COMPARATIVE STUDY OF LOAD BEARING BLOCK MASONRY WORK IN HOUSING

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Abstract—**In order to improve the quality of construction and its sustainability without sacrificing strength, stability, performance, life of the structure and environmental friendly properties, usage of different eco-friendly materials are considered in load bearing masonry structure. In this study a suitable plan is selected and structural elements are designed as per Indian standard codes. Cost comparisons are made between building materials and labour required for construction of a ground plus four residential building using clay bricks, fly ash bricks and cellular light weight concrete blocks. The loads transferred to foundation from block masonry are also considered. From this, based on resources, cost optimized solutions are derived.**

Keyword - Load bearing masonry, Clay bricks, Fly Ash bricks, Cellular Lightweight Concrete blocks.

I. INTRODUCTION

Until 1950's there were no engineering methods of designing masonry for buildings. Thicknesses of walls were considered from 'Rule-of-Thumb' tables given in building codes and regulations. As a result walls used to be very thick and masonry structures were found to be very uneconomical beyond 3 or 4 storeys. Buildings exceeding 3 or 4 storeys had thus to be constructed with steel or RCC frames. Since 1950's intensive theoretical and experimental research has been conducted on various aspects of masonry in advanced countries.

But, it is suited for a building in which floor area is subdivided into a large number of rooms of small or medium size and in which the floor plan is repeated in each storey throughout the height of the building. These conditions are met within residential buildings, schools, hostels, hospitals, nursing homes and certain types of administrative buildings. Extensive research, including large scale testing, has been carried out in regard to the behaviour of masonry which has enabled engineers and architects to design tall masonry structures on sound engineering principles with greater exactitude, economy and confidence.

There are many recent examples in other countries of well-designed 12 to 20 storeyed load bearing masonry buildings which have only 25 to 40 cm thick walls. This is in contrast to the 16 storey 'Monadnock Building' in Chicago designed by John Rort in 1891 with 180 cm thick brick walls at the base.

In India, there has not been much progress in the construction of tall load bearing masonry structures, mainly because quality of bricks generally manufactured in the country is poor, their normal strength being of the order of only 7 N/mm^2 to 10 N/mm^2. In many Western countries, bricks of even medium quality have crushing strength of 30 N/mm^2 to 50 N/mm^2. However, recently mechanized brick plants have been set up at a few places in the country which are producing bricks of strength 17.5 N/mm^2 to 25 N/mm^2. Thus, it should now be possible in some parts of the country to go in for 5 to 6 storeyed load bearing structures at costs less than those of RCC framed structures. With this development, structural design of load bearing masonry buildings has assumed additional importance in India as well. In fact, under the experimental projects scheme of the National Buildings Organization,Central Building Research Institute, Roorkee.

There is need and considerable scope in this country of intensifying experimental, research and study in the field of load bearing masonry in order to make better and more economical use of this wonderful and versatile building material, the brick. In India, we have been trying to keep pace to some extent with the developments taking place in other countries in regard to masonry.

In this context, the authors have studied various properties and usage of different eco-friendly construction materials like clay bricks, fly ash bricks and cellular light weight concrete blocks. A suitable plan is selected and structural elements are designed as per Indian standard codes with these materials. From this, based on resources, cost optimized solutions are derived.

II. LITERATURE REVIEW

Many experiential studies and researches are carried out on load bearing masonry originated from different sources, they are clinical in construction industry mainly reducing the cost of construction and improving quality of structures built with them. Attempts were made early in U.S.S.R and empirical formulae based on brick strength to predict compressive strength of brick work was formulated (Onishchik. L. I, 1937)[15] which helped a lot in further research, Large scale experimental study was also carried on this field in the western countries to improve the standards of house construction by research on usage of load bearing masonry with improved quality and reduced cost (Mathur. D. C and Berry. S, 1981)[14]. The importance of brick masonry walls as a support to structure was realised early and many studies were conducted in such aspects including load bearing walls (Davidson et al. 1952)[3] (Cross and James. C, 1965)[2].To ensure the stability and strength of multi-storeyed brick structures up to 5 storeys, different realistic tests were also designed to check effect of wind loading, lateral strength of panels with pre-compression, floor/wall interaction, accidental removal of members and many other factors (Sinha B. P and Hendry A. W, 1976)[20] . In recent years the success of construction of buildings with load bearing masonry is such that not only medium storeyed buildings but buildings spanning 5-15 storeyes were constructed in Brazil on thin walls (Santos F. A et al., 2009)[18], many studies were also carried on the potential of structural masonry in construction industry and the causes for the raise and decline of these type of constructions (Braj P. Sinha, 2002)[1].

