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The study of the fundamental natural time period of the AAC block infill wall under seismic conditions

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Abstract – I*nfill walls play a crucial role in modern building construction, contributing to structural integrity, thermal performance, and aesthetic appeal. For high-rise buildings, AAC (Autoclaved Aerated Concrete) blocks are frequently used as masonry infill compared to traditional bricks. AAC blocks are lightweight, requiring less material for infill compared to standard bricks. Historically, masonry has been considered a non-structural element, and its impact on buildings under seismic loads has often been overlooked. However, recent studies have shown that infill wall panels significantly affect structural performance during earthquakes. Key parameters studied include base shear, story displacement, story drifts, frequency, and time period. This study focuses on the time period taken for AAC block infill in the seismic analysis of RC (Reinforced Concrete) buildings with masonry infill, based on IS 1893:2016 (Part 1). The strength and stiffness of masonry infill are calculated using the diagonal strut method, as specified in the earthquake resistance code IS 1893:2016 (Part 1). The research analyzed 28 models of 4, 8, and 12 stories, along with one realistic model of an RC frame, in three scenarios: bare frame, brick infill, and AAC block infill. Two configurations were considered: one with only columns and the other with a combination of columns and shear walls. The models were further analyzed for seismic performance using response spectrum analysis in CSI ETABS software, considering the strength and stiffness of the infill walls using the diagonal strut method, as per clause 7.9.2 of IS 1893:2016 (Part 1).*

***Key Words*: Time period, Bricks infill, AAC Block infill. Modal periods, RC frame, bare frame, Response spectrum analysis**

1.INTRODUCTION

Reinforced concrete and steel buildings often incorporate masonry infills, which fill the spaces between the building's vertical and horizontal structural elements. Traditionally, these infills are assumed to be non-contributory to the building's load resistance, whether axial or lateral, and thus are typically excluded from structural analysis. This oversight is partly due to the lack of straightforward and realistic analytical models for infills. However, infill walls significantly enhance the strength and rigidity of structures. It has been observed that frames with infills are stronger and more rigid compared to bare frames. Ignoring the contributions of infill walls has led to the failure of many multi-story buildings.

Infill walls, traditionally placed between structural elements, are now seen as vital for enhancing a building's structural stability and energy efficiency. The selection of materials and design of infill walls can greatly influence a building's load-bearing capacity, thermal insulation, and sustainability. Introducing ion-based materials offers a novel approach, inspired by the unique properties of ions, to potentially improve the structural and thermal performance of infill walls

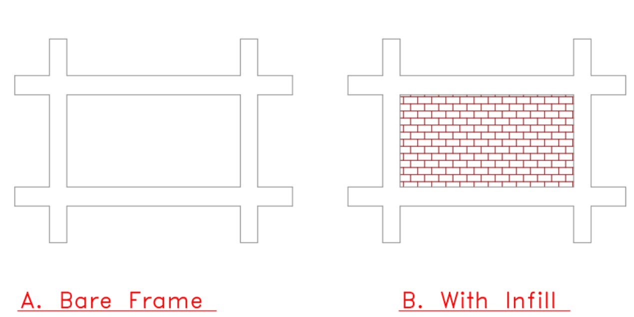

Fig -1.1: (A)Bare frame and (B) infill frame

1.1 Aim

Research work aims to know which fundamental period formula as per earthquake resistance code (IS:1893 (part-1):2016) is used for the with infill (AAC block) structure's Seismic Analysis

1.2 Objective

1.Determine the Time Period Formula: Identify the specific formula used to calculate the time period for infill (AAC block) in RC and MRF buildings according to the earthquake resistance code (IS 1893:2016 Part 1).

2. Compare Bare Frame and Infill Wall Behavior: Evaluate whether the behavior of a bare frame is the same as that of a frame with infill walls using AAC blocks as infill materials.

3. Study Drift Pattern with Wall Openings: Analyse the drift patterns for different percentages of wall openings to understand how various opening sizes affect the structure's behavior.

4. Calculate Base Shear for Different Models: Determine the base shear for various models to assess how different configurations impact the seismic response.

