3ELy)
12) .9DL-1.5(ELx-.3ELy)

IV. DETAILS OF STRUCTURE CONSIDERED

The buildings of plan area 15.0 m x 15.0 m are considered having 5 bays of 3 m width in X-direction and Y-direction. For the analysis, story height of 3.0 m (floor to floor) is considered in this work. All the joints of beam and column are considered as a rigid. Diaphragm shall be provided at each level of the structure to connect the building masses to the primary vertical element of the lateral force resisting system. For the analysis, particulars and details of building model of G + 9 story structure for four different cases are listed in the Table 1.

A view of plan, elevation and 3D view of AAC block, Brick fully infilled, AAC block infilled building with soft storey at 4th and 8th floor and brick wall infilled building with soft storey at 4th and 8th floor are shown below from Figure 2 to Figure 6

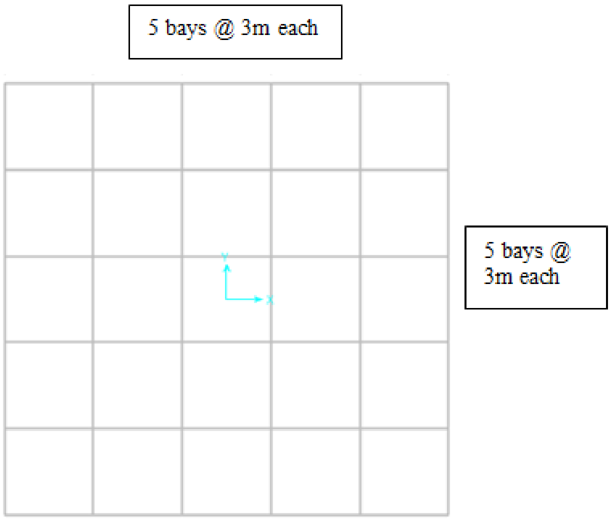


Figure 2. Plan area of building consider for the analysis of 15.0 m x 15.0 m

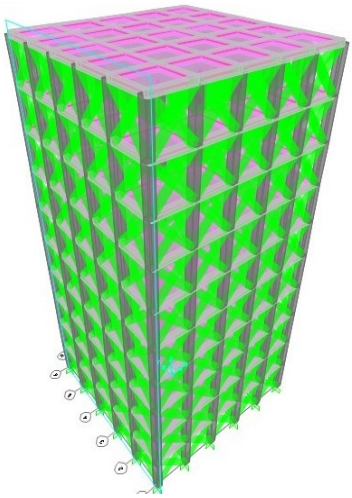


Figure 3. 3D view of AAC block equivalent strut fully infilled building.

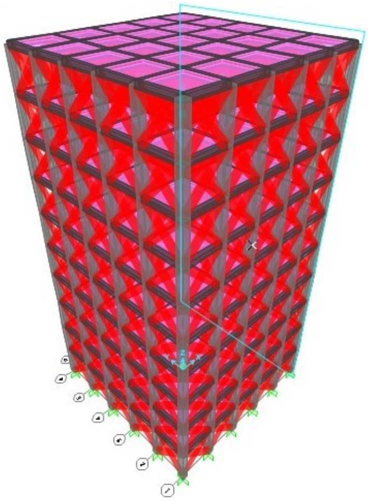


Figure 4. 3D view of Brick wall equivalent strut fully infilled building.

