# A Comparative Study On Various Building Blocks As An Alternative To Conventional Bricks

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**Abstract:**

*The comparison has to be made between Chamber Clay bricks, Fly ash bricks, AAC blocks, CLC blocks and Poro therm blocks based on their engineering properties and economic aspects. The major tests that to be carried out to determine the engineering properties are:*

1.*Bulk density*

2. *Direct Compressive strength test*

3. *Water absorption test*

4. *Thermal conductivity test*

*The above tests were carried out to check how far the products are conforming to Indian Standards.*

*Based on the obtained results, Cost Benefit Analysis is made for each building blocks and these values are discussed to know their economic benefits.*

*KEYWORDS:- Chamber Clay bricks, Fly ash bricks, AAC blocks, CLC blocks,Major Tests,Indian Standarads,Analysis*

## I.INTRODUCTION

Clay brickwork is made from selected clays moulded or cut into shape and fired in ovens. The firing transforms the clay into a building component with high compressive strength and excellent weathering qualities, attributes that have been exploited for millennia. Clay brickwork is India's most widely used external wall cladding.

Clay bricks are affordable, readily available, mass-produced, thoroughly tested modular building components. Their most desirable acoustic and thermal properties derive from their relatively high mass. They require little or no maintenance and possess high durability and loadbearing capacity.

Concrete bricks are the same size and intended for the same uses as clay bricks. They share many of the same attributes of clay bricks but may require more control joints, may stain more easily and their colour may be subject to fading over time. They are more

porous than clay bricks and must be sealed to prevent water penetration.

The use of clay and concrete brickwork is informed by extensive Indian research, manufacturing and construction experience.

There are various building blocks which are recently emerged in our construction Industry. In practice the better choice of adaptation of suitable wall units is made by comparison on their engineering properties.

The AAC blocks, Chamber clay bricks, Fly ash bricks, Porotherm blocks and CLC blocks are different building blocks which are really competitive in today's construction field

## II.TESTING PROGRAM

### .1. COMPRESSIVE STRENGTH TEST

The test was conducted based on the procedure described in Indian Codal provisions IS 3495(part 1): 1992

### TEST RESULTS

*A.Chamber clay Bricks*

The Compression strength of Chamber clay bricks = 7.933 N/mm2

*B.Fly-Ash Bricks*

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The Compression strength of Fly-Ash bricks = 9.604 N/mm$^2$

| Brick no | Size (cm) L x B | Weight (Kg) | Compression Load (KN) |
|---|---|---|---|
| 1 | 15 x 15 | 3.442 | 69.3 |
| 2 | 15 x 15 | 3.274 | 63.1 |
| 3 | 15 x 15 | 3.278 | 48.5 |
| 4 | 15 x 15 | 3.290 | 43.7 |

*C.Porotherm Blocks*

| Brick no | Size (cm) L x B | Weight (Kg) | Compression Load (KN) |
|---|---|---|---|
| 1 | 15 x 15 | 1.995 | 83.2 |
| 2 | 15 x 15 | 2.047 | 83 |
| 3 | 15 x 15 | 1.986 | 61.2 |
| 4 | 15 x15 | 2.035 | 68.8 |

*The Compression strength of Porotherm blocks = 1.4579 N/mm$^2$*

*D.AAC Blocks*

| Brick no | Size (cm) L x B | Weight (Kg) | Compression Load (KN) |
|---|---|---|---|
| 1 | 23 x 10 | 3.370 | 175 |
| 2 | 23 x 10 | 3.467 | 166.7 |
| 3 | 23 x 10 | 3.434 | 205.7 |

| Brick no | Size (cm) L x B | Weight (Kg) | Compression Load (KN) |
|---|---|---|---|
| 1 | 22.9 x 10.6 | 3.444 | 251.2 |
| 2 | 22.9 x 10.5 | 3.445 | 253.6 |
| 3 | 22.9 x 10.6 | 3.276 | 190.5 |

*The Compression strength of AAC blocks = 3.291 N/mm$^2$*

*E.CLC Blocks*

| Brick no | Size (cm) L x B | Weight (Kg) | Compression Load (KN) |
|---|---|---|---|
| 1 | 22.9 x 10.6 | 3.444 | 251.2 |
| 2 | 22.9 x 10.5 | 3.445 | 253.6 |
| 3 | 22.9 x 10.6 | 3.276 | 190.5 |

