

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 Standards, 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

The Compression strength of Fly-Ash bricks = 9.604 N/mm²

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	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	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/mm²

E. CLC 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 x 15	2.035	68.8

The Compression strength of Porotherm blocks = 1.4579 N/mm²

D. AAC 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/mm²

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

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.Porothem Blocks

Average water absorption = 14%

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 cementitious material within the brick pores that provides most of the bond between the brick and the mortar, and thus gives the wall its strength.

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%

TEST RESULTS

A.Chamber Clay Brick

Average water absorption = 10.54%

B.Fly-Ash Brick

Average water absorption = 13.52%

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

The dry density of chamber clay bricks = 1885.6 Kg/m³

B.Fly-Ash Bricks

Average water absorption = 8.72%

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/m³

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

C.Porotherm Blocks

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/m³ = Mass of block in kg/Mass of block in cm³ * 10⁶

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

TEST RESULTS

A.Chamber clay Bricks

The dry density of Porotherm blocks= 741.674 Kg/m³

D.AAC Blocks

The dry density of AAC blocks = 562.67 Kg/m³

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/m³

RESULTS:

AAC Blocks

S.NO	V	A	INNER HEATER		cooling plate	
			T1	T2	T5	T6
1	40	0.28	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	31	0.46269
19.4	56	35	0.75726
36	62.5	35	1.00048
57	92	36	0.79146
Avg			0.7585 w/mk

Thermal conductivity of AAC block specimen = 0.7585W/mk

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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

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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		cooling plate	
			T1 (°C)	T2 (°C)	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	0.76785
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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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 spent in the building blocks. The plan and sectional-elevation of the building is shown in the fig.

3. Porotherm Blocks

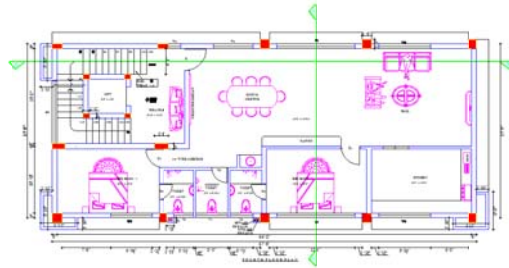
S.NO	L (mm)	B (mm)	INNER HEATER			ceiling plate	
			T1 (deg.c)	T2 (deg.c)	T3 (deg.c)	T4 (deg.c)	T5 (deg.c)
1	40	0.23	50	46	31	28	18
2	40	0.34	50	46	31	28	18
3	80	0.45	80	72	54	48	29
4	100	0.57	100	90	63	54	30

W (mm)	Th (mm)	Lc (mm)	k
62	46	30.5	0.90217
20.4	15	11	0.40182
24	76	32.5	0.45788
37	107.5	34.5	0.45187
Avg			0.4308 w/mk

Thermal conductivity of Porotherm block specimen = 0.4308 w/mk

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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)

CLC Blocks

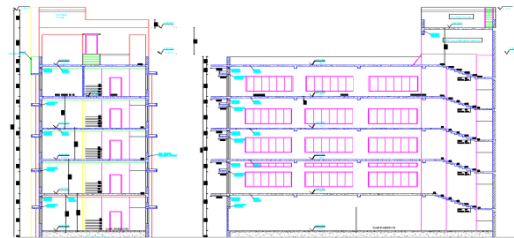
S.NO	L (mm)	B (mm)	INNER HEATER			ceiling plate	
			T1 (deg.c)	T2 (deg.c)	T3 (deg.c)	T4 (deg.c)	T5 (deg.c)
1	40	0.23	40	30	17	16	10
2	40	0.34	50	30	18	17	10
3	80	0.45	80	40	20	18	10
4	100	0.57	100	50	22	20	10

W (mm)	Th (mm)	Lc (mm)	k
62	46	32.5	1.01192
20.4	15	11.5	0.50172
24	64	34	1.01600
37	90.5	36	1.04528
Avg			0.8841 w/mk

Thermal conductivity of CLC block specimen = 0.8841 W/mK

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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]
1 st floor	3.81	74.87	8.49
2 nd floor	3.505	68.88	7.82
3 rd floor	3.505	68.88	7.82
4 th floor	3.505	68.88	7.82
Total		281.5 m ³	31.95 m ³