Table 1. Particular and details for all building models

Particulars	**Details**
Plan size	15.0 m x 15.0 m
No. of bays in X-Direction	5 Bays @ 3.0 m each
No. of bays in Y-Direction	5 Bays @ 3.0 m each
Storey height	3.0 m
Depth of foundation below ground	1.5 m
Type of soil	Type II, Medium as Per IS:1893
Grade of concrete	M25
Grade of steel	Fe-500
Column size	500 mm x500 mm
Beam size	300 mm x 400 mm
Slab thickness	150 mm
Brick strut thickness	230 mm
Brick strut width	563 mm
AAC strut thickness	250 mm
AAC strut width	543 mm
AAC wall load	4.87 kN/m^2
Brick wall load	11.48 kN/m^2
Roof live load	1.0 kN/m
Floor live load	3.0 kN/m
Building importance factor	1
Response reduction factor	1.5
Zone factor	0.36

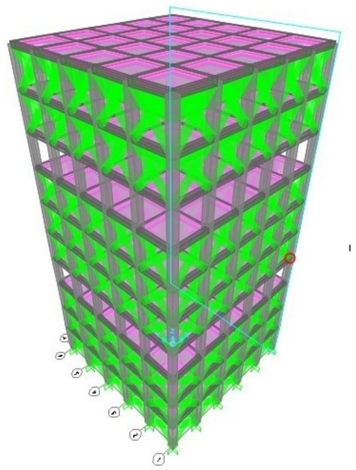


Figure 5. 3D view of AAC block infilled building with soft storey at 4th and 8th floor building.

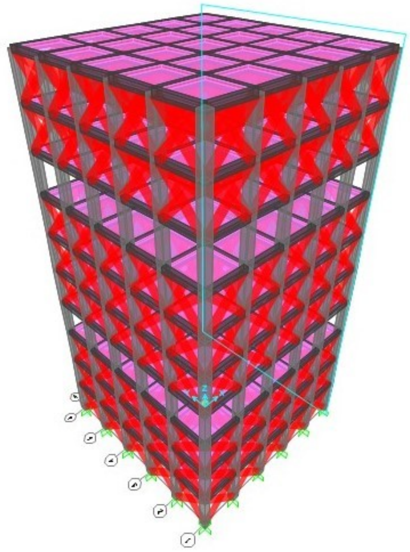


Figure 6. 3D view of brick wall infilled building with soft storey at 4th and 8th floor.

V. ANALYSIS DETAILS

For the analysis of all four the cases for the nonlinear condition, it consists of dead load (self-weight of structure), floor load, roof load, wall load which is acting in the gravity direction and seismic earthquake load is taken as per is IS 1893-2016 code. The beams are assigned as M3 hinges while columns are assigned P-M2-M3 hinges since column consists of interaction between axial load and bending moment at relative distance zero and one and axial hinge P in strut at centre is assigned and pushover analysis is performed on structures using SAP 2000.

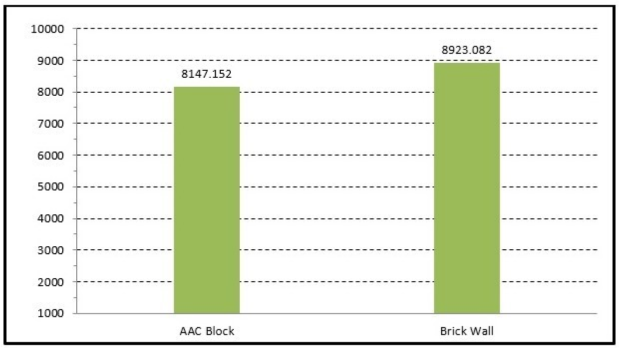
VI. RESULTS

The results include base shear, top displacement and storey drift at performance point obtained from nonlinear analysis of all the four cases are presented here under static loading condition using SAP2000 and is shown in table and graph below. comparisons between base shear and displacement of all the four cases are presented in the tabular form in Table 2 and storey drift in Table 3.

