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COST EFFECTIVE BUILDING CONSTRUCTION USING AAC BLOCKS

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ABSTRACT

This research paper investigates the cost-effectiveness of using Autoclaved Aerated Concrete (AAC) blocks as an alternative to traditional building materials such as red bricks. The study reviews the properties of AAC blocks in terms of their low density, porosity and lower water absorption. The research presents a cost comparison between AAC blocks and red bricks for a multi-storeyed structure. This comparison is carried out for a G+6 residential building wherein the quantities of steel and concrete are calculated after analysing the structure using STAAD Pro. The paper also presents a comparison between the physical properties of AAC blocks and red bricks. AAC blocks prove beneficial in a number of ways as they reduce the dead load acting on the structure as a result of which the sections of corresponding beams and columns are reduced. Moreover, the production process of these blocks is eco-friendly. The use of AAC blocks reduces on-site losses and these blocks can be recycled unlike most other building materials. The expenses incurred on the quantities of concrete, steel and other materials, labour, transport, etc. are reduced. This reduction in cost for the building under consideration is about **16 - 18%** which amounts to approximately **Rs 21.5 lakhs**

Keywords: lower water absorption, porous nature, cost-effectiveness, reduction in dead load, eco-friendly.

I. INTRODUCTION

This paper presents a cost comparison between autoclaved aerated concrete AAC blocks and conventional red bricks for a multi storeyed structure. Bricks are one of the most important structural components in the India. In recent times, with expanding urbanization and increasing demand for construction, brick kilns have grown to meet the demand. It has directly or laterally caused a series of environmental and health problems. At a global position, environmental pollution from brick- making operations contribute to the global warming and climate change. Global warming and Environmental pollution is now a global concern. In India the Supreme Court and the National Green Tribunal have also recommended to stop the operation of red bricks. In agreement to the same, government systems in India don't allow the operation of red bricks. Different types of blocks can be used as an alternative to the red bricks, to reduce environmental pollution and Global warming. Autoclaved aerated concrete(AAC) blocks may be one of these. Analogous to foam concrete, Autoclaved Aerated Concrete(AAC) is one of the green structure materials, which can be used for marketable, artificial and domestic construction.

It is pervious, non-toxic, renewable and recyclable. Also it proves to be a better alternative to the normal bricks that are used extensively in terms of cost, strength, continuity, etc. All these factors combined make it an essential product which should be used in order to achieve the target of sustainable development which is veritably essential in order to reduce the carbon footmark and promoting energy effectiveness. In this paper we've performed a cost comparison between AAC blocks and conventional red bricks. Soft wares like Auto CAD and STAAD Pro have been used to plan and design the building under consideration to perform the cost comparison. STAAD is a popular structural analysis operation known for analysis, diversified operations of use, interoperability. STAAD Pro. helps perform 3D structural analysis and design for both steel and concrete structures.

II. METHODOLOGY

1) CODES AND STANDARDS USED-

IS 456: 2000 - Code of Practice for Plain and Reinforced Concrete.
IS 1786:2008 - High Strength Deformed Steel Bars and Wires for Concrete Reinforcement specification.
IS: 6441 (Part V) – 1972 – Methods for test for autoclaved cellular concrete products
IS: 6441 (Part II) – 1972- Determination of drying shrinkage of AAC products
IS: 3495 (Part 1 to Part IV) – 1992 – Methods of tests of burnt clay building bricks
IS: 2185 (Part 3) – 1984 – Specification for concrete masonry units (AAC blocks)

2) TESTING OF BURNT CLAY BRICKS (RED BRICKS) –

a) DRY DENSITY–
It is defined as the ratio of the mass of the brick to its volume when it is oven dried or free of any moisture.
Table-1 Dry Density of red brick

S.NO	DIMENSION	DRY MASS
1.	22.5 x 10 x 7.5 cm	2.905 Kg
2.	22.5 x 10 x 7.5 cm	2.810 Kg
3.	22.5 x 10 x 7.5 cm	2.785 Kg

Volume of the bricks = 1687.5 cm^3

Average dry mass of the bricks = 2.833 Kg

Dry Density= $\frac{\text{Mass of the brick}}{\text{Volume of the brick}}$ = **1678Kg/m^3** approximately

b) WATER ABSORPTION –

This test is used to determine whether the bricks are able to keep away the rainwater thereby increasing the lifespan of the walls/structure. It depends upon the porosity of the brick i.e.;the number of voids or pores present in it.