*The Compression strength of CLC blocks = 2.495 N/mm$^2$*

| Block no | Dry oven weight (M1) [kg] | Wet weight (M2) [kg] |
|---|---|---|
| 1 | 0.558 | 0.890 |
| 2 | 0.575 | 0.909 |
| 3 | 0.555 | 0.896 |

2.WATER ABSORPTION TEST

Water absorption

A standard soaking-in-water test can determine the porosity of bricks and blocks, which can then be used as an indication of the potential for the development of problems related to the penetration of salts and other materials into the units, such as salt attack and efflorescence.

Initial rate of absorption

As soon as the bricklayer puts the mortar on a brick, the brick starts to absorb water out of the mortar. The microscopic pores in the brick soak up the water, which carries with it some of the partly-dissolved cement and lime. It's the setting of this cementious material within the brick pores that provides most of the bond between the brick and the mortar, and thus gives the wall its strength.

*TEST RESULTS*

*A.Chamber Clay Brick*

*Average water absorption = 10.54%*

*B.Fly-Ash Brick*

*Average water absorption = 13.52%*

| Brick no | Dry oven weight (M1) [kg] | Wet weight (M2) [kg] |
|---|---|---|
| 1 | 3.150 | 3.580 |
| 2 | 3.239 | 3.637 |
| 3 | 2.893 | 3.316 |

*C.Porotherm Blocks*

*Average water absorption = 14%*

| Brick no | Dry oven weight (M1) [kg] | Wet weight (M2) [kg] |
|---|---|---|
| 1 | 3.150 | 3.580 |
| 2 | 3.239 | 3.637 |

*D.AAC Blocks*

*Average water absorption = 59.675%*

*E.CLC Blocks*

| Brick no | Dry oven weight (M1) [kg] | Wet weight (M2) [kg] |
|---|---|---|
| 1 | 3.136 | 3.462 |
| 2 | 3.140 | 3.468 |
| 3 | 3.080 | 3.412 |

| Brick no | Size (cm) L x B x D | Dry Oven Weight(Kg) | Density ($Kg/m^3$) |
|---|---|---|---|
| 1 | 200 x 100 x 50 | 0.558 | 558 |
| 2 | 200 x 100 x 50 | 0.575 | 575 |
| 3 | 200 x 100 x 50 | 0.555 | 555 |

*Average water absorption = 8.72%*

| Block no | Dry oven weight (M1) [kg] | Wet weight (M2) [kg] |
|---|---|---|
| 1 | 1.020 | 1.110 |
| 2 | 1.057 | 1.137 |
| 3 | 1.045 | 1.125 |
| 4 | 1.017 | 1.127 |

3.DENSITY TEST

THREE BLOCKS SHALL BE DRIED TO CONSTANT MASS IN A SUITABLE OVEN HEATED TO APPROXIMATELY 100°C. AFTER COOLING THE BLOCKS TO ROOM TEMPERATURE, THE DIMENSIONS OF EACH BLOCK SHALL BE MEASURED IN CENTIMETRES TO THE NEAREST MILLIMETRE AND THE OVERALL VOLUME COMPUTED IN CUBIC CENTIMETRES. THE BLOCKS SHALL THEN BE WEIGHTED IN KILOGRAMS TO THE NEAREST 10 GM. THE DENSITY OF EACH BLOCK CALCULATED AS FOLLOWS:

Density in $kg/m^3$ = Mass of block in kg/Mass of block in $cm^2 * 10^6$

*TEST RESULTS*

*A.Chamber clay Bricks*

The dry density of chamber clay bricks = 1885.6 $Kg/m^3$

B.Fly-Ash Bricks

| Brick no | Size (cm) L x B x D | Dry Oven Weight(Kg) | Density ($Kg/m^3$) |
|---|---|---|---|
| 1 | 10.7 x 10 x 5.5 | 1.108 | 1882.753 |
| 2 | 11 x 10.5 x 5.8 | 1.192 | 1779.370 |
| 3 | 10.8 x 10.5 x 5.8 | 1.154 | 1754.546 |