5. Model Behavior with Diagonal Strut Infill: Investigate the behavior of RC and MRF frames with AAC block infill by modeling the infill as a diagonal strut to understand the impact on the overall structural performance

2. METHODOLOGY

A study was conducted to analyze the time period formula for infill walls using AAC blocks and evaluate the behavior of reinforced concrete (RC) and moment-resisting frame (MRF) structures with AAC block infills. The research utilized 28 models created in CSI ETABS software. Three types of special RC moment frames were examined, each with six bays and heights of 4, 8, and 12 stories. The frames were modeled in three configurations: (1) Column models, (2) Combined column and shear wall models, and (3) Realistic models. The time periods were analyzed using three methods: calculations with first-class bricks as infill, AAC blocks as infill, and manual calculations based on IS codes.

The study also examined the models under gravity and seismic loads using response spectrum analysis in ETABS software. The strength and stiffness of the infill walls were evaluated using the equivalent diagonal strut method, where the infill was modeled as diagonal struts or bracing. This comprehensive approach enabled a detailed assessment of how different infill materials and structural configurations affect the dynamic behavior of RC moment frames under various loading conditions.

2.1 Data to be consider

1. Length x Width = 27m x 18m
2. Story Height = 3.3m
3. bay length = 4.5m
4. No. of stories 4,8 and 12
5. soil type – 2
6. seismic zone – (III-0.16)
7. Response reduction factor – 5
8. Importance factor – 1
9. Beam, column, and shear wall section as per Table 1
10. Grade of concrete as per Table 2
11. Grade of steel as per Table 3
12. Properties Infill material
    i. First-class bricks as per Table 4
    ii. Autoclaved Aerated Concrete as per Table 5
13. Wall thickness 230mm
14. Width of strut(bracing) 230mm
15. Strut(bracing) depth as per Table 6
16. Depth of slab 150mm
17. Dead load as per IS 875(part-1): 1987
18. Live load as per IS 875(part-2) 1987
19. Live load on all stories except roof 2KN/M
20. Live load on Roof 1.5KN/M
21. Floor Finish 1.5KN/M
22. Waterproofing 2.5KN/M
23. Wall load
24. Earthquake load in x-direction (EQx)
25. Earthquake load in y-direction (EQy)

Story number	Column size (mm)	Beam size (mm)	Shear wall size (mm)
4 Story			
1 to 4	450x450	230X450	230X900
8 Story			
1 to 4	525x525	230X600	230X1050
5 to 8	450x450	230X600	230X900
12 Story			
1 to 4	600x600	230x600	230X1200
5 to 8	525x525	230x600	2302X1050
9 to 12	450x450	230x450	230X900

Table -2.1: Beam, column, and shear wall sizes

Properties	Value
Compressive Strength (MPa)	25
Modulus of Elasticity (MPa)	25000
Specific weight (Kg/m3)	2548
Poisson's ratio	0.2

Table -2.2: Grade of concrete

Properties	Value
Yield Strength (MPa)	500
Ultimate Strength (MPa)	545
Modulus of Elasticity (MPa)	200000
Specific weight (Kg/m3)	7850

Table -2.3: Grade of steel

Properties	**Value**
Compressive Strength (MPa)	11.5
Modulus of Elasticity (MPa)	6325
Density (Kg/m3)	2000
Poisson's ratio	0.25

Table -2.4: First-class bricks

Properties	**Value**
Compressive Strength (MPa)	6
Modulus of Elasticity (MPa)	2200
Density (Kg/m3)	700
Poisson's ratio	0.2

Table -2.5: Autoclaved Aerated Concrete

Story number	depth of strut (mm)	
	Bricks	AAC blocks
4 Story		
1 to 4	510	550
8 Story		
1 to 4	560	590
5 to 8	510	550
12 Story		
1 to 4	610	650
5 to 8	560	590
9 to 12	510	550

