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A COMPARATIVE STUDY ON THE STRUCTURAL PERFORMANCE AND COST-EFFECTIVENESS OF RED BRICKS AND AAC BLOCKS IN RC BUILDINGS

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Abstract

The construction industry is rapidly evolving, with new innovations and techniques being introduced regularly. With this, it has become imperative to find efficient and cost-effective alternatives to conventional construction materials. One such material is Autoclaved Aerated Concrete (AAC), which can replace conventional red bricks with a more efficient and eco-friendly solution. AAC is a lightweight concrete building material that can be easily cut into masonry blocks or formed into larger planks and panels. Using AAC blocks in construction projects can significantly reduce the overall cost of construction, while also minimizing the production of harmful gases, making it a more sustainable option. This paper aims to analyze, design, and estimate the structural performance and cost of G+3, G+5, G+7, G+9 RC buildings using AAC blocks and conventional red bricks. The software STAAD Pro is used to compare the structural performance and cost of the two building materials. Red clay bricks and AAC blocks are used in walls based on their properties, availability, and cost. A brief comparison between red clay bricks and AAC blocks is presented in this report to help readers make an informed choice. The findings of this study will provide valuable insights to construction professionals and stakeholders looking to adopt more sustainable and cost-effective building materials.

I. INTRODUCTION

Construction practices have advanced significantly in recent times, with brick being a critical material used in building construction. While it is one of the most commonly used and conventional building materials worldwide, it has several disadvantages. Brick production results in the emission of harmful gases, contributing to air pollution, global warming, and affecting vegetation cover. Additionally, bricks are prone to water absorption, causing efflorescence when not exposed to air, and are comparatively heavier, requiring more material to achieve the same strength. Therefore, it has become imperative to find an efficient and sustainable alternative that can replace bricks in construction. One such alternative is Autoclaved Aerated Concrete (AAC) blocks, which offer several benefits over conventional red bricks. AAC blocks are eco-friendly and do not emit harmful gases during production, making them a more sustainable option. They also have low water absorption, reducing the chances of efflorescence. Moreover, being lightweight, they require less material to achieve the same strength, resulting in cost savings. The advantages of AAC blocks over traditional bricks in the construction industry. The findings of this study will help construction professionals and stakeholders choose a more sustainable and cost-effective building material.

AAC Blocks are building materials made from a mixture of cement, water, fly ash, quicklime, gypsum, and Aluminum powder. They are lightweight because they contain 80 percent air due to a special expanding agent added to them during production. AAC Blocks have a unit weight of 6-7 KN/m3, which is much lighter than bricks, whose unit weight is 18-22 KN/m3. They come in various sizes, depending on site conditions and requirements. AAC Blocks are also durable and can withstand extreme earthquake conditions. AAC Blocks are eco-friendly, which means they do not produce pollution in the environment, and they are certified as a green building material. Additionally, AAC Blocks provide better insulation against sound than other building materials. Overall, AAC Blocks are a lightweight, durable, and eco-friendly option for building construction.

For the purpose of analysis, design and structural comparison STAAD Oro software is used. STAAD Pro can be used in different cases. The typical problems have been solved using basic concept of loading, analysis, condition as per IS code. STAAD Pro makes us able to add seismic loadings, wind loadings, etc. For design purpose IS 456:2000, IS 1893:2002 are used. This software gives accurate results in Shear Force, bending moment diagram, deflection and reinforcement detailing for each & every beam, and structure.

II. LITERATURE REVIEW

1. Kalyana Chakravarthy P.R studied., the constructional and structural differences between AAC blocks and red clay bricks were analyzed and compared. The study concluded that AAC blocks are more suitable for high-rise constructions than red clay bricks due to their lower consumption of steel reinforcements.