In Switzerland a series of laboratory tests on unreinforced masonry were conducted which made possible the construction of buildings up to 18 storeyes high and of 16 storey buildings with bearing walls measuring $5\frac{7}{8}$"(149.2 mm) in thickness (Haller P)[5]. In addition to this many construction companies and private organizations were conducting studies on the load bearing masonry made from various materials to reduce the cost of their construction projects. The effect of earth quake loading was also considered and its effects were also studied systematically in research process (Dina D'Ayala, 2014)[4]. Not only this, economy of load bearing masonry structures over conventional reinforced concrete structures were also studied and it was found that load bearing structures are significantly economical (Shashank B. S and Raghunath S, 2014)[19], the load bearing masonry are again classified based on their material sources like burnt clay bricks, fly ash bricks, cellular lightweight concrete blocks (Chiranjeevi Rahul. R and Lakshmayya.M.T.S, 2014)[16] or other types such as brick masonry and hollow concrete masonry and evaluation is made on their load bearing capabilities and economy (Rafiq Ahmad and Mohammad Iqbal Malik, 2014)[17]

In India also the trend of constructing structures with load bearing masonry is increasing rapidly because of its advantages, IIM Ahmadabad is a profound example for such structures in India, hence, In current study, cost of construction is compared for a multi storeyed load bearing structures using various types of materials like Clay bricks (IS 2212: 1991)[10], Fly Ash bricks (IS 12894: 2002)[11], Cellular Lightweight Concrete blocks (IS 2185: 2008 part IV)[12]. There by evaluating their scope in building construction. Design was done based on (SP 20(S&T) : 1991)[13],the properties of these materials were evaluated following the Indian standard codes for usage of plain and reinforced concrete(IS 456-2000)[6], code of practise for design loads, dead loads and live loads(IS 875 Part-I-1987)[7], (IS 875 Part-II-1987)[8],and code for usage of unreinforced masonry as structural members(IS 1905-1987)[9].

III.METHODOLOGY

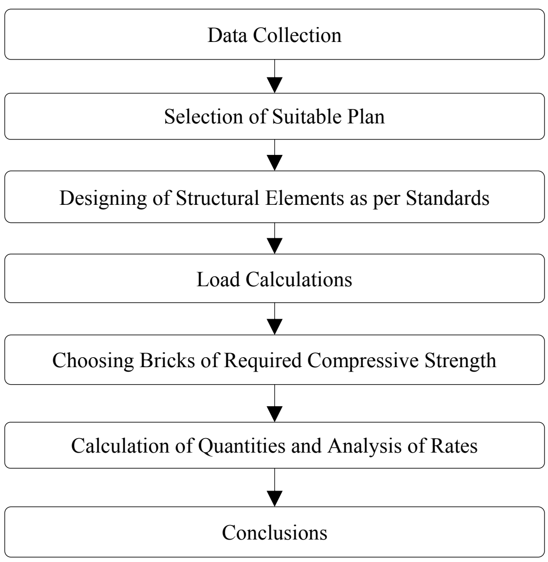

Fig.1. Methodology

Data collection is performed and by analysing the data, suitable plan is selected, then the structural elements are designed following the standard specifications. After the design process the structural elements are introspected again and load calculations are performed. Then in the next stage bricks of required compressive strength are chosen for the structure based on the load calculations. Rate analysis of the items involved in the structure and labour costs are estimated, these costs are compared with the conventional materials used and necessary conclusions are made. This process is depicted in a flow chart above.

IV. DESIGN CONSIDERATIONS

In this study a suitable plan is selected as shown in Fig. 2 and structural elements are designed as per Indian standard codes.