Table -2.6: Strut(bracing) depth

2.2 Modeling

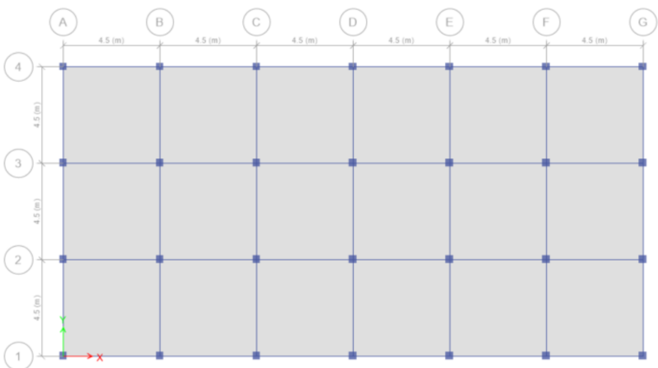

Fig -2.1: Plan of the only column

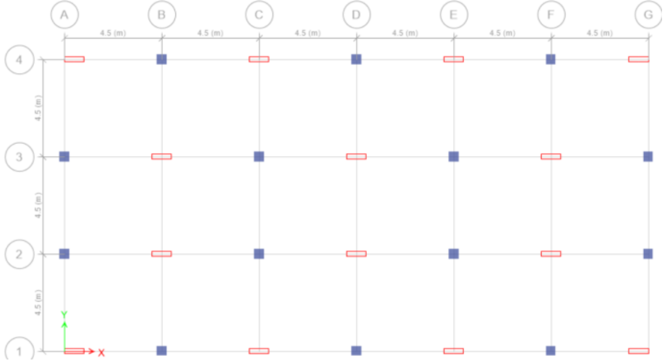

Fig -2.2: Plan of the combined column and shear wall

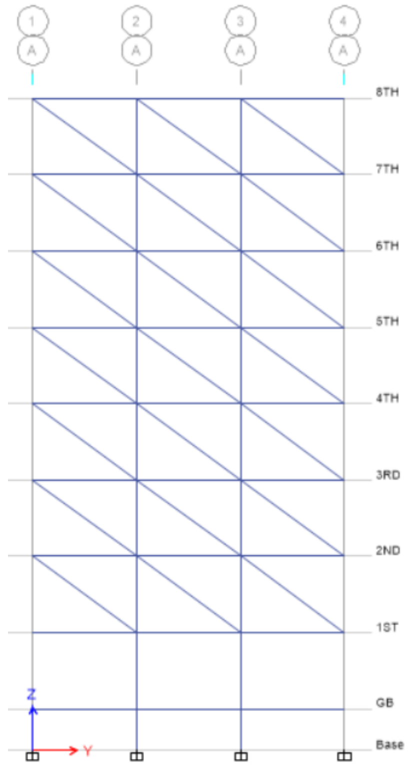

Fig -2.3: Bracing

2.3 Analysis

For the analysis of the model using response spectrum analysis as per the IS 1893-2016(Part-1). for the strength and stiffness of the infill wall provide strut or bracing. The width of the bracing is equal to the width of the infill wall. For the depth of the infill wall use an equivalent diagonal strut method as per the Cl.7.9, Pg.25, IS 1893-2016 (part 1). And analyzed a few parameters like base shear, story drifts, and time periods.

The diagonal stiffness k of the infill is equal to the reciprocal of the deflection when P = 1.

If an equivalent diagonal strut of length L replaces the infill, the stiffness of the strut is given by,

$$K = \frac{AE_m}{L}$$

Hence the cross-sectional area of the equivalent diagonal strut is, $A = \frac{LK}{E_m}$

The infilled frame can then be converted into the frame with the equivalent diagonal struts, and analyzed by the usual method of frame analysis.

The width of the diagonal strut is equal to the width of the infill wall. And calculation steps of the depth of the diagonal strut are followed.