The dry density Fly-Ash bricks = 1805.56 $Kg/m^3$

*C.Porotherm Blocks*

| Brick no | Size (cm) L x B x D | Dry Oven Weight(Kg) | Density ($Kg/m^3$) |
|---|---|---|---|
| 1 | 39.5 x 20 x 15.2 | 8.899 | 741.089 |
| 2 | 39.5 x 20 x 15.2 | 8.906 | 741.672 |
| 3 | 39.5 x 20 x 15.2 | 8.912 | 742.172 |

The dry density of Porotherm blocks= 741.674 $Kg/m^3$

*D.AAC Blocks*

The dry density of AAC blocks = 562.67 Kg/m$^3$

*E.CLC Blocks*

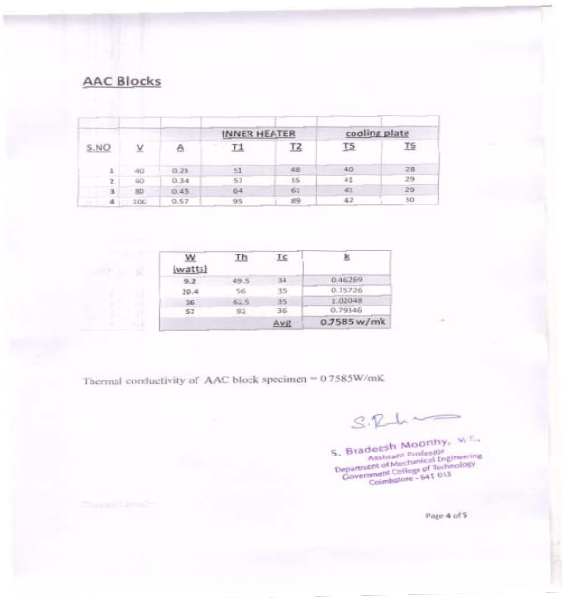
**4.THERMAL CONDUCTIVITY TEST**

| Brick no | Size (cm) L x B x D | Dry Oven Weight(Kg) | Density (Kg/m$^3$) |
|---|---|---|---|
| 1 | 204 x 103 x 53 | 1.072 | 962.612 |
| 2 | 204 x 103 x 54 | 1.101 | 970.345 |
| 3 | 203 x 101 x 53 | 1.077 | 991.111 |
| 4 | 203 x 102 x 53 | 1.059 | 964.992 |

The dry density of CLC blocks = 972.265 Kg/m$^3$

| Brick no | Size (cm) L x B x D | Dry Oven Weight(Kg) | Density (Kg/m$^3$) |
|---|---|---|---|
| 1 | 10.2 x 6.1 x 6 | 0.697 | 1867.031 |
| 2 | 10 x 6.5 x 6.7 | 0.795 | 1825.488 |
| 3 | 10.2 x 5.8 x 5.8 | 0.674 | 1964.287 |

**RESULTS:**



AAC Blocks

| S.NO | V | A | INNER HEATER T1 | T2 | cooling plate T5 | T6 |
|---|---|---|---|---|---|---|
| 1 | 40 | 0.23 | 51 | 48 | 40 | 28 |
| 2 | 60 | 0.34 | 57 | 55 | 41 | 29 |
| 3 | 80 | 0.45 | 64 | 61 | 41 | 29 |
| 4 | 100 | 0.57 | 95 | 89 | 42 | 30 |

| W (watts) | Th | Tc | k |
|---|---|---|---|
| 9.2 | 49.5 | 34 | 0.46269 |
| 20.4 | 56 | 35 | 0.35726 |
| 36 | 62.5 | 35 | 1.02048 |
| 57 | 92 | 36 | 0.79346 |
| | | Avg | 0.7585 w/mK |