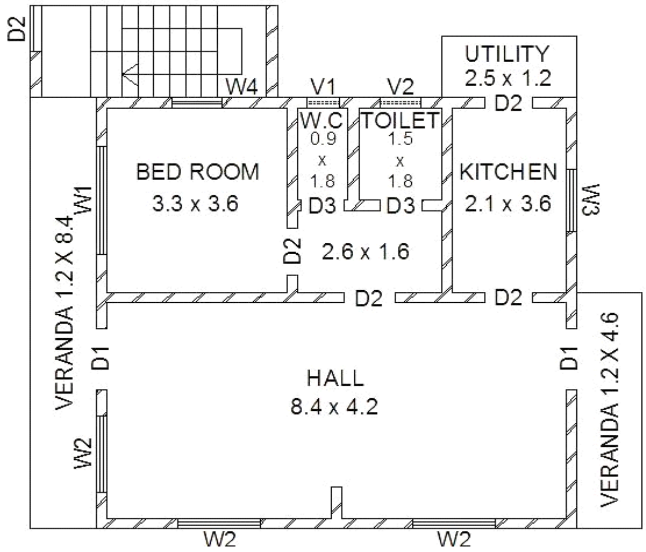

Fig. 2. Floor plan [Note: All dimensions are in m.]

This structure is designed as ground plus four residential building with reinforced concrete slab supported on load bearing masonry. The slab thickness is taken as 120mm, masonry thickness as 200mm, floor height as 3.0m c/c. door height is 2.1 m, and window height is 1.5 m. Floor plan is same for all floors.

Slab:

Size of the slab (L_y x L_x) = 4.30m x 8.50m

Overall thickness of the slab = 120mm

$$\frac{L_y}{L_x} = \frac{8.50}{4.30} = 1.97(<2)$$

Hence the slab is designed as two-way slab

Loads on roof slab

Self-weight : 3.0kN/m^2

Live load : 1.5kN/m^2

Total : 4.5kN/m^2

Loads on slab for intermediate floors

Self-weight : 3.0kN/m^2

Live load : 2.0kN/m^2

Unknown force : 1.0kN/m^2

Total : 6.0kN/m^2

Loads on each walls*:*

Load on load bearing masonry wall from roof slab and intermediate slab are calculated.