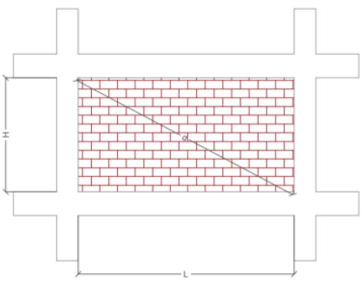

Fig -2.4: Equivalent diagonal strut dimensioning

1. Height of the infill wall (H) = Story height – depth of the beam
2. Length of the infill wall (L) = Bay length – width of the column
3. Moment of inertia of the column I_c=bd^3/12
4. The angle of Diagonal s with the horizontal Θ=$\tan^{-1}\left(\frac{H}{L}\right)$length of Diagonal strut L_{ds}=H/$\sin\theta$ αh=h ($\sqrt[4]{\frac{E_m t \sin 2\theta}{4E_f I c h}}$)
5. Depth of diagonal strut W_{ds}=0.175$\alpha_h^{-0.4}L_{ds}$

3. OBSERVATION

3.1 Time periods

The time period as per clause 7.6.2 of IS 1893-2016(part-1).

For RC MRF building Ta=0.075h^0.75 (without any masonry)
For other building Ta=0.09h/ √d

Where h is the height of the building and d is the length or width of the building.

	Story	AAC BLOCK	BRICKS	BARE FRAME
COL	4S	0.78	0.84	0.75
	8S	1.02	1.028	0.9
	12S	1.37	1.29	1.1
COL-SW	4S	0.89	1.438	1
	8S	1.159	1.18	1.02
	12S	1.59	1.44	1.10
Realistic model	10S	1.25	1.1	1.028

Table -3.1(a): Time period of different model

	Story	0.09H/(D)^0.5	0.075H ^0.75	Average of clause (a) & (c)
COL	4S	0.84	0.57	0.71
	8S	1.028	0.91	0.97
	12S	1.29	1.22	1.26
COL-SW	4S	1.438	0.57	1
	8S	1.18	0.91	1.05
	12S	1.44	1.22	1.33
Realistic model	10S	1. 1	1.29	1.19

Table -3.1(b): Time period of different model

AAC block, Bricks, and bare frame time period as per the software are compared by the time as per earthquake resistance code IS 1893-2016. the time period value of all models is described in the above table.

The comparison shows that the time periods for brick infill structures as calculated by the software closely match the values specified in IS code clause 7.6.2 (a). Additionally, the time periods for AAC block infill structures as calculated by the software closely match the average values specified in IS code clauses 7.6.2 (a) and (c) and values specified in IS code clause 7.6.2 (a).

Therefore, for accurate predictions of structural behavior, it is recommended to use the average values specified in IS code clauses 7.6.2 (a) and (c).

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3.2 Base shear

The base shear as per clause 7.6.1 of IS 1893-2016(part-1).