Water Absorption = $\frac{W2-W1}{W1} \times 100$

Where W1 – Dry weight of sample

W2 – Wet weight of sample

Table - 2 - Water absorption of red brick

S.NO	DRY WEIGHT (Kg)	WET WEIGHT (Kg)	WATER ABSORPTION (%)
1	2.601	3.092	18.877
2	2.462	2.960	20.227
3	2.550	3.004	17.803

Average value of water absorption = $\frac{18.877+20{,}227+17.803}{3}$

= **18.969%**

c) COMPRESSIVE STRENGTH –

It is the capacity of a material or structure to withstand loads in other words it is the ability to resist compressive loads. According to **IS 1077- 1992** the compressive strength of clay brick varies according to the class designation of the sample. Minimum 3 samples are to be tested for determining the compressive strength of any particular class of brick and the average of these values is to be calculated.

Table - 3 - Compressive strength of red brick

S.NO	DIMENSION (cm) (l x b x h)	DRY WEIGHT (Kg)	FAILURE LOAD (kN)	COMPRESSIVE STRENGTH (N/mm^2)
1	22.5 x 10 x 7.5	2.905	150	6.67
2	22.5 x 10 x 7.5	2.810	147	6.53
3	22.5 x 10 x 7.5	2.785	130	5.78

Compressive Strength = $\frac{\text{Maximum Load at failure(N)}}{\text{Area of specimen (mm}^2\text{)}}$

Average Compressive strength = 6.32 N/mm^2

3) TESTING OF AUTOCLAVED AERATED CONCRETE (AAC) BLOCKS-

a) DRY DENSITY –

It is defined as the ratio of the mass of the block to its volume when it is oven dried or free of any moisture.

Dimensions of the block – 600 x 200 x 100 mm

Dry Mass of the block – 8.984 Kg

Dry Density of the block = $\frac{8.984\ Kg}{0.6\times0.2\times0.1\ m^3}$ = **748.66 Kg/m^3**

b) WATER ABSORPTION

This test is used to determine whether the bricks are able to keep away the rainwater thereby increasing the lifespan of the walls/structure. It depends upon the porosity of the brick i.e.; the number of voids or pores present in it.

Table - 4 - Water absorption of AAC block

S.NO	DRY WEIGHT (Kg)	WET WEIGHT (Kg)	WATER ABSORPTION (%)
1	4.70	5.234	11.36
2	4.74	5.142	9.40
3	4.70	5.206	10.7

Average value of water absorption = $\frac{11.36+9.40+10.7}{3}$

= 10.48%

c) **COMPRESSIVE STRENGTH–**

To perform this test place a AAC block on the plate of the compression testing machine. Align the block according to the plate dimensions so as to obtain accurate results.

Compressive Strength is defined as the ratio of the failure load in N to the area which is under compressive load

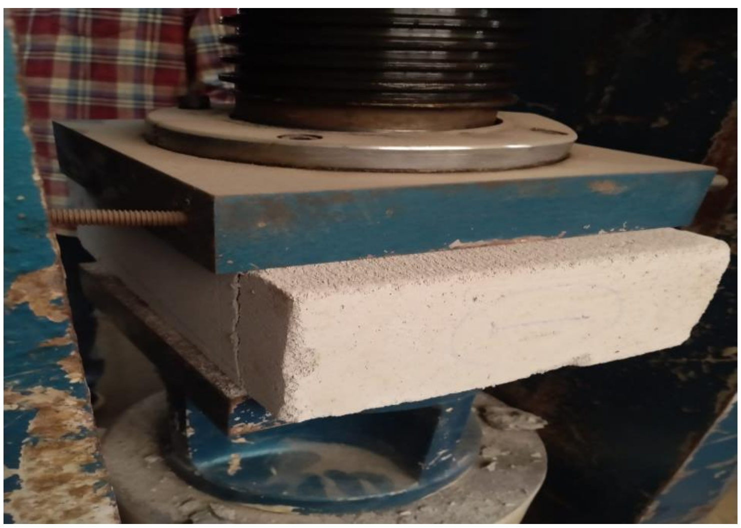
$$\textbf{Compressive Strength} = \frac{\textbf{Maximum Load at failure(N)}}{\textbf{Area of specimen (mm}^2\textbf{)}}$$