Thermal conductivity of AAC block specimen = 0.7585W/mK

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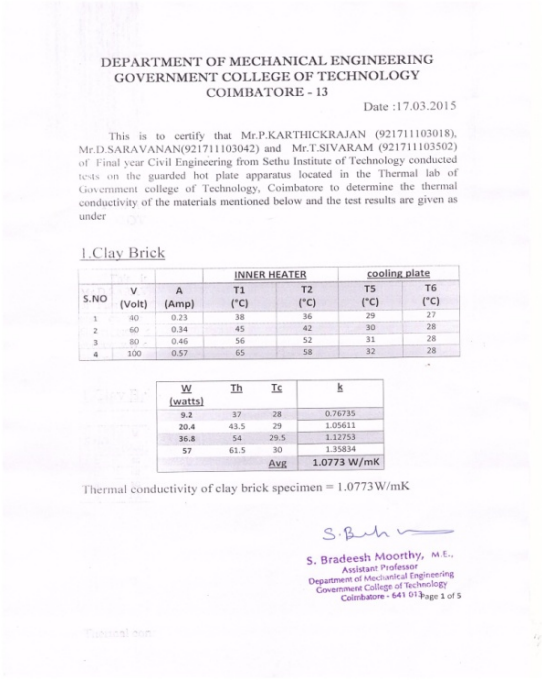

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Date :17.03.2015

This is to certify that Mr.P.KARTHICKRAJAN (921711103018), Mr.D.SARAVANAN(921711103042) and Mr.T.SIVARAM (921711103502) of Final year Civil Engineering from Sethu Institute of Technology conducted tests on the guarded hot plate apparatus located in the Thermal lab of Government college of Technology, Coimbatore to determine the thermal conductivity of the materials mentioned below and the test results are given as under

1.Clay Brick

| S.NO | V (Volt) | A (Amp) | INNER HEATER T1 (°C) | T2 (°C) | cooling plate T5 (°C) | T6 (°C) |
|---|---|---|---|---|---|---|
| 1 | 40 | 0.23 | 38 | 36 | 29 | 27 |
| 2 | 60 | 0.34 | 45 | 42 | 30 | 28 |
| 3 | 80 | 0.46 | 56 | 52 | 31 | 28 |
| 4 | 100 | 0.57 | 65 | 58 | 32 | 28 |

| W (watts) | Th | Tc | k |
|---|---|---|---|
| 9.2 | 37 | 28 | 0.76735 |
| 20.4 | 43.5 | 29 | 1.05611 |
| 36.8 | 54 | 29.5 | 1.12753 |
| 57 | 61.5 | 30 | 1.35834 |
| | | Avg | 1.0773 W/mK |

Thermal conductivity of clay brick specimen = 1.0773W/mK

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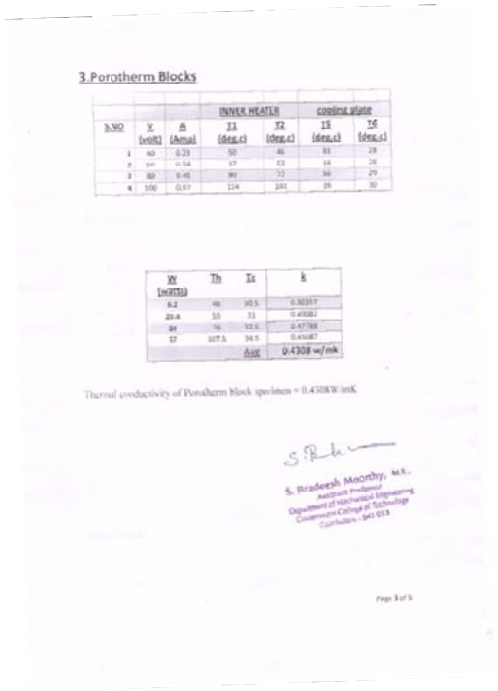
3.Porotherm Blocks

| S.NO | V (volt) | A (Amp) | INNER HEATER T1 (deg.c) | INNER HEATER T2 (deg.c) | cooling plate T5 (deg.c) | cooling plate T6 (deg.c) |
|---|---|---|---|---|---|---|
| 1 | 40 | 0.23 | 50 | 46 | 33 | 29 |
| 2 | 60 | 0.34 | 67 | 53 | 34 | 28 |
| 3 | 80 | 0.45 | 90 | 72 | 36 | 29 |
| 4 | 100 | 0.57 | 114 | 101 | 39 | 30 |

| W (watts) | Th | Tc | k |
|---|---|---|---|
| 9.2 | 46 | 30.5 | 0.30357 |
| 20.4 | 53 | 33 | 0.40682 |
| 34 | 76 | 33.6 | 0.47788 |
| 57 | 107.5 | 34.5 | 0.45087 |
| | | Avg | 0.4308 w/mk |