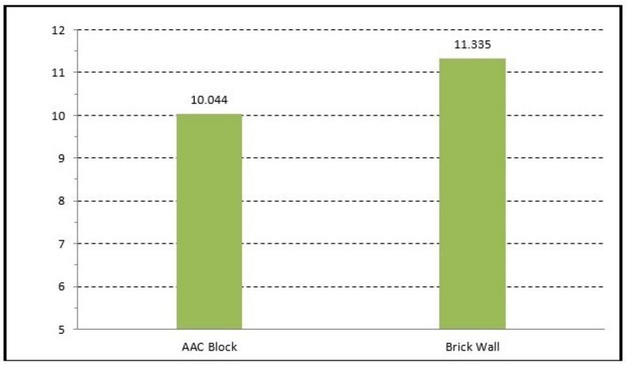
Table 2. Comparison of base shear and displacement of all 4 cases at performance point

SN.	Building type	Base shear	Displacement
1	AAC block fully infilled building	8147.152 kN	10.044 mm
2	Brick wall fully infilled building	8923.082 kN	11.335 mm
3	AAC block infilled building with soft storey at 4th and 8th floor	7163.973 kN	10.248 mm
4	Brick infilled building with soft building with soft storey at 4th and 8th floor	7756.030 kN	11.364 mm

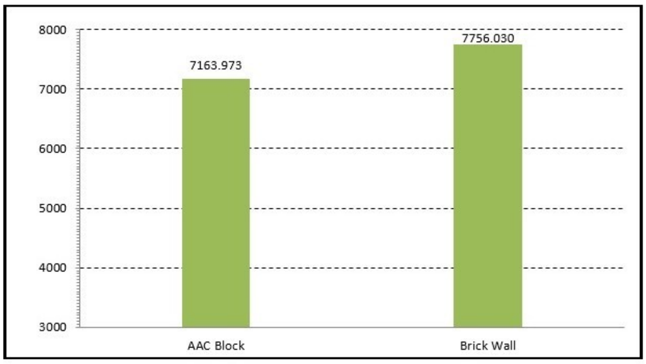
A. Comparison of Base Shear of AAC Block and Brick Wall fully infilled Building



B. Comparison of Top displacement of AAC Block and Brick Wall fully infilled Building



C. Comparison of Base shear of AAC Block and Brick Wall fully infilled Building with soft storey at 4th and 8th floor



D. Comparison of Top displacement of AAC Block and Brick Wall fully infilled Building with soft storey at 4th and 8th floor

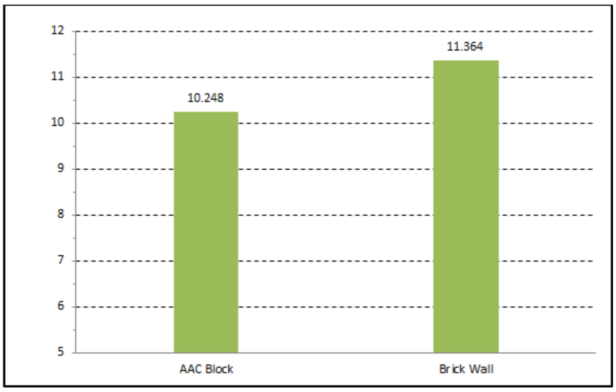


Table 3: Comparison of storey drift of AAC Block and Brick Wall fully infilled Building

Storey Nos.	Storey Height (m)	Storey Drift	
		AAC Block Fully Infilled Building	Brick wall Fully Infilled Building
10	3.0	0.0008	0.0007
9	3.0	0.0012	0.0011
8	3.0	0.0015	0.0015
7	3.0	0.0018	0.0018
6	3.0	0.0019	0.0020
5	3.0	0.0020	0.0021
4	3.0	0.0021	0.0021

3	3.0	0.0020	0.0021
2	3.0	0.0019	0.0020
1	3.0	0.0014	0.0013

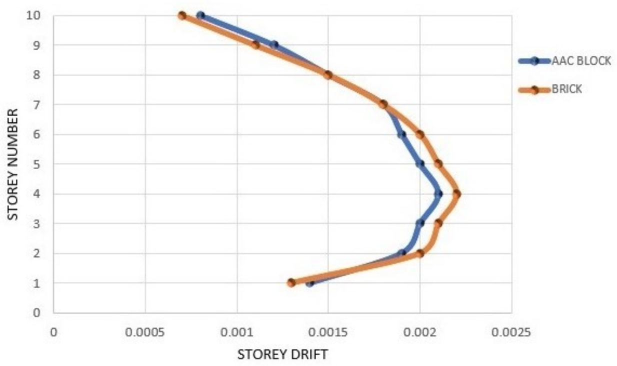


Figure 7. Graphical representation of storey drift of AAC Block and Brick Wall fully infilled Building