Table - 5 - Compressive strength of AAC block

S.NO	DIMENSION (mm) (l x b x h)	FAILURE LOAD (kN)	COMPRESSIVE STRENGTH (N/mm^2)
1	600 x 200 x 100	170	3.85
2	600 x 200 x 100	182	4.12
3	600 x 200 x 100	180	4.08

$$\textbf{Compressive Strength} = \frac{\textbf{Maximum Load at failure(N)}}{\textbf{Area of specimen (mm}^2\textbf{)}}$$

Average Compressive strength = 4.01 N/mm^2

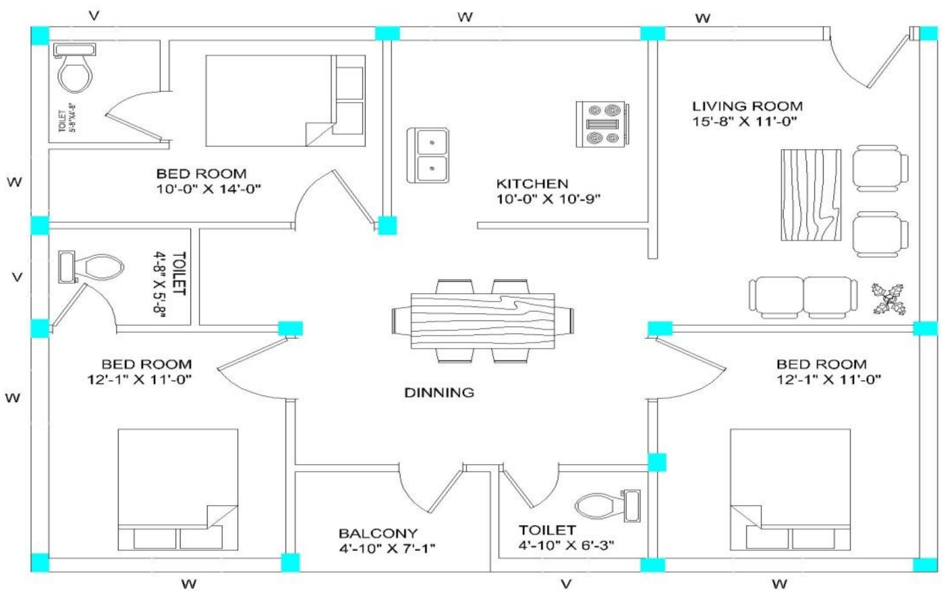


MODELING AND ANALYSIS

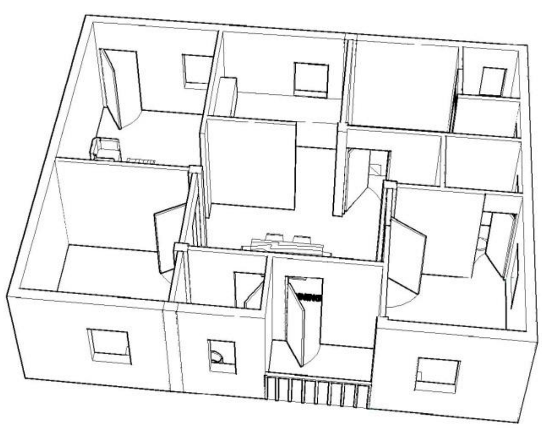
PLANNNIG -

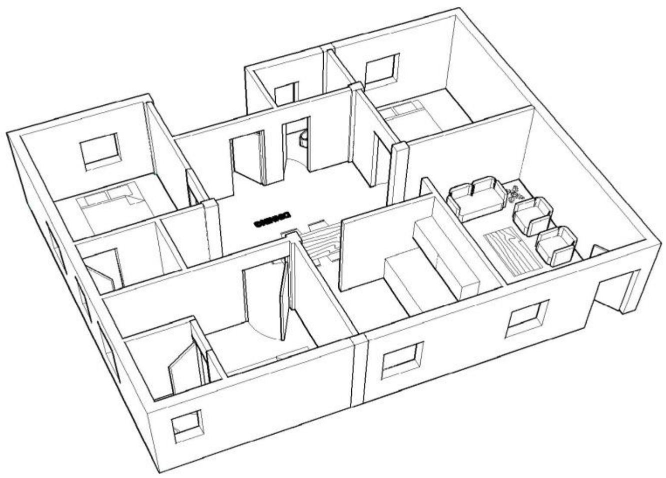
This is the plan/top view of a typical **3BHK** flat of the residential building.
The built-up area of the flat is **1140 sq. ft. (105.9 sq.m)**

Carpet area - **950.38 sq. ft. (88.29 sq.m)**
In total there are **40** such flats in the building