Thermal conductivity of Porotherm block specimen = 0.4308W/mK

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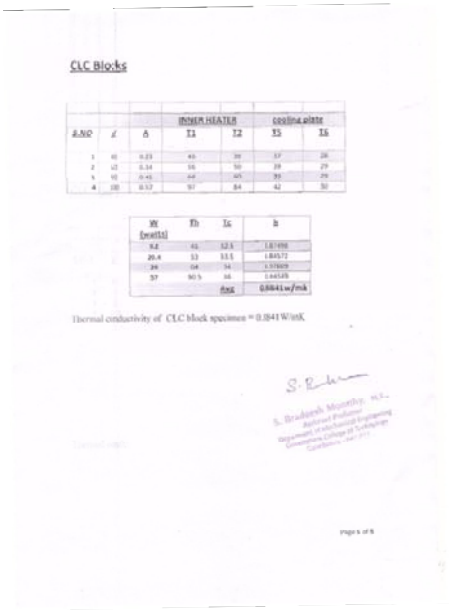
CLC Blocks

| S.NO | V | A | INNER HEATER T1 | INNER HEATER T2 | cooling plate T5 | cooling plate T6 |
|---|---|---|---|---|---|---|
| 1 | 40 | 0.23 | 46 | 39 | 37 | 28 |
| 2 | 60 | 0.34 | 56 | 50 | 38 | 29 |
| 3 | 80 | 0.45 | 68 | 60 | 39 | 29 |
| 4 | 100 | 0.57 | 97 | 84 | 42 | 30 |

| W (watts) | Th | Tc | k |
|---|---|---|---|
| 9.2 | 46 | 32.5 | 1.81498 |
| 20.4 | 53 | 33.5 | 1.84572 |
| 34 | 68 | 34 | 1.97809 |
| 57 | 90.5 | 36 | 1.94588 |
| | | Avg | 0.8841 w/mk |

Thermal conductivity of CLC block specimen = 0.8841 W/mK

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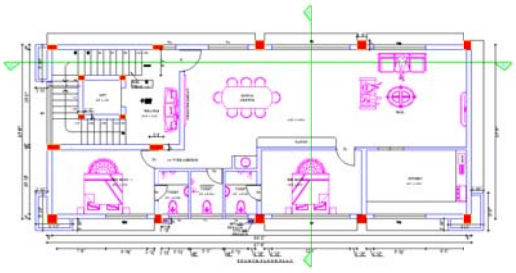
## III. COST BENEFIT ANALYSIS

### *A. Brick work estimation:*

The brick work estimation is made for an apartment building to obtain the costs that are to be spend in the building blocks. The plan and sectional-elevation of the building is shown in the fig.

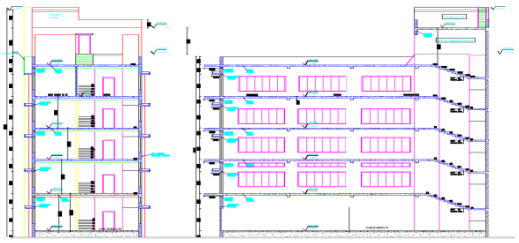


Plan of the Building

Sectional plan of the Apartment building

The walls in the building are divided in to two types:

- M-Type walls (230mm thick walls)
- P-Type walls (115mm thick walls



Brickwork quantity for individual floors is shown in the table:

| | Floor height [m] | M-type wall (230mm wall) [$m^3$] | P-type wall (115mm wall) [$m^3$] |
|---|---|---|---|
| 1st floor | 3.81 | 74.87 | 8.49 |
| 2nd floor | 3.505 | 68.88 | 7.82 |
| 3rd floor | 3.505 | 68.88 | 7.82 |
| 4th floor | 3.505 | 68.88 | 7.82 |
| | Total | 281.5 $m^3$ | 31.95 $m^3$ |

Total quantity of brick work = 313.45 $m^3$

*B.Cost of blocks in the brickwork of the building*

| Blocks | Cost(₹) |
|---|---|
| Clay brick | 8, 38,779 |
| Fly-ash brick | 6, 82,574 |
| Porotherm brick | 11, 96,483 |
| AAC | 14, 45,006 |
| CLC | 10, 84,804 |