Total quantity of brick work = 313.45 m³

B. Cost of blocks in the brickwork of the building

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

BLOCK TYPE	Percentage difference in cost (%)	REMARK
<i>Fly-ash brick</i>	18.62	Reduction in cost
<i>Porotherm brick</i>	42.65	Increase in cost
<i>AAC</i>	72.26	Increase in cost
<i>CLC</i>	29.33	Increase in cost

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

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%

IV. LOAD EFFICIENCY ANALYSIS

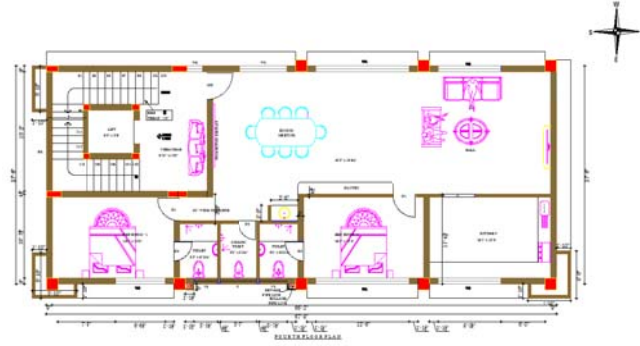
A. Assumptions

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.

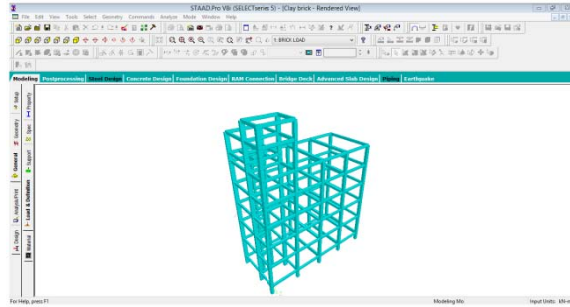
c) Building is residential and has the layout as shown:



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

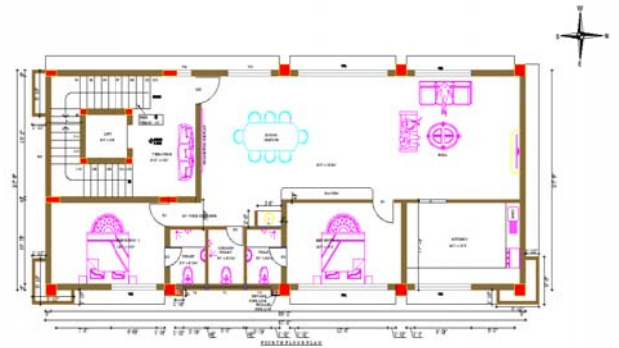
- Sand 1 unit (100 cu.ft) = ₹ 3250 → 1 cu.ft = ₹ 32.5
- Cement 1 bag (50kg) = ₹ 370
- Course aggregate [20mm-size] 1 unit (100 cu.ft) = ₹ 2800 → 1 cu.ft = ₹ 28

Cost incurred in total Concrete take off for individual blocks

	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

	<i>CLAY BRICK</i>	<i>FLY-ASH BRICK</i>	<i>POROTHERM</i>	<i>AAC</i>	<i>CLC</i>
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 with clay brick walls = 7.722 ton = 23366.56 kcal/hr.
- Total Heating Load in the building with Fly-ash brick walls = 7.646 ton = 23136.59 kcal/hr.
- Total Heating Load in the building with Porotherm block walls = 7.039 ton = 21299.82 kcal/hr.
- Total Heating Load in the building with AAC block walls = 6.882 ton = 20824.74 kcal/hr.
- Total Heating Load in the building with CLC 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 are used 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 does not come under light weight blocks and thermal efficient. Thus, it is the most economic choice among the building blocks we considered. Hence, it is very suitable for both framed and load bearing buildings.

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

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

Cost wise AAC blocks show 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 rise 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 are 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 efficiency of 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 vary depends on manufacturing units.

The Thermal and Cost efficiency of Porotherm blocks is 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 plumbing lines.

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