The figures shown below represent 3- D models of one flat.





Plan of the building: -

https://drive.google.com/file/d/1Zd7Td1xOeLZCDHKMVuPgyrs6XFyMjM8a/view?usp=share_link

Column axis drawing: -

https://drive.google.com/file/d/1dPuECdOGTZN51xn591RxdtvgjrHSIu2I/view?usp=share_link

ANALYSIS

(a) FOR RED BRICKS

Dead load on outer walls:**12kN/m**

Dead load on inner walls:**6kN/m**

Dead load on parapet walls:**3kN/m**

The columns and beams are placed in accordance with the plan of the building. Properties of the beams, columns and slabs of the structure are applied. The 3D rendering view of the structure is represented by the figure below

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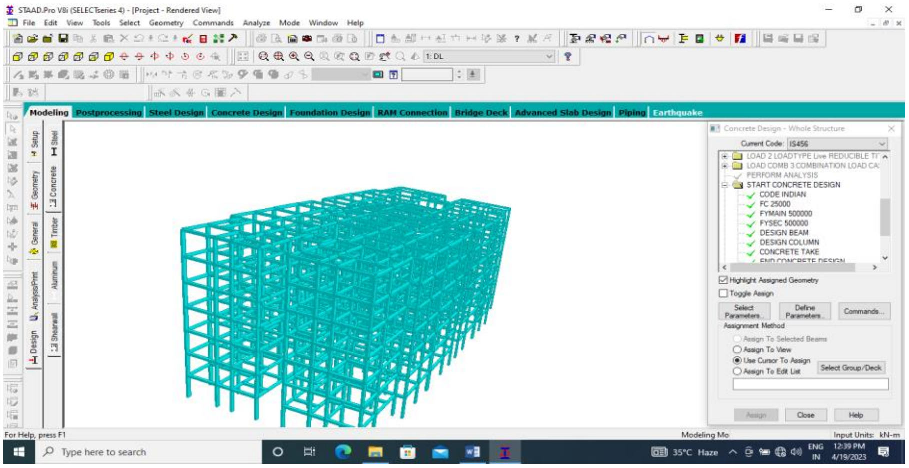
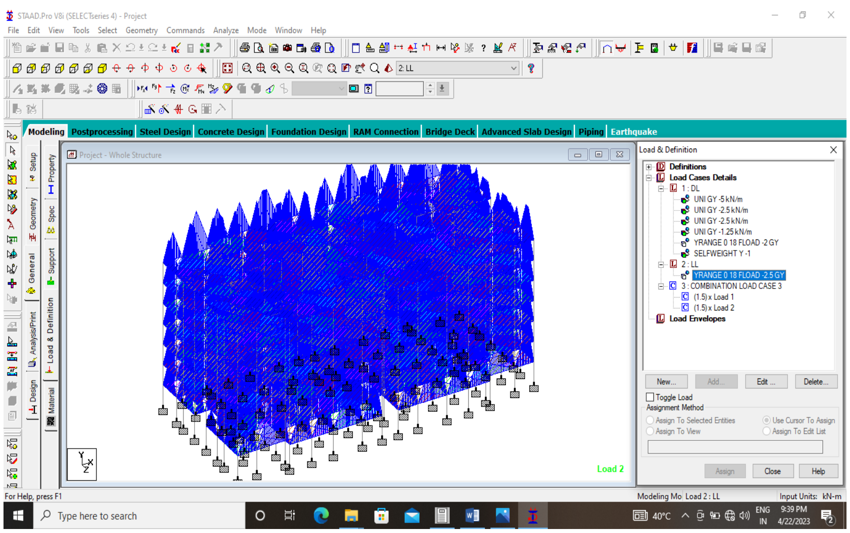