2. Vikas P. Jadhao, Prakash S. Pajgade," This paper aimed to investigate the behavior of RC frames filled with both AAC blocks and conventional clay bricks under seismic loads. The study focused on the behavior of reinforced concrete (RC) framed structures with infill panels made of traditional heavy materials like clay bricks or concrete blocks, as well as newer lightweight options like AAC blocks. The researchers found that the type of infill material used had a significant impact on the overall performance of the structure. Previous studies had shown that structures filled with AAC blocks performed better than those filled with conventional clay bricks under lateral loads.

3. Riyaz Sameer Shah (2016), this literature review compares the economics of using autoclave aerated concrete and conventional brick in construction. The study analyzes the design and cost estimates of a structure using both materials and focuses on the amount of steel consumption required. The study aims to compare reinforced concrete design using AAC blocks and conventional bricks. As AAC blocks are lighter than conventional bricks, it is believed that using AAC blocks in the infill wall can reduce the weight on beams, columns, and footings, leading to a reduction in steel consumption.

4. Nagesh. Mustapure et.al. (2014) conducted a study on cellular lightweight concrete (CLC) blocks, testing their properties such as compressive strength, water absorption, and thermal conductivity for different densities. The results showed that CLC blocks of Grade B are a viable option for construction due to their excellent insulating properties and eco-friendliness. The multi-cellular structure of the blocks contributes to their insulating properties, making them advantageous for general construction purposes.

5. P.S. Bhandari et.al. (2014) conducted research on the characteristics of cellular lightweight concrete in relation to its density and compressive strength. The study found that the compressive strength of cellular lightweight concrete decreases as the density decreases and as the number of voids increases. The use of 53-grade cement slightly increases the compressive strength compared to 43-grade cement, but with a corresponding increase in density. Based on the findings, cellular lightweight concrete is deemed appropriate for use in framed structures and can be a viable option for construction in earthquake-prone areas.

METHODOLOGY

In this paper, total 12 models of RC building have been prepared. We have designed G+3, G+5, G+7, G+9 RC Buildings, each having models with conventional red bricks, with AAC Blocks of same dimensions of structural members and with AAC Blocks with reduced dimensions. For the purpose of structural comparison; Shear Force, Bending Moments, Deflection of the structural members of buildings with Red Bricks and AAC Blocks having same dimensions. For cost comparison; estimate of each building has been calculated and percentage cost saved in building with AAC Blocks is determined.

Data assumed for the purpose of design is as follows:

- Material Properties

Grade of Concrete: M25; Grade of Steel: Fe415; Unit Weight of Brick 19.5 KN/m^3; Unit Weight of AAC Blocks: 6 KN/m^3; Unit weight of concrete: 25KN/m^3.

- Sizes of elements

Table 1: Beams and Columns size

Building	Red Brick		AAC blocks with reduced dimensions	
	Beams	Columns	Beams	Columns
G+3	0.23mm*0.3mm	0.3mm*0.3mm	0.23mm*0.3mm	0.23mm*0.23mm
G+5	0.23mm*0.3mm	0.38mm*0.38mm	0.23mm*0.3mm	0.3mm*0.3mm
G+7	0.23mm*0.3mm	0.45mm*0.45mm	0.23mm*0.3mm	0.38mm*0.38mm
G+9	0.3mm*0.45mm	0.45mm*0.45mm	0.23mm*0.3mm	0.38mm*0.38mm

- Description of loads

Uniform load exerted by Bricks on external wall: 12.1KN/m; Uniform load exerted by Bricks on internal wall: 6.05KN/m; Uniform load exerted by AAC on external wall: 3.76KN/m; Uniform load exerted by AAC on internal wall: 2.01KN/m; Floor Finish: -1 KN/m^2; Self-weight: 1 KN/m^3; Live Load: 3.75 KN/m^2. After design of the RC Building, analysis of shear force, bending moment and deflection has been done for the purpose of structural comparison. Comparison has been carried out between internal beam, external beam, external column and internal column of building with red bricks and AAC Blocks having members with same dimensions.

For Cost Comparison estimate of each building has been calculated:
The volume of Concrete and Weight of Reinforcement is gained from the Design Report.
The number of bricks and AAC Blocks is obtained by calculating the volume of the walls accordingly.
By multiplying the calculated figures by their rates, the cost is determined.