Short span: $\frac{wL_x}{4}$

Long span: $\frac{wL_x}{2}(1-\frac{1}{2r})$; where r = $\frac{L_y}{L_x}$

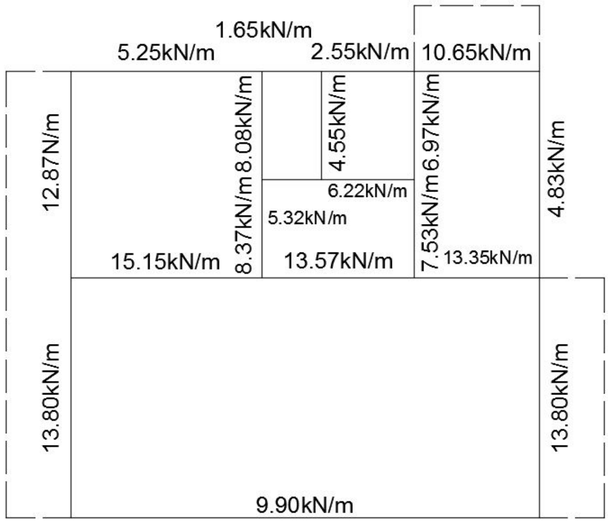

Fig. 3. Load on walls coming from roof slab

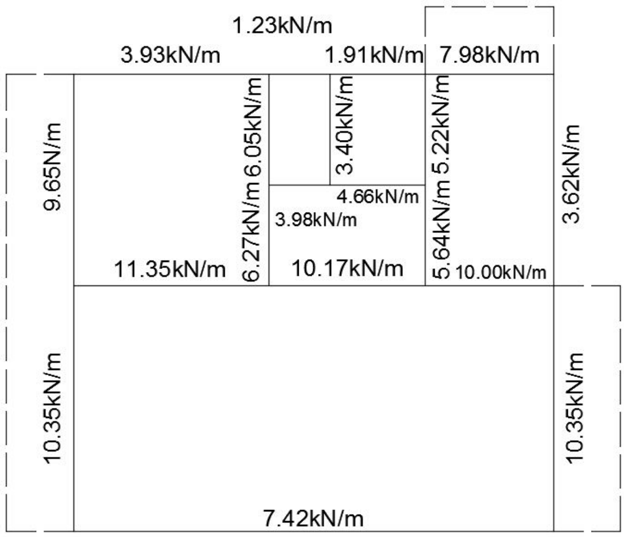

Fig. 4. Load on walls coming from intermediate floor slabs

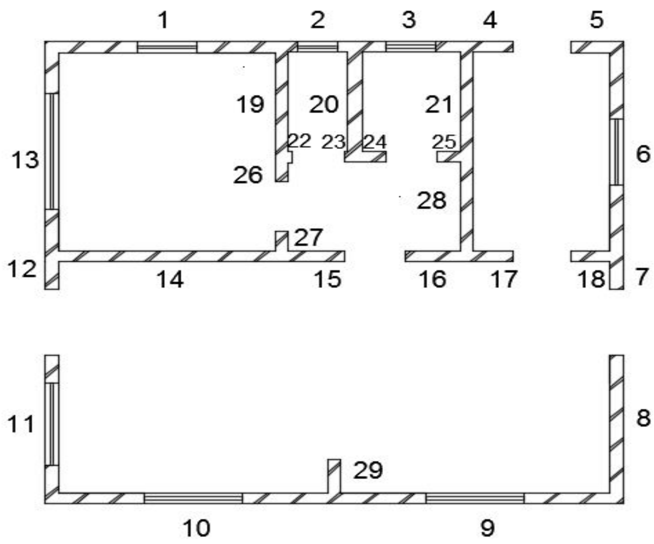

Fig. 5.Brick Work Elements

V. DESIGN OF A WALL CARRYING AXIAL LOAD

A. *Masonry work in superstructure*

Maximum load from the roof slab of top floor is 11.35kN/m. whereas for remaining floors including ground floor maximum load from the slab is 15.15kN/m. Since *wall 14* is bearing the maximum load.

Table1.Comparison of Characteristics of Different Masonry Blocks

	Density(kgf/m^3)	**Compressive strength(kgf/cm^2)**	**Water absorption (%)**
Clay Bricks	2000	Not less than75.00	25.00 – 30.00
Fly Ash Bricks	1800	75.00 – 110.00	18.00 – 22.00
CLC Blocks	1200	65.00 – 120.00	10.00 -10.05

Table2. Values of Slenderness Ratio

Brickwork Element	**Ground Floor, t=0.20**				**1,2,3,4 Floors, t=0.20**				**Remarks**
	h	**l**	**k_n**	**SR**	**h**	**l**	**k_n**	**SR**	
1	2.54	3.15	1.10	11.54	2.25	3.15	1.10	10.22	Value of SR shown in the table is the one that is to be taken into consideration for design
2	2.54	0.37	2.00	1.85	2.25	0.37	2.00	1.85	
3	2.54	1.36	1.62	6.80	2.25	1.36	1.62	6.80	
4	2.54	1.05	1.00	5.25	2.25	1.05	1.00	5.25	
5	2.54	1.40	1.00	7.00	2.25	1.40	1.00	7.00	
6	2.54	3.42	1.04	12.21	2.25	3.42	1.04	10.81	
7	2.54	0.85	1.00	4.25	2.25	0.85	1.00	4.25	
8	2.54	3.64	1.00	12.70	2.25	3.64	1.00	11.25	
9	2.54	3.87	1.00	12.70	2.25	3.87	1.00	11.25	
10	2.54	3.87	1.00	12.70	2.25	3.87	1.00	11.25	
11	2.54	3.64	1.00	12.70	2.25	3.64	1.00	11.25	
12	2.54	0.85	1.00	4.25	2.25	0.85	1.00	4.25	
13	2.54	3.42	1.04	12.21	2.25	3.42	1.04	10.81	
14	2.54	3.24	1.05	12.09	2.25	3.24	1.05	10.71	
15	2.54	1.41	1.00	7.05	2.25	1.41	1.00	7.05	
16	2.54	1.41	1.00	7.05	2.25	1.41	1.00	7.05	
17	2.54	1.05	1.00	5.25	2.25	1.05	1.00	5.25	
18	2.54	1.40	1.00	7.00	2.25	1.40	1.00	7.00	
19	2.54	3.00	1.00	12.70	2.25	3.00	1.00	11.25	
20	2.54	2.00	1.00	10.00	2.25	2.00	1.00	10.00	
21	2.54	3.00	1.30	9.76	2.25	3.00	1.30	8.65	
22	2.54	0.35	1.00	1.75	2.25	0.35	1.00	1.75	
23	2.54	0.35	1.00	1.75	2.25	0.35	1.00	1.75	
24	2.54	0.60	1.00	3.00	2.25	0.60	1.00	3.00	
25	2.54	0.60	1.00	3.00	2.25	0.60	1.00	3.00	
26	2.54	0.90	1.00	4.50	2.25	0.90	1.00	4.50	
27	2.54	0.90	1.00	4.50	2.25	0.90	1.00	4.50	
28	2.54	3.15	1.20	10.58	2.25	3.15	1.20	9.37	
29	2.54	1.05	1.00	12.70	2.25	1.05	1.00	5.25	

Note: In case of walls SR= $\frac{h}{t \times kn}$ or $\frac{l}{t}$ and for design lesser of the two values is considered.