This is followed by the application of loads and load combinations on the structure .



After the application of loads, relevant Code (IS 456) is selected for concrete design which can be opted from the design tab on the screen. The structure is then analysed to calculate the quantities of reinforcement and concrete.

(b) FOR AAC BLOCKS: The same structure in now analysed for AAC blocks. The dead load and the beam and column sections are changed and the rest of the procedure is followed as it is:

Dead load on outer walls:**6kN/m**

Dead load on inner walls:**3kN/m**

Dead load on parapet walls:**1.5kN/m**

The same procedure is followed for applying loads to the structure and properties to beams and columns.

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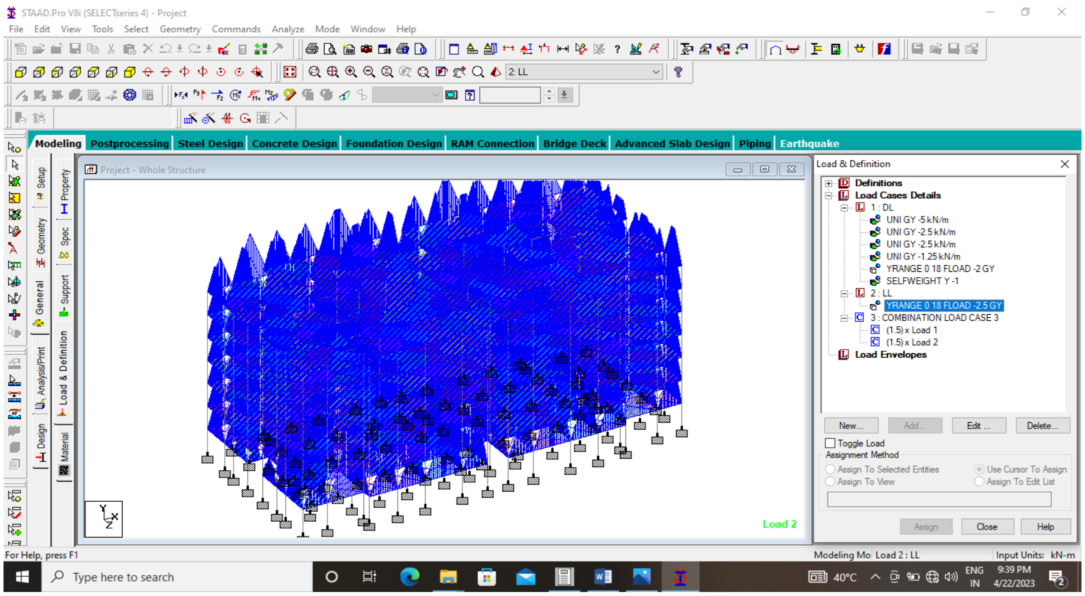
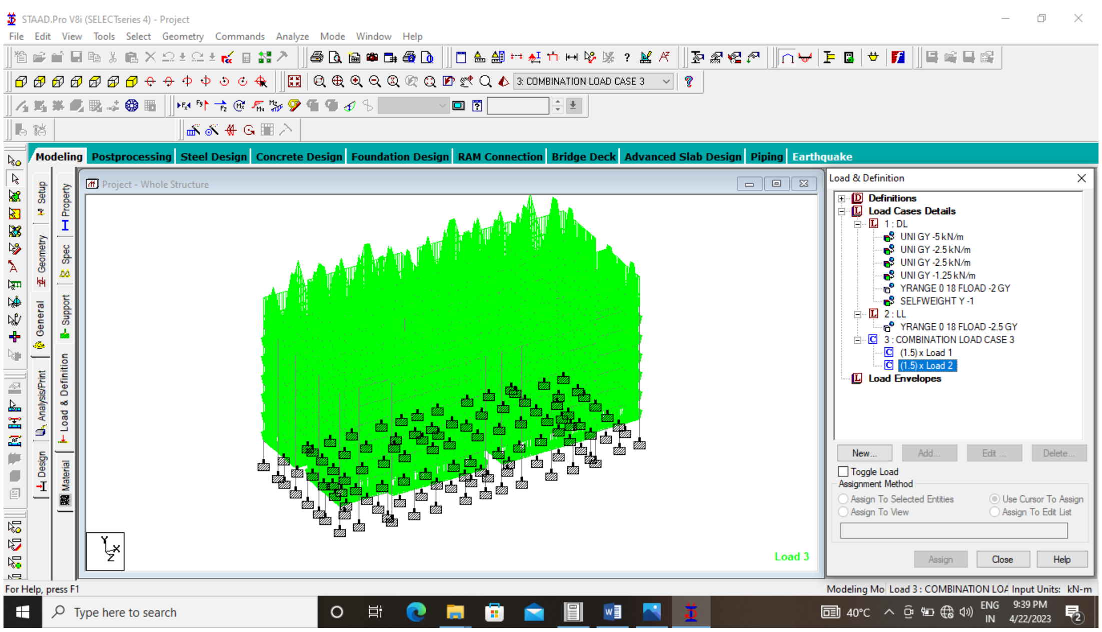
Here, the sizes of corresponding beams and columns are reduced in accordance with the reduction in load