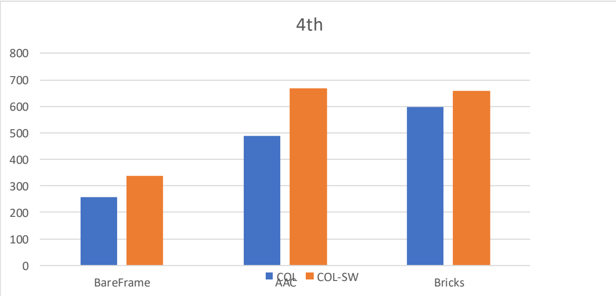

Chart -3.1: base shear of the 4th story

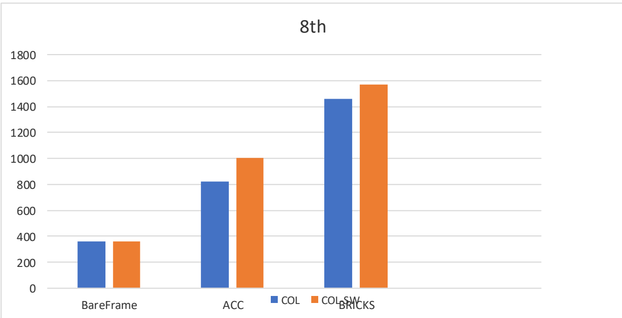

Chart -3.2: base shear of the 8th story

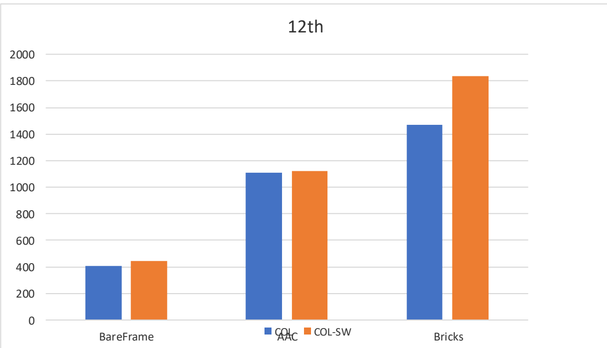

Chart -3.3: base shear of the 12th story

Based on the model results, the base period for structures with AAC block infill is less than that for brick infill, while the base period for bare frame structures is even less than that of AAC block infill. Additionally, the analysis shows that the base period values for structures with brick infill, AAC block infill, and bare frame configurations are higher in combined column and shear wall structures compared to column-only structures.

As a structure rises vertically, lateral loads increase from the base upwards. This increase is directly related to the base shear—the higher the shear force, the greater the lateral loads experienced by the building. However, using AAC blocks as infill materials can significantly reduce these lateral forces, lowering them by approximately 40% to 45%. These observations indicate that shear walls in combined column and shear wall structures contribute to shorter base periods compared to column-only structures. Therefore, it is recommended to use column-only structures

3.3 Story drifts

Story drift in any story shall not exceed 0.004 times the story height, under the action of design base of shear with no load factors mentioned in 6.3, that is, with partial safety factor for all loads taken as 1.0.

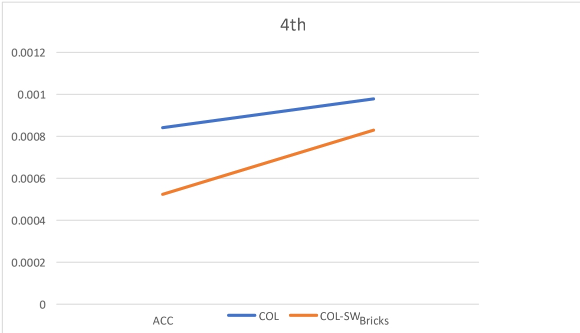

Chart -3.4: story drift of the 4th story

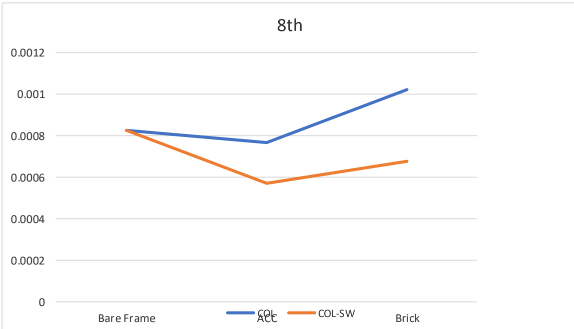

Chart -3.5: story drift of the 8th story

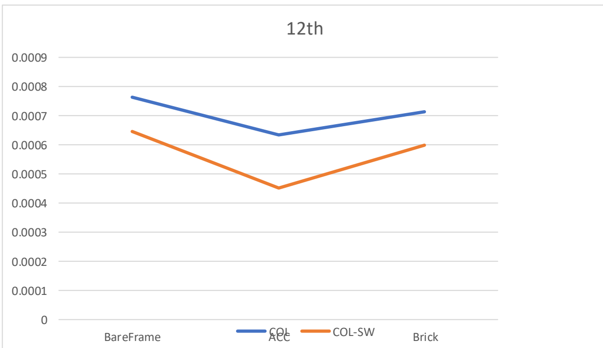

Chart -3.6: story drift of the 12th story

Based on the model results, the story drift for AAC block infill is less than that for brick infill, and the story drift for bare frame structures is even less than that for AAC block infill.

The model analysis also indicates that the story drift values for structures with brick infill, AAC block infill, and bare frame configurations are higher in combined column and shear wall structures compared to column-only structures.