III. RESULTS

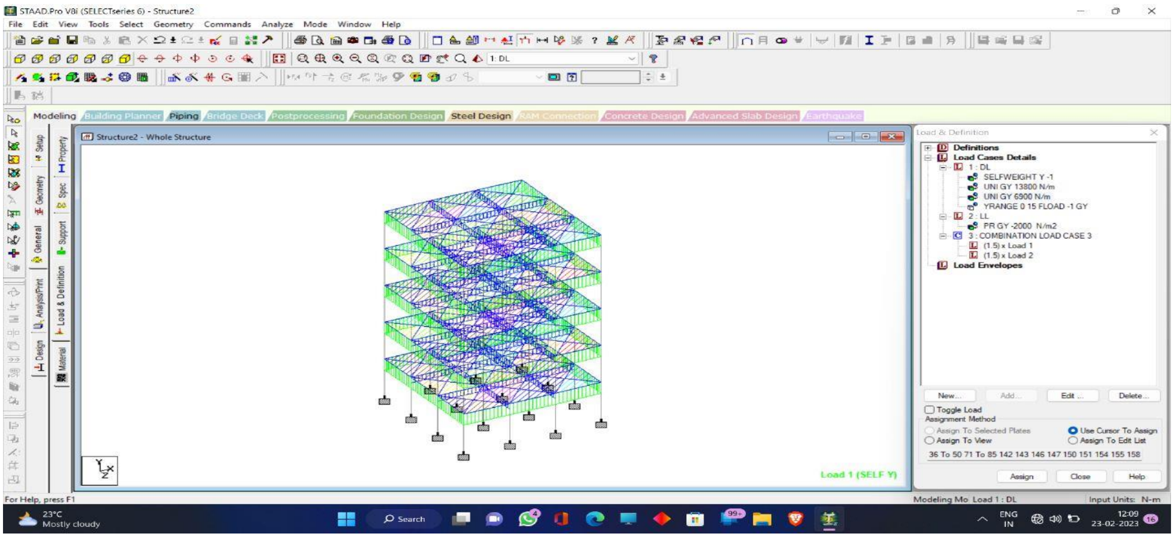

Fig.4.1 Loading of Building

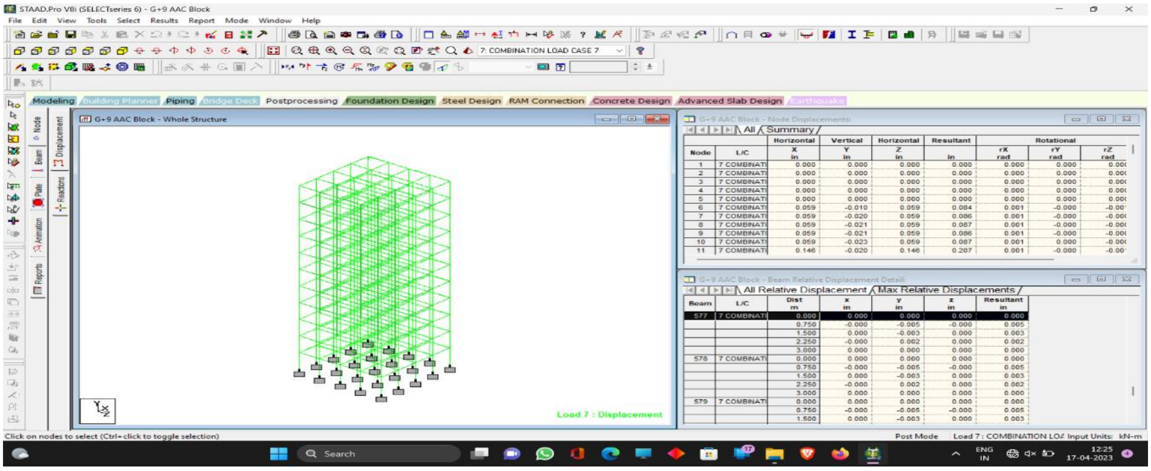

Fig4.2 Shear Force acting on building

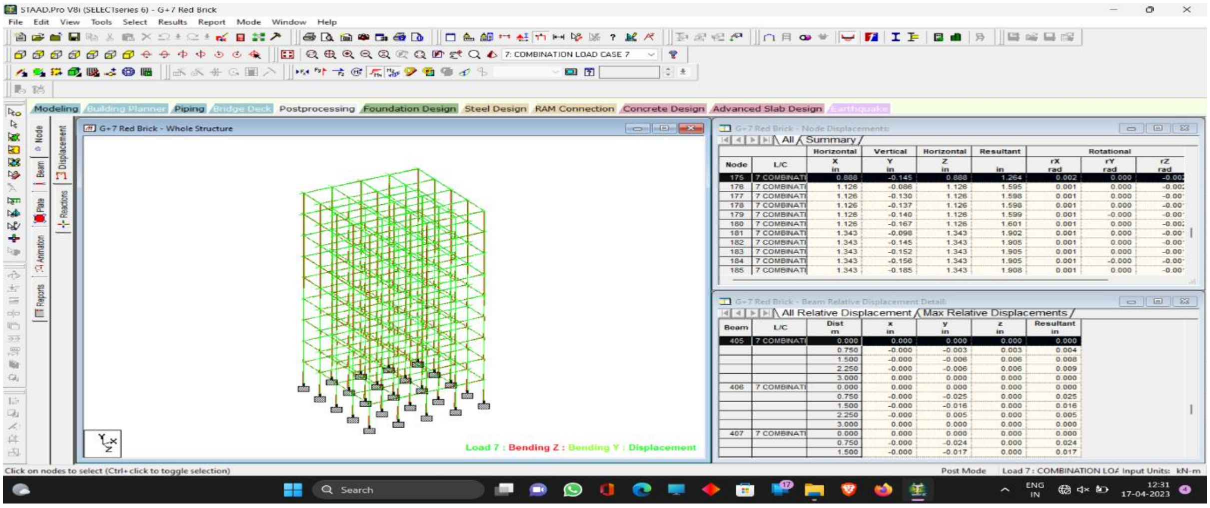

Fig4.3 Bending Moments acting on building

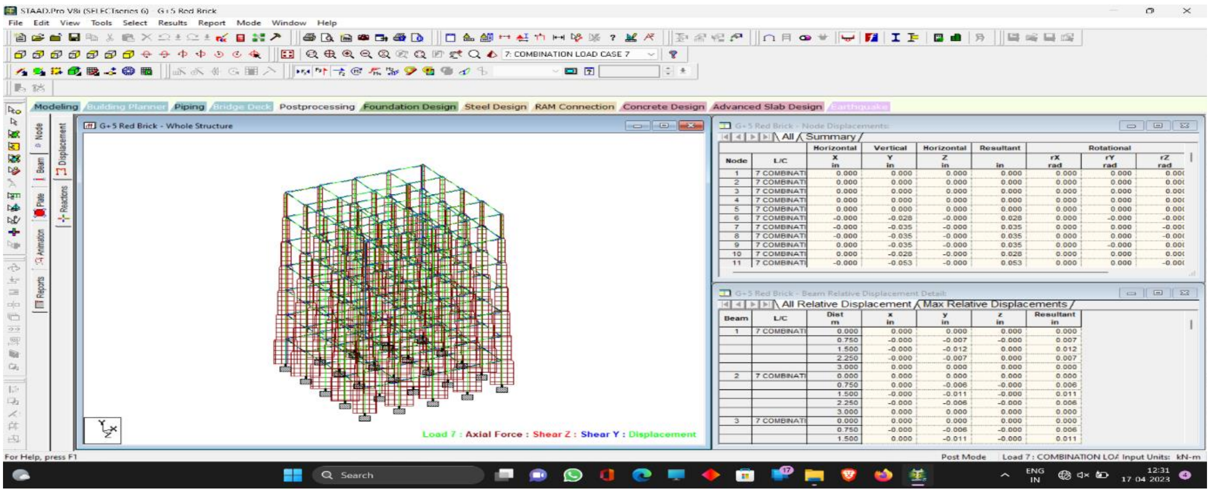

Fig4.4 Deflection of members in building

A. Structural Comparison:

Structural Comparison has been done by comparing Shear Force, Bending Moment and Deflection of beams and columns of buildings with Red Bricks and AAC Block having same size of elements.

Table 2: External Beam of G+3

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.23m*0.3m	0.23m*0.3m
Max Shear Force (KN)	(Y Direction)	-21.85	-9.32
	(Z Direction)	0	0
Max Bending Moment (KN-m)	(Y Direction)	1.62	1.78
	(Z Direction)	98.13	42.22
Max Deflection(m)		-0.011	-0.005

Table 3: Internal Beam of G+3

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.23m*0.3m	0.23m*0.3m
Max Shear Force (KN)	(Y Direction)	-13.85	-7.82
	(Z Direction)	0	0
Max Bending Moment (KN-m)	(Y Direction)	1.54	1.54