Table 4. Comparison of storey drift of AAC block and Brick wall infilled building with soft storey at 4th and 8th floor

Storey Nos.	Storey Height (m)	Storey Drift	
		AAC Block Infilled Building with Soft Storey at 4th & 6th Floor	Brick Wall Infilled Building with Soft Storey at 4th & 6th Floor
10	3.0	0.0006	0.0006
9	3.0	0.0011	0.0011
8	3.0	0.0023	0.0021
7	3.0	0.0015	0.0015
6	3.0	0.0014	0.0015
5	3.0	0.0019	0.0020
4	3.0	0.0037	0.0035
3	3.0	0.0018	0.0020
2	3.0	0.0013	0.0015
1	3.0	0.0009	0.0010

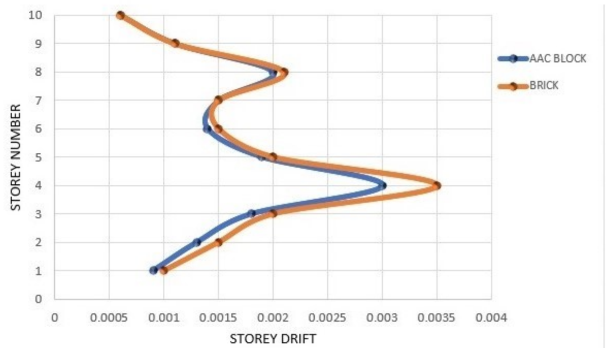


Figure 8. Graphical representation of storey drift of AAC block and Brick wall infilled building with soft storey at 4th and 8th floor

VII. CONCLUSION

Following conclusions are obtained from the analysis of AAC block fully infilled building, brick wall fully infilled building, AAC block infilled building with soft storey at 4th and 6th floor and brick wall infilled building with soft storey at 4th and 6th floor on sap2000(v16) and using IS 1893-2016

- The base shear of AAC block fully infilled building is estimated as 8147.152 kN and base shear of brick wall fully infilled building is estimated as 8923.082 kN. These results concluded that the base shear of AAC block fully infilled building is 8.71% less than the base shear of brick wall fully infilled building.
- The Top displacement of AAC block fully infilled building is estimated as 10.044 mm and Top displacement of brick wall fully infilled building is estimated as 11.335 mm. These results concluded that the top displacement of AAC block fully infilled building is 11.26% less than the base shear of brick wall fully infilled building.
- The base shear of AAC block infilled building with soft storey at 4th and 6th floor is estimated as 7163.973 kN and base shear of brick wall infilled building with soft storey at 4th and 6th floor is estimated as 7756.030 kN. These results concluded that the base shear of AAC block infilled building with soft storey at 4th and 6th

floor is 7.16% less than the base shear of brick wall infilled building with soft storey at 4th and 6th floor.

- The Top displacement of AAC block infilled building with soft storey at 4th and 6th floor is estimated as 10.248 mm and Top displacement of brick wall infilled building with soft storey at 4th and 6th floor is estimated as 11.364 mm. These results concluded that the base shear of AAC block infilled building with soft storey at 4th and 6th floor is 9.85% less than the base shear of brick wall infilled building with soft storey at 4th and 6th floor.
- AAC block fully infilled and AAC block building with soft at 4th and 8th floor suffers lesser drift than Brick wall fully infilled and Brick wall infilled building with soft storey at 4th and 8th floor building because AAC block have more stiffness then brick.
- Sudden increase in drift is observed in the building having soft storey at 4th and 8th floor this is due to reduce in stifness of at that floor. In such situation, the columns in the soft storey should comply with the ductility provision.
- The storey drift for all the model within permissible limits as per IS 1893-2016.