Determination of minimum compressive strength required for a masonry unit and grade of mortar mix is as follows.

Effective Height, h = 0.75H

= 0.75 x3.0 = 2.25m

Effective length, l =0.9L

= 0.9 x 3.6= 3.5 m

Since effective height is less than effective length, SR based on height will control the design.

(From Table 9 of the Code for SR 12)

t = 19 cm

SR= 12.09 ≈ 12.00

Therefore Stress reduction factor $K_s$with zero eccentricity

= 0.84

1) Clay bricks

Unit weight of Clay Bricks of 2000 kg/m^3 density = 19.62kN/m^3

Self-weight of block work = unit weight x length x breadth x height

= 19.62 x 1.00 x 0.20 x 2.88= 11.30kN/m

Total load for single floor is load on slab + self-weight of block work.

i.e., 11.35 + 11.30 = 21.93kN/m (for 5th floor)

15.15 + 11.30 = 26.45kN/m (for remaining floors including ground floor)

Self-weight of block work in plinth = 19.62 x 1.00 x 0.20 x 0.55 = 2.15kN/m

Therefore, total load at base of plinth = 130.60kN/m

Compressive stress in masonry at base of plinth

$$= \frac{130.60 \times 1000}{20 \times 100}$$

= 65.30 kg/cm^2

= 0.65 N/mm^2

With Shape modification factor = 1, Basic Compressive stress of masonry

= 0.65/0.84= 0.77 N/mm^2

Since modular bricks are used which have height to width ratio of 1.0, value of Shape modification factor (from Table 10 of the Code) equals to 1.2.

Thus Basic Compressive stress required

= 0.77/1.1 = 0.70 N/mm^2

Referring to Table 8 of IS: 1905- 1987, masonry required is-bricks of strength 7.5 N/mm^2 and mortar of M1 grade. (M1 grade is 1:5 ratios of cement and sand respectively)

2) Fly Ash bricks

Unit weight of Fly Ash Bricks of 1800 kg/m^3 density = 17.65kN/m^3

Self-weight of block work = unit weight x length x breadth x height

= 17.65 x 1.00 x 0.20 x 2.88= 10.16kN/m

Total load for single floor is load on slab + self-weight of block work.

i.e., 11.35 + 10.16 = 21.51kN/m (for 5th floor)

15.15 + 10.16 = 25.31kN/m (for remaining floors including ground floor)

Self-weight of block work in plinth = 17.65 x 1.00 x 0.20 x 0.55 = 1.94kN/m

Therefore, total load at base of plinth = 124.70kN/m

Compressive stress in masonry at base of plinth

$$= \frac{124.70 \times 1000}{20 \times 100}$$

= 62.30 kg/cm^2

= 0.62 N/mm^2

With Shape modification factor = 1, Basic Compressive stress of masonry

= 0.62/0.84= 0.74 N/mm^2

Since modular bricks are used which have height to width ratio of 1.75, value of Shape modification factor (from Table 10 of the Code) equals to 1.0.

Thus Basic Compressive stress required

= 0.74/1.0= 0.74 N/mm^2

Referring to Table 8 of IS: 1905- 1987, masonry required is-bricks of strength 7.5N/mm^2 and mortar of M1 grade. (M1 grade is 1:5 ratios of cement and sand respectively)

3) Cellular Light weight Concrete blocks

Unit weight of Cellular Light weight Concrete Blocks of 1200 kg/m^3 density = 11.77kN/m^3

Self-weight of block work = unit weight x length x breadth x height

= 11.77 x 1.00 x 0.20 x 2.88= 6.78kN/m

Total load for single floor is load on slab + self-weight of block work.

i.e., 11.35 + 11.30 = 21.93kN/m (for 5th floor)

15.15 + 11.30 = 21.93kN/m (for remaining floors including ground floor)

Self-weight of block work in plinth = 11.77 x 1.00 x 0.20 x 0.55 = 1.30kN/m

Therefore, total load at base of plinth = 107.15kN/m

Compressive stress in masonry at base of plinth

$$= \frac{107.15 \times 1000}{20 \times 100}$$

= 53.57 kg/cm^2

= 0.53 N/mm^2

With Shape modification factor = 1, Basic Compressive stress of masonry

= 0.53/0.84= 0.63 N/mm^2

Since modular bricks are used which have height to width ratio of 1.0, value of Shape modification factor (from Table 10 of the Code) equals to 1.2.