	(Z Direction)	64.16	36.18
Max Deflection(m)		-0.007	-0.005

Table 4: External Column of G+3

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.3m*0.3m	0.3m*0.3m
Max Shear Force (KN)	(Y Direction)	-3.51	-2.12
	(Z Direction)	3.53	2.12

Max Bending Moment (KN-m)	(Y Direction)	47.81	28.94
	(Z Direction)	47.60	28.88
Max Deflection(m)		-0.002	-0.001

Table 5: Internal Column of G+3

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.3m*0.3m	0.3m*0.3m
Max Shear Force (KN)	(Y Direction)	-0.88	-0.20
	(Z Direction)	0.95	0.14
Max Bending Moment (KN-m)	(Y Direction)	13.74	2.12
	(Z Direction)	12.36	2.90
Max Deflection(m)		0	-0.001

Table 6: External Beam of G+5

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.23m*0.3m	0.23m*0.3m
Max Shear Force (KN)	(Y Direction)	-21.74	9.25
	(Z Direction)	0	0
Max Bending Moment (KN-m)	(Y Direction)	1.13	1.01
	(Z Direction)	96.62	41.47
Max Deflection(m)		-0.071	-0.005

Table 7: Internal Beam of G+5

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.23m*0.3m	0.23m*0.3m