In structural analysis, it's noted that maximum drifts typically occur at the lowest story of infilled frames. Bare frames initially show lower drifts, which gradually increase with height, eventually surpassing those of infilled structures. Structures with AAC blocks perform particularly well in minimizing drift values, making AAC blocks highly effective in reducing structural deflections and enhancing overall stability across various stories of a building

4. Conclusions

This study evaluated the impact of AAC block and brick infill materials on the dynamic behavior of RC moment frames using CSI ETABS software. The analysis revealed that the base period for AAC block infill is shorter than that for brick infill, with bare frame structures having the shortest base periods. Additionally, combined column and shear wall structures exhibited higher base periods and story drifts compared to column-only structures, indicating the significant influence of shear walls on the structural response.

The study further demonstrated that as we move vertically in a structure, lateral loads increase, correlating directly with base shear. Notably, using AAC blocks as infill material significantly reduced these lateral forces by approximately 40% to 45%, highlighting their effectiveness in mitigating seismic impacts.

Furthermore, AAC blocks showed superior performance in minimizing story drifts compared to brick infill and bare frame configurations, particularly at higher stories. This performance underscores AAC blocks' capability to enhance overall stability. Therefore, for better stability under seismic loads, column-only structures with AAC block infill are recommended. This combination not only optimizes the dynamic behavior of the building but also ensures a more resilient structural design capable of withstanding seismic activities more effectively.

REFERENCES

[1] Jalaeefar, A., & Zargar, A. (2020, December). Effect of infill walls on behavior of reinforced concrete special moment frames under seismic sequences. In Structures (Vol. 28, pp. 766-773). Elsevier.

[2] Bârnaure, M., Ghiţă, A. M., & Stoica, D. N. (2016). Influence of the infill panels masonry type on the seismic behaviour of reinforced concrete frame structures. In The 1940 Vrancea Earthquake. Issues, Insights and Lessons Learnt: Proceedings of the Symposium Commemorating 75 Years from November 10, 1940 Vrancea Earthquake (pp. 319-331). Springer International Publishing.

[3] Kose, M. M. (2009). Parameters affecting the fundamental period of RC buildings with infill walls. Engineering Structures, 31(1), 93-102

[4] Fasil Mohi ud din (2017). Behaviour of Infill Wall under Seismic Loading in RC Framed Structure, International Journal of Engineering and Technical Research 7(7):65-70

[5] Patel, P., & Shah, D. (2021). Comparative Study of Brick Infill Wall and Autoclaved Aerated Concrete (AAC) Blocks Using Response Spectrum Analysis

[6] Wilson, E. L. (2015). CSI analysis reference manual for SAP 2000, ETABS, SAFE and CSI bridge. Computers and Structure, Inc.: Berkeley, CA, USA.

[7] IS 1893-(2016): Criteria for Earthquake Resistant Design of Structures, Part 1: General Provisions and Buildings

[8] IS 456 (2000): Plain and Reinforced Concrete - Code of Practice [CED 2: Cement and Concrete]

[9] Earthquake Resistant Design of Structures book by Pankaj Agarwal, Manish Shrikhande.

[10] Decanini, L.D., Liberatore, L. & Mollaioli, F. Strength and stiffness reduction factors for infilled frames with openings. *Earthq. Eng. Eng. Vib.* **13**, 437–454 (2014). https://doi.org/10.1007/s11803-014-0254-9

[11] IS 2185-3 (1984)_ concrete masonry units, Part 3_ Autoclaved cellular Aerated concrete blocks.

[12] Diptesh Das , C V R Murty DzBrick Masonry)nfills in seismic design of RC buildingdz,)ndian Concrete Journal, ISSN 0019-4565, 2004.

[13] Stafford Smith, B., Lateral Stiffness of lnfilled Frames, Proc. A.S.C.E., Vol. 88, No. S.T.6., pp. 183-99, 1962.

[14] IS 875-2 (1987): Code of Practice for Design Loads (Other Than Earthquake) For Buildings And Structures, Part 2:Imposed Loads [CED 37: Structural Safety