Thus Basic Compressive stress required

= 0.63/1.1= 0.57 N/mm^2

Referring to Table 8 of IS: 1905- 1987, masonry required is-bricks of strength 7.5 N/mm^2 and mortar of M2 grade. (M2 grade is 1:6 ratios of cement and sand respectively)

B. *Masonry works in staircase*

Rise = 170 mm

Tread = 290 mm

No of risers= 18 No's

Loads on Staircase:

Staircase slab thickness is 6" (i.e. 150mm) As per IS: 875

Self-weight (6" thick) = 0.15 x 1.00 x 1.00 x 25= 3.75kN/m^2

Floor finish : 1.00kN/m^2

Total : 4.75kN/m^2

Vertical component:

Weight of waist slab= 0.15 x 1.00 x 1.00 x 25 x $\frac{\sqrt{290^2+170^2}}{290}$

= 0.15 x 1.00 x 1.00 x 25 x 1.16

= 4.35kN/m^2

Floor finish : 1.00kN/m^2

Weight of steps = $\frac{170}{2 \times 1000}$ x 1.00 x 1.00 x 20= 1.70kN/m^2

Live load : 5.00kN/m^2

Total : 12.05kN/m^2

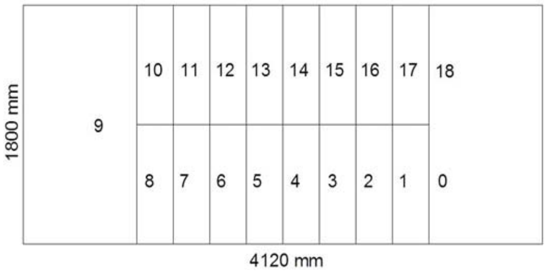

Fig. 6.Details of Stair Case

C. *Comparison of loads on foundation from block work*

Clay Brick:

Unit weight of Clay Bricks of 2000 kg/m^3 density = 19.62kN/m^3

Self-weight of block work = unit weight x length x breadth x height

= 19.62 x 1.00 x 0.20 x 2.88= 11.30kN/m

Load from block work of 5 floors on to the foundation using Clay bricks is 56.50kN/m

Fly Ash Bricks:

Unit weight of Fly Ash Bricks of 1800 kg/m^3 density = 17.65kN/m^3

Self-weight of block work = unit weight x length x breadth x height

= 17.65 x 1.00 x 0.20 x 2.88 = 10.16kN/m

Load from block work of 5 floors on to the foundation using Fly Ash bricks is 50.80kN/m

Cellular Lightweight Concrete Blocks:

Unit weight of Cellular Lightweight Concrete Blocks of 1200 kg/m^3 density = 11.77kN/m^3

Self-weight of block work = unit weight x length x breadth x height

= 11.77 x 1.00 x 0.20 x 2.88 = 6.78kN/m

Load from block work of 5 floors on to the foundation using Cellular Lightweight Concrete blocks is 33.90kN/m

VI. CALCULATION OF QUANTITIES

Comparative statements of costs and materials are prepared for Clay bricks, Fly ash bricks and Cellular Lightweight Concrete blocks and percentage of saving is defined compared to Fly Ash bricks over Clay bricks, Cellular Lightweight Concrete blocks over Clay bricks, Cellular Lightweight Concrete blocks over Fly Ash bricks.

Table3. Quantities of Materials Required

	CLAY BRICKS	FLY ASH BRICKS	CLC BLOCKS
BRICK WORK IN WALLS(for single floor):			
Quantity	25.00cu.m	25.00cu.m	25.00cu.m
Cement	36.02bags	24.50bags	15.13bags
Sand	6.25cu.m	4.25cu.m	3.20cu.m
BRICK WORK IN STAIRCASE(for single floor):			
Quantity	2.00cu.m	2.00cu.m	2.00cu.m
Cement	2.47bags	1.61bags	1.21bags
Sand	0.51cu.m	0.33cu.m	0.26cu.m
BRICK WORK IN FOUNDATION:			
Quantity	23.00cu.m	23.00cu.m	23.00cu.m
Cement	28.53bags	18.44bags	13.92bags
Sand	5.91cu.m	3.86cu.m	2.94cu.m
PLASTERING:			
Quantity	300.00sq.m	300.00sq.m	300.00sq.m
Cement	31.50bags	25.80bags	21.60bags
Sand	5.25cu.m	4.50cu.m	3.75cu.m

Table4. Item Rates

Clay brick	Rs.6.00per brick
Fly Ash brick	Rs.12.00per brick
CLC block	Rs.3600 per cu. m
Cement	Rs.300per Bag
Sand	Rs.1200per cu. m
Mason	Rs.450per no.
Male coolie	Rs.300per no.