*C.Percentage increase or decrease in Cost difference between Clay bricks and other blocks*

| BLOCK TYPE | Percentage difference in cost (%) | REMARK |
|---|---|---|
| *Fly-ash brick* | **18.62** | Reduction in cost |
| *Porotherm brick* | **42.65** | Increase in cost |
| *AAC* | **72.26** | Increase in cost |
| *CLC* | **29.33** | Increase in cost |

## IV. LOAD EFFICIENCY ANALYSIS

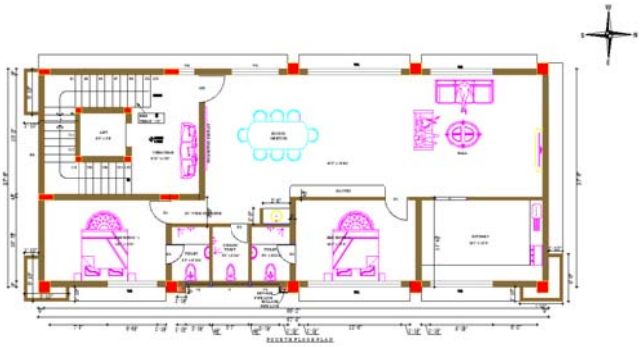
### *A. Assumptions*

The Buildings have the following criteria:

a) Building is 5 storeys(G+4) high and has floor area 20 m x 8.5 m.

b) Building is a framed Concrete structure.

c) Building is residential and has the layout as shown:



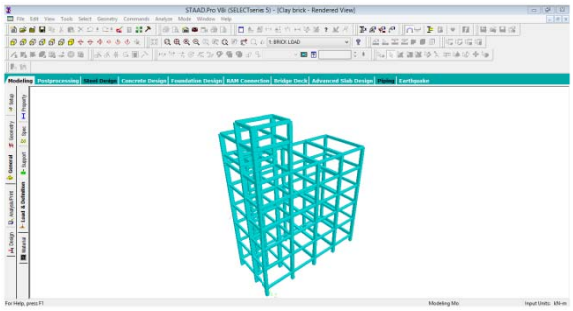
On comparing the loadings of each building blocks with clay brick loading, Weight reduction percentage in Partition wall are given below:

| Blocks | Weight reduction percentage |
|---|---|
| Fly-Ash brick | *3.2 %* |
| Porotherm block | *45.6%* |
| AAC block | *52.7%* |
| CLC block | *36.4%* |

## V. CONCRETE QUANTITY TAKE OFF OF THE BUILDING

The frames of the building is modeled and analyzed individually for each blocks using Staad.pro V8i. The

structural members of the frame are optimized for corresponding loadings influenced by the blocks.



**NOTE:** CONCRETE QUANTITY REPRESENTS VOLUME OF CONCRETE IN BEAMS, COLUMNS AND FOOTINGS DESIGNED ABOVE.

Cost Benefit Analysis for Concreting

Assumptions

- M25 grade concrete
- Mix ratio= 1 : 1 : 2

| BLOCK | Concrete quantity take off (m3) |
|---|---|
| *Clay brick* | 216.97 |
| *Fly-ash brick* | 206.85 |
| *Porotherm block* | 160.72 |
| *AAC block* | 152.14 |
| *CLC block* | 172.1 |

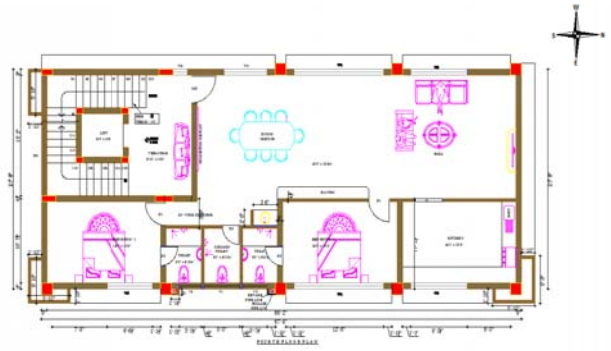
- Sand 1 unit (100 cu.ft) = ₹ 3250 → 1 cu.ft = ₹ 32.5
- Cement 1 bag (50kg) = ₹ 370
- Course aggregate [20mm-size] 1 unit (100 cu.ft) = ₹ 2800 → 1 cu.ft = ₹ 28