Hence, overall this research findings concluded that beside lower cost of construction of AAC block structures has also higher lateral stiffness, rigidness against lateral load minimizing the maximum lateral deformation then brick infilled structures.

VIII. REFERENCES

[1]. Mathey,R.G. and Rossiter,W.J. (1988). A Review of Autoclaved Aerated Concrete Products,National engineering laboratory center for building technology,Gaithersburg.

[2]. ATC(1996).Seismic Evaluation and retrofit of Concrete buildings,Vol.1,ATC-40 Report,Applied Technology Council,Redwood City,California.

[3]. Federal Emergency Management Agency(1998).Evaluation of Earthquake Damaged Concrete and Masonry Wall Buildings: Basic Procedures Manual,FEMA-306,Applied Technology Council,Washington DC.

[4]. FEMA-356(2000).Prestandard and Commentary for the Seismic Rehabilitation of Buildings,Building Seismic Safety Council,Washington DC.

[5]. Turkish Republic the Ministry of Public Works and Settlement,Turkish Earthquake Design Code TEC-2007,Ankara,Turkey,2007.

[6]. Costa,A.A.,Penna,A.,Magenes,G. and Galasco,A. (2008). Seismic performance assessment of autoclaved aerated concrete (AAC) masonary building,14 World Confrence On Earthquake Engineering.

[7]. CSI,(2010),Structural Analysis Program(SAP) 2000,Version 14,Computers and Structures Inc.,USA.

[8]. Ayudhya,B. I. N. (2011). Compressive and splitting tensile strength of autoclaved aerated concrete (AAC) containing perlite aggregate and polypropylene fiber subjected to high temperatures,Songklanakarin journal of science and technology(SJST),Vol.33 (5),555-563.

[9]. Murty,C.V.R.,Goswami,R.,Vijayanarayanan,A.R .and Mehta,V.(2012).Some Concepts in Earthquake Behaviour of Buildings,Gujarat State Disaster Management Authority,Government of Gujarat.

[10]. Rivera,J. V.,Baqueiro,L. F. and Esquivel,S. C. (2012). Overstrength factors for the seismic design of AAC Structures,15 World Confrence Of Earthqake Engineering.

[11]. Penna,A.,Magenes,G.,Rota,M. and Mandirola,M. (2012). Enhancement of the seismic performance of AAC masonry by means of flat-truss bed-joint reinforcement,15 World Confrence of Eathquake Engineering.

[12]. Samoila,D. M. (2012). Analytical Modelling of Masonry Infills,Acta Technica Napocensis: Civil Engineering & Architecture Vol.55(2),127-136.

[13]. Siddiqui,R. Ul. H. and Vidyadhara,H. S. (2013). Seismic Analysis of Earthquake Resistant Multi Bay Multi Storeyed 3D - RC Frame,International Journal of Engineering Research & Technology,Vol.2(10).

[14]. Jadhao,V.P. and Pajgade,P.S. (2013). Influence of Masonry Infill Walls on Seismic Performance of RC Framed Structures a Comparisons of AAC and Conventional Brick Infill,International Journal of Engineering and Advanced Technology (IJEAT),Vol. 2(4),148-153.

[15]. Akpınar,U. and Binici,B. (2013). The Effect of Infill Wall Collapse on the Deformation Estimations of Reinforced Concrete Frames,Journal of Civil Engineering and Science,Vol.2(3),171-177.

[16]. Catherin,J. M.,JayalekshmIi B.R. and Venkataramana,K. (2013). Modeling of Masonry infills-A review,American Journal of Engineering Research (AJER),Vol.2,59-63.

[17]. Niruba,S. (2014). Analysis of Masonry Infill in a Multi-Storied Building,Civil & Environmental Engineering,Vol.4(2).