These rates are taken in to account on the basis of present construction rates in Visakhapatnam and rates are collected by conducting a survey to the construction sites, builders and material suppliers and quantity of work done per a day by a mason and a coolie is considered from the data collected from the experienced builders and masons considering the weight, size and shape of clay bricks, fly ash bricks and Cellular Lightweight Concrete blocks.

Table5. Quantities of Item and Labour Required

	CLAY BRICKS	**FLY ASH BRICKS**	**CLC BLOCKS**
BLOCK WORK IN WALLS:			
Bricks	62,500 no’s	15,395 no’s	5,210 no’s
Cement	180.10 bags	122.50 bags	76.65 bags
Sand	31.25cu.m	21.25cu.m	16.00cu.m
Mason	84 no’s	63 no’s	32 no’s
Coolie	42 no’s	32 no’s	16 no’s
BLOCK WORK IN STAIRCASE:			
Bricks	5,000 no’s	1,235 no’s	420 no’s
Cement	12.35 bags	8.05 bags	6.05 bags
Sand	2.55cu.m	1.65cu.m	1.30cu.m
Mason	7 no’s	5 no’s	3 no’s
Coolie	4 no’s	3 no’s	2 no’s
BLOCK WORK IN FOUNDATION:			
Bricks	57,500 no’s	14,165 no’s	4,795 no’s
Cement	142.65 bags	92.20 bags	69.6 bags
Sand	29.55cu.m	19.3cu.m	14.70cu.m
Mason	13 no’s	9 no’s	5 no’s
Coolie	7 no’s	5 no’s	3 no’s
PLASTERING:			
Cement	157.50 bags	129.00 bags	108.00 bags
Sand	26.25cu.m	22.5cu.m	18.75cu.m
Mason	162 no’s	121 no’s	81 no’s
Coolie	162 no’s	121 no’s	81 no’s

Table6. Cost of Item and Labour Required

	CLAYBRICKS	FLYASH BRICKS	CLCBLOCKS
BRICK WORK IN WALLS:			
Bricks	Rs.3,75,000.00	Rs.1,84,740.00	Rs.4,42,850.00
Cement	Rs.54,030.00	Rs.36,750.00	Rs.22,695.00
Sand	Rs.37,500.00	Rs.25,500.00	Rs.19,200.00
Mason	Rs.37800.00	Rs.28,350.00	Rs.14,400.00
Coolie	Rs.12,600.00	Rs.9,600.00	Rs.4,800.00
BRICK WORK IN STAIRCASE:			
Bricks	Rs.30,000.00	Rs.14,820.00	Rs.35,700.00
Cement	Rs.3,705.00	Rs.2,415.00	Rs.1,815.00
Sand	Rs.3,060.00	Rs.1,980.00	Rs.1,560.00
Mason	Rs.3,150.00	Rs.2,250.00	Rs.1,350.00
Coolie	Rs.1,200.00	Rs.900.00	Rs.600.00
BRICK WORK IN FOUNDATION:			
Bricks	Rs.3,45,000.00	Rs.1,69,980.00	Rs.4,07,575.00
Cement	Rs.42,795.00	Rs.27,660.00	Rs.20,880.00
Sand	Rs.35,460.00	Rs.23,160.00	Rs.17,640.00
Mason	Rs.5,850.00	Rs.4,050.00	Rs.2,250.00
Coolie	Rs.2,100.00	Rs.1,500.00	Rs.900.00
PLASTERING:			
Cement	Rs.47,250.00	Rs.38,700.00	Rs.32,400.00
Sand	Rs.31,500.00	Rs.27,000.00	Rs.22,500.00
Mason	Rs.72,900.00	Rs.54,450.00	Rs.36,450.00
Coolie	Rs.48,600.00	Rs.36,300.00	Rs.24,300.00
TOTAL	**Rs.11,89,500.00**	**Rs.6,90,105.00**	**Rs.11,09,865.00**