*Cost incurred in total Concrete take off for individual bocks*

| | Concrete quantity take off (m3) | Cost incurred (₹) |
|---|---|---|
| *Clay brick* | **216.97** | 11,73,564 |
| *Fly-ash brick* | **206.85** | 11,18,852 |
| *Porotherm block* | **160.72** | 8,69,340 |
| *AAC block* | **152.14** | 8,22,945 |
| *CLC block* | **172.1** | 9,30,997 |

*Percentage reduction in Concrete take off costs of individual blocks with the Clay brick:*

| | *Cost difference (₹)* | *Percentage reduction (%)* |
|---|---|---|
| *Fly-ash brick* | 54,712 | *4.66* |
| *Porotherm block* | 3,04,224 | *25.92* |
| *AAC block* | 3,50,638 | *29.88* |
| *CLC block* | 2,42,567 | *20.67* |



VI.THERMAL EFFICIENCY

*A. Thermal Conductivity*

The Heating Loads induced inside the buildings

| | *CLAY BRICK* | *FLY-ASH BRICK* | *POROTHERM* | *AAC* | *CLC* |
|---|---|---|---|---|---|
| Dining hall | 5.334 | 5.296 | 4.979 | 4.895 | 5.058 |
| Bedroom - 1 | 1.155 | 1.131 | 0.975 | 0.937 | 1.013 |
| Bedroom - 2 | 1.233 | 1.219 | 1.085 | 1.050 | 1.117 |
| Total Heat load *(Ton)* | 7.722 | 7.646 | 7.039 | 6.882 | 7.188 |

Summary:

- Total Heating Load in the building withclay brick walls = 7.722 ton = 23366.56 kcal/hr.
- Total Heating Load in the building withFly-ash brick walls = 7.646 ton = 23136.59 kcal/hr.
- Total Heating Load in the building withPorotherm block walls= 7.039 ton = 21299.82 kcal/hr.
- Total Heating Load in the building withAAC block walls = 6.882 ton = 20824.74 kcal/hr.
- Total Heating Load in the building withCLC block walls= 7.188 ton = 21750.69 kcal/hr.

| **Blocks** | **Thermal Conductivity k** | |
|---|---|---|
| | (W/m.k) | (Btu.in/h.ft$^2$.°F) |
| **Clay brick** | 0.72 | 0.416[1] |
| **Fly-ash** | 0.66 | 0.381 |
| **Porotherm** | 0.30 | 0.175 |
| **AAC** | 0.24[2] | 0.1387 |
| **CLC** | 0.37[3] | 0.215 |

## VII.CONCLUSION

Based on the above tests and analysis made we came to conclusions as follows:

Even though Clay bricks areused for so many years even more than a millennium in the construction field, it has its own limitations too. This makes an impact to go for the alternative building blocks in the construction industry.

Fly-Ash brick:

On comparing with clay brick, it shows better results in strength and heating load.Cost wise it is best in all cases. But it do not comes under light weight blocks and thermal efficient.Thus, it is the most economic choice among the building blocks we considered. Hence, it is very suitableto for both framed and load bearing buildings.

The other blocks we considered are Porotherm block, AAC block, CLC block:

These blocks comes under Light-weight and Thermal efficient blocks. Hence these blocks do not perform load bearing.

Cost wise AAC blocks shows higher cost of construction than other blocks. The light-density property of AAC blocks can be effectively utilized only for High-rise buildings and not for any typical structures. Hence it is an uneconomical choice for low raise buildings like apartments (< [G + 4]), individual houses and so on. It shows higher thermal efficiency than other blocks. Hence, better comfort can be felt.

CLC blocks is a better economic choice of construction than other light-weight blocks. The cost of construction is nearly same as the construction cost of clay bricks. The load efficiencyof CLC block

is less than Porotherm and AAC blocks.Its thermal efficiency is nearer to Porotherm blocks. Unlike AAC blocks, CLC blocks are not manufactured as factory made products. Hence, Quality of blocks may varies depends on manufacturing units.

The Thermal and Cost efficiency of Porotherm blocksis between AAC and CLC blocks. Based on our test results, it shows low compression strength than the expected values. The construction of wall units using Porotherm requires skilled labor and there may be difficulties in fixing electrical and plumping lines.

VIII.REFERENCE

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5. Is.6441 (Part 1 To 9) - Methods Of Test For Autoclaved Cellular Concrete Products

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