Max Shear Force (KN)	(Y Direction)	13.79	7.76
	(Z Direction)	0	0

Max Bending Moment (KN-m)	(Y Direction)	1.5	1.50
	(Z Direction)	62.79	35.66
Max Deflection(m)		-0.008	-0.005

Table 8: External Column of G+5

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.38m*0.38m	0.38m*0.38m
Max Shear Force (KN)	(Y Direction)	4.93	3.18
	(Z Direction)	4.93	3.18
Max Bending Moment (KN-m)	(Y Direction)	-84.65	-43.05
	(Z Direction)	84.65	43.05
Max Deflection(m)		-0.001	-0.001

Table 9: Internal Column of G+5

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.38m*0.38m	0.38m*0.38m
Max Shear Force (KN)	(Y Direction)	1.12	2.15
	(Z Direction)	1.12	2.15
Max Bending Moment (KN-m)	(Y Direction)	29.53	15.51
	(Z Direction)	-29.53	-15.51
Max Deflection(m)		0	-0.001

Table 10: External Beam of G+7

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.23m*0.3m	0.23m*0.3m
Max Shear Force (KN)	(Y Direction)	-45.64	-26
	(Z Direction)	0	0
Max Bending Moment (KN-m)	(Y Direction)	1.67	1.95
	(Z Direction)	389.89	239.39
Max Deflection(m)		-0.023	-0.014