RESULTS AND DISCUSSION:

Table - 6 - Comparison of the properties of AAC block and red brick

S.NO	TEST PERFORMED	RESULT (RED BRICK)	RESULT (AAC BLOCK)
1.	DRY DENSITY	1678 Kg/m^3	748.66 Kg/m^3
2.	WATER ABSORPTION	18.969%	10.48%
3.	COMPRESSIVE STRENGTH	6.32N/mm^2	4.01 N/mm^2

Dry density of red brick is much more than that of AAC block. This means that AAC block is much lighter in comparison to the conventional clay brick. This is because the **porosity** of the block is very high

Water Absorption of AAC block is much lower than that of the red brick. This implies that AAC blocks would absorb less water thereby providing a better protection from rain which would in turn ensure that the problems of seepage, etc. are avoided and durability of the structure/walls is increased.

Compressive Strength of the brick is greater than that of the AAC block. This is due to the porous nature of the blocks.

It is due to this reason that these blocks are not recommended for substructure construction.

Results obtained from the analysis of the structure in STAAD Pro.:

a)For Red bricks:

Total Volume of Concrete - **551.7 cu. metre** (includes quantities of concrete for beams, columns and slabs)

Total Weight of Steel - **56.2 Tonnes** (includes quantities of steel required for beams and columns)

b) **ForAAC Blocks:**

Total Volume of Concrete - **434 cu. metre** (includes quantities of concrete for beams, columns and slabs)

Total Weight of Steel - **49.2 Tonnes** (includes quantities of steel required for beams and columns)

COST COMPARISION - (i) **Concrete and steel quantities:**

a) FOR RED BRICKS

Table - 7 - Cost incurred on the quantities of steel and concrete for the structure when red bricks are used

S.NO	PARTICULARS	VOLUME/WT.	RATE	COST
1.	CONCRETE	551.7cu.metre	Rs. 5000 per cu m	Rs 27,58,500
2.	STEEL	56.10tonnes	Rs 78 per kg	Rs 43,75,800
	TOTAL	-	-	Rs 71,34,300

b) FOR AAC BLOCKS

Table - 8 - Cost incurred on the quantities of steel and concrete for the structure when AAC blocks are used

S.NO	PARTICULARS	VOLUME/WT.	RATE	COST
1.	CONCRETE	434 cu.metre	Rs. 5000 per cu m	Rs 21,70,000
2.	STEEL	49.2 tonnes	Rs 78 per kg	Rs 38,37,600
	TOTAL	-	-	Rs 60,07,600

As we can observe from a brief comparison between the amount of concrete and steel required for the structure when the above said types of bricks are taken into consideration and their respective costing is carried out we can observe a difference of approximately **Rs 11.3 lakh**.