[18]. Rahman,Md. A. and Masum,M.,Farzana,S.Z. and Alam,Md. J.B. (2014). A Study on Drift Analysis for Lateral Stability of High Rise Building in Sylhet City Corporation Area. International Journal of Engineering Research & Technology (IJERT). Vol. 3(6),235-239.

[19]. Cerny,V. and Drochytka,R. (2014). Utilization of FBC ash in autoclaved aerated concrete technology,international journal of materials,Vol. 1,79-83

[20]. Shukla,R.,(2014). Burnt Clay Bricks Versus Autoclaved Aerated Concrete Blocks,International Journal of Engineering Research & Technology (IJERT),Vol. 3(11),575-580.

[21]. Deshmukh,R. A. and Pajgade,P. S. (2015). A study of effect of infill material on seismic performance of RC buildings,international journal of engineering sciences & research technology,4(1),678-687.

[22]. Miao,J.,Tao,J. and Liu,Y. (2015). Research on self-thermal insulation wall construction technology of autoclaved aerated concrete block,5th International conference on civil engineering and transportation (ICCET 2015),1063-1068.

[23]. Aminudin,E.,Din,M. F.,Hussin,M.W.,Iwao,K.,Mohanadoss,P. and Ichikawa,Y. (2015). Properties of industrial boiler ash as sand replacement and thermal improvement in aerated concrete,Malaysian Journal of Civil Engineering,155-169.

[24]. Sandeep,T. (2015). Importance of storey drift ratio,ductility and performance point levels on multistory with and without infills,International Journal Of Advance Engineering And Research Development,Vol. 2(6),704-716.

[25]. Elhamed,A. and Mahmoud,S. (2015). Effect of Infill Walls on Response of Multi Storey Reinforced Concrete Structure,World Academy of Science,Engineering and Technology International Journal of Civil,Environmental,Structural,Construction and Architectural Engineering Vol.9(5),578-582.

[26]. Rubene,S. and Vilnitis,M. (2016). Impact of porous structure of the AAC material on moisture distribution throughout the cross section of the AAC masonry blocks,WSEAS transactions on heat and mass transfer,Vol. 11,13-20.

[27]. Khandve,P. V. (2016),Applications of AAC in Construction Industry,Journal of Environmental Science,Computer Science and Engineering & Technology,Vol.5(1).

[28]. Desani,P.,Soni,M.,Gandhi,N. and Mishra,V. (2016). Autoclaved Aerated Concrete: A Sustainable Alternate of Clay Brick Masonry in Form of Light Weight Concrete,Global

Research and Development Journal for Engineering,436-441

[29]. Rathi,S. O. and Khandve,P. V. (2016). Cost effectiveness of using AAC blocks for building construction in residential building and public buildings,International Journal of Research in Engineering and Technology,Vol.5(5),517-520.

[30]. Pahade,A. and Khare,P. (2016). Comparison of Water analysis between AAC blocks-Gypsum plaster & Burnt red clay bricks-Sand cement plaster,International Research Journal of Engineering and Technology (IRJET),Vol.3(6),2969-2972.

[31]. Namboothiri,V. P. (2016). Seismic evaluation of RC building with AAC block infill walls,International Journal of Science and Research (IJSR),Vol.5(7),704-707.

[32]. Dhote,S. and Singh,N.,(2016),Feasibility study for setting up a new autoclaved aerated concrete blocks manufacturing plant,International Journal of Management Research,Vol. 4(4),145-152.

[33]. Shivananda,K. P.,Dattatreya,J. K. and SANTHOSH,T. M. (2016). Investigation on autoclave aerated concrete slab,International Journal of Advances in Mechanical and Civil Engineering,Vol. 3(1),36-39.

[34]. IS 1893: Part 1(2016); "Criteria for earthquake resistant design of structures",Bureau of Indian Standards,New Delhi.

[35]. Kurweti,A.,Chandrakar,R. and Rabbani,A. (2017). Comparative analysis on AAC,CLC and flyash concrete Blocks,International Journal of Engineering Development and Research,Vol. 5(2),1924-1931.