The Cost of building (Material and Labour) as per the plan shown in the Fig.2 is as follows,

- The cost of G+4 Residential building with Clay Brick is Rs.1,486.87/- per sq.m.
- The cost of G+4 Residential building with Fly Ash Brick is Rs.826.63/- per sq.m.
- The cost of G+4 Residential building with CLC Block is Rs.1,387.33/- per sq.m.
- The cost of G+4 Residential building with Clay Brick is Rs.20,677.20/- per cu.m.
- The cost of G+4 Residential building with Fly Ash Brick is Rs.11,397.60/- per cu.m.
- The cost of G+4 Residential building with CLC Block is Rs.20,157.80/- per cu.m.

VII. CONCLUSIONS

- Finally, by using Fly Ash Bricks Rs.4,99,395/- and Rs.4,19,760/- may be saved for this G+4 residential building over Clay Bricks and Cellular Lightweight Concrete Blocks respectively means around 42% and 38% of cost of the construction can be reduced using Fly Ash Bricks.
- By using Fly Ash bricks 10.09% of loads are reduced over Clay bricks. By using Cellular Lightweight Concrete blocks 40.00% of loads are over Clay bricks. By using Cellular Lightweight Concrete blocks 10.09% of loads are over Fly Ash bricks.
- By using Fly Ash bricks with cement mortar mix M2 (1:6), 34.96 % of cement and 36.00% of sand can be reduced per cu.m of brickwork over Clay bricks with cement mortar mix M2 (1:6), as number of mortar joins are less when compared with clay bricks.

- By using Cellular Lightweight Concrete blocks with cement mortar mix M2(1:6), 51.22 % of cement and 48.00% of sand can be reduced per cu.m of brickwork over Clay bricks with cement mortar mix M2(1:6), as number of mortar joins are less when compared with Clay bricks.
- By using Cellular Lightweight Concrete blocks with cement mortar mix M2(1:6), 25.00 % of cement and 18.75% of sand can be reduced per cu.m of brickwork over Fly Ash bricks with cement mortar mix M2(1:6), as number of mortar joins are less when compared with Fly Ash bricks.
- By using Fly Ash bricks, 31.95 % of cement and 32.00% of sand can be reduced per sq.m of plastering work over Clay bricks with cement mortar mix M1(1:5).
- By using Cellular Lightweight Concrete blocks, 58.33 % of cement and 48.00% of sand can be reduced per sq.m of plastering work over Clay bricks with cement mortar mix M1(1:5).
- By using Cellular Lightweight Concrete blocks, 25.00 % of cement and 18.75% of sand can be reduced per sq.m of plastering work over Fly Ash bricks with cement mortar mix M1(1:5).
- By using Fly Ash bricks, cost of labour for masonry block work in superstructure can be reduced by 49.41% by using Fly Ash bricks when compared with clay bricks. Whereas by using Cellular Lightweight Concrete blocks 61.91% savings over clay bricks and 49.41% savings over Fly Ash bricks.
- By using Fly Ash bricks, cost of labour for masonry block work in foundation can be reduced by 30.19% by using Fly Ash bricks when compared with clay bricks. Whereas by using Cellular Lightweight Concrete blocks 60.38% savings over clay bricks and 43.25% savings over Fly Ash bricks.
- By using Fly Ash bricks, cost of labour for plastering work can be reduced by 25.31% by using Fly Ash bricks when compared with clay bricks. Whereas by using Cellular Lightweight Concrete blocks 50.00% savings over clay bricks and 33.06% savings over Fly Ash bricks.
- From the above statements, if cost is the factor Fly Ash bricks are suggested to use since it is cheaper and readily available all over. Also suggested by many organizations and Government to use Fly Ash in construction sector since, it is available in large quantities and even eco-friendly in nature.
- If time is the factor Cellular Lightweight Concrete blocks are suggested to use due to its size, shape and weight, work becomes easy and fast for labour in construction of block work and plastering work. As well as time required for construction may also be reduced.
- Having several advantages like low water absorption, high thermal insulation, high fire protection, high sound insulation and eco-friendly to environment Cellular Lightweight Concrete blocks can be used for block work constructions.

ACKNOWLEDGMENT

I humbly express my profound gratitude to Prof. B. V. Sarma and my parents for their support during the study period; I would also like to thank Dr. B. Harish, G. Aditya for their cooperation.

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