Table 11: Internal Beam of G+7

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.23m*0.3m	0.23m*0.3m
Max Shear Force (KN)	(Y Direction)	-37.97	-25.66
	(Z Direction)	0	0
Max Bending Moment (KN-m)	(Y Direction)	1.42	1.84
	(Z Direction)	335.38	225.41
Max Deflection(m)		-0.02	-0.014

Table 12: External Column of G+7

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.45m*0.45m	0.45m*0.45m
Max Shear Force (KN)	(Y Direction)	23.63	15.37
	(Z Direction)	-23.63	-15.37
Max Bending Moment (KN-m)	(Y Direction)	-338.04	-219.69
	(Z Direction)	-338.04	-219.69

Max Deflection(m)		-0.004	-0.003

Table 13: Internal Column of G+7

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.45m*0.45m	0.45m*0.45m
Max Shear Force (KN)	(Y Direction)	62.52	39.43
	(Z Direction)	-62.52	-39.43
Max Bending Moment (KN-m)	(Y Direction)	-848.19	-534.72
	(Z Direction)	-848.19	-534.72
Max Deflection(m)		-0.008	-0.005

Table 14: External Beam of G+9

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.3m*0.45m	0.3m*0.45m
Max Shear Force (KN)	(Y Direction)	-61.74	-33.66
	(Z Direction)	0	0
Max Bending Moment (KN-m)	(Y Direction)	1.86	1.76
	(Z Direction)	595.32	335.08
Max Deflection(m)		-0.009	-0.004

Table 15: Internal Beam of G+9

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.3m*0.45m	0.3m*0.45m
Max Shear Force (KN)	(Y Direction)	-50.26	-29.85
	(Z Direction)	0	0
Max Bending Moment (KN-m)	(Y Direction)	1.37	1.46
	(Z Direction)	515.05	296.76

Max Deflection(m)	-0.008	-0.005

Table 16: External Column of G+9

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.45m*0.45m	0.45m*0.45m
Max Shear Force (KN)	(Y Direction)	19.01	10.04
	(Z Direction)	-19.01	-10.04
Max Bending Moment (KN-m)	(Y Direction)	-258.42	-136.46
	(Z Direction)	-258.42	-136.46
Max Deflection(m)		-0.002	-0.001

Table 17: Internal Column of G+9

Building		Red Brick Building	AAC Blocks Building
Cross-section		0.45m*0.45m	0.45m*0.45m
Max Shear Force (KN)	(Y Direction)	48.96	25.99
	(Z Direction)	-48.96	-25.99
Max Bending Moment (KN-m)	(Y Direction)	-652.82	-345.78
	(Z Direction)	-652.82	-345.78
Max Deflection(m)		-0.006	-0.003

B. Cost Comparison

Cost comparison for framed structure including beams, columns and walls.

Table 18: Cost comparison

Building	Red Brick	AAC Blocks with reduced dimensions	Saving In Percentage
G+3	1605088/-	1447870/-	9.79%
G+5	2720538/-	2272960/-	16.45%
G+7	3972429/-	3298705/-	16.96%

G+9	5425330/-	4145160/-	23.59%

IV. CONCLUSION

After analyzing whole report of the design and comparing each important property of red bricks and AAC Blocks it is Concluded that

1. In building constructed with AAC Blocks instead of bricks, there is reduction in Shear-Force of about 40-70% accordingly.
2. There is Considerable decrease in Bending Moment of the structural elements due to AAC Blocks. Bending Moment of the building with AAC blocks becomes nearly half as compared to red brick one.
3. In the building constructed with the AAC Blocks less deflection is observed.
4. By using AAC Blocks we can reduce the sizes of structural members like beams, columns and footing safely.
5. It is possible to reduce cost of project considerably by alternating the AAC Blocks with bricks.
6. AAC Blocks are environmental friendly than red bricks not producing harmful gases and air pollution in environment and it is certified green building material.

Thus, AAC Block is an economic, efficient and safe alternative to the conventional red bricks.

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