(ii) **Masonry work and plastering:**

Table - 9 - Cost comparison for constructing walls of 200mm thickness for the structure

S.NO	MATERIAL USED	RATE	VOLUME	COST
1.	RED BRICKS	Rs 4100 per cu. m	856 m^3	Rs 35,09,100
2.	AAC BLOCKS	Rs 3500 per cu.m	856 m^3	Rs 29,96,000

The difference comes out to be approximately **Rs 5 lakhs**

Table - 10 - Cost comparison for constructing walls of 100mm thickness for the structure

S.NO	MATERIAL USED	RATE	VOLUME	COST
1.	RED BRICKS	Rs 4100 per cu. m	281.63 m^3	Rs 11,54,704
2.	AAC BLOCKS	Rs 3500 per cu.m	281.63 m^3	Rs 9,85,705

The difference comes out to be approximately **Rs 2 lakhs**

Plastering:

Total area of plastering for one flat is equal to:

(i) Outer walls - **131 sq.m**

(ii) Inner walls - **77 sq.m**

a) Brick masonry is to be provided with **15mm** thick plaster on both the sides. Rate of plastering according to **CG PWD SOR** code number 11.1 is **Rs 107 per sq.m**(1:6; Cement: Sand).

Therefore, cost of plastering walls built using **red bricks** @ Rs 107 per sq.m

= 107*208*2 = **Rs 44,512**

b) Block masonry is to be provided with **6mm** thick plaster on the inner face and **12mm** on the outer face. Rate of plastering according to **CG PWD SOR code number 11.1** for 6mm plaster is **Rs 87 per sq.m**(1:4; Cement: Sand) and for 15mm plaster is **Rs 91.5 per sq.m**(1:6;Cement: Sand)**.**

Now, cost of plastering walls built using AAC blocks @ Rs 87 for inner faces

and @ Rs 91.5 for outer faces = (131*91.5) +(131*87) +(2*77*87) = **Rs 36,781**

Therefore, from above calculations it is observed that per flat approximately **Rs 8,000** is saved for plastering the walls.

Total amount saved for **40** flats - **Rs 3,20,000/-**

III. CONCLUSION

The outcome of our project is to create a cost comparison between normal clay bricks and AAC blocks when used in a multi storeyed building. The analysis of the building is done using STAAD Pro. Various load combinations were used according to the Indian Standards to calculate the shear force, bending moment and deflection of the structure. The usage of AAC blocks reduces the dead load of the structure significantly which would in turn prove to be a cost effective way of construction.Therefore, from the above calculations we observe that AAC blocks prove to be cost effective in terms of workability as compared to red bricks. This reduction in cost comes out to be approximately **16%** which amounts to approximately **Rs 21.5 lakhs**. As the volume of work increases the savings are further increased. Moreover, the savings incurred on transport, labour, etc. are significant. Taking into consideration these factors the savings can be of amount to **16 - 18 %** of the total project cost.

However, usage of such blocks is not recommended in load bearing structures as these are light weight and have a lower compressive strength as compared to red bricks.Usage of such blocks in high rise buildings is highly recommended as they reduce the costs significantly due to their workability factor and the overall reduction in dead load of a structure. As, the dead load acting on the structure is reduced, the sizes of beams and columns can also reduced thereby reducing the quantity of concrete and steel making the structure cost efficient. AAC block being a green material does not release harmful toxins in the environment during its production phase. Moreover, these blocks can be easily recycled for further usage which helps in the reduction of waste generated.

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