Study on Optimization of Bricks Production Considering Embodied Energy as Parameter

Fatheali Shilar[1] Rohit Malawade[2]
[1]M.Tech Student [2]Assistant Professor
[1,2]Department of Civil Engineering
[1,2]Jain College of Engineering, Belagavi, India

Abstract— The study involves the experimental investigation of effect of granite waste powder and corn cob in the clay brick and also effect of granite waste powder in the fly ash brick, on the compressive strength and water absorption property. Three different types of clay bricks were prepared, for first brick with clay and granite waste powder as a raw material, for second brick clay and corn cob waste as a raw material, for third brick clay, granite waste powder and corn cob as a raw material, after casting the clay bricks for different proportions, bricks were sun dried, and then burnt in the kiln, tests was carried out on the bricks. For fly ash bricks, fly ash, granite waste powder and lime was used as raw material, Fly ash bricks were manually casted, air dried 7, 14, 21 days compressive strength and percentage of water absorption was determined. Even the study involves the computation of embodied energy for the clay and fly ash bricks.

Key words: Compressive Strength, Water Absorption, Embodied Energy

I. INTRODUCTION

Bricks are one of the oldest well known construction materials from 7000 B C first sited at Jericho and in Turkey. Initially bricks were prepared by using mud, popularly known as mud bricks and basically bricks were sun dried and then used. Due to its high water absorption property of mud bricks a new alternative firing technology was introduced in roman, they were successful to introduce the kiln for burning the bricks. Shape of bricks they manufactured were of rectangular, square, round and triangular.

The growth rate of urbanization in India was 31.3% during the period 1991-2001 and 31.8% during 2001-2011, it was estimated 217.7 million was urban population during 1991, and population was 377.10 million during 2011. As there is increase in the urban population, number of cities and also towns were also increased from 3768 to 7951, in during 1991-2001, due to growth of urbanization which lead to increase in the demand in construction sector .As construction sector is growing rapidly, the demand of construction materials is also rising.

Presently China is the largest bricks producer in Asia and India is second in productions of bricks. During 9th five year plan 1997-2002, it was estimated that US $4.5 billion as revenue can be generated from 170 million brick (annual demand) produced. During the 11th five year plan 2007-2012 it was estimated that about US$ 5.3 billion as revenue can be generated from 220 million bricks. Bricks are most widely used as infill material in India, for next up coming years India could require the large quantity of building material. It has been estimated that during the period of 2005-2030 in India, there will be increase in the demand for the bricks, which could be approximately 500 billion bricks by 2030.

II. MATERIALS AND METHODOLOGY

Materials used for the experiment for both clay brick and fly ash brick are

A. Clay

Clay was collected from Mamigathi village, in Dharwad, which is available in plenty quantity, IS 2117-1975 code recommends for the field test for the clay, specific gravity and density of clay was found to be 2.31, 1.5 g/cc respectively.

Fig. 1: Clay

B. Granite Waste Powder

Granite waste powder was collected from the Granite enterprises, in Hubli. Granite waste powder was obtained during the cutting and polishing of granite. Specific gravity of Granite Waste Powder is found to be 2.5

Fig. 2: Granite Waste Powder (GWP)

C. Corn Cob

Corn Cob is an agriculture waste product collected from Mamigathi village, in Dharwad, Corn cob is the middle portion of maize after removing the grain from cob, the empty cob is sundried then it is crushed into small pieces, .Specific gravity of corn cob is found to be 0.56

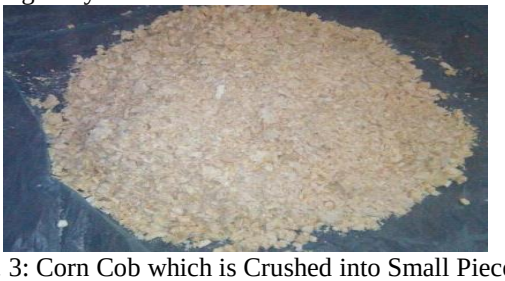

Fig. 3: Corn Cob which is Crushed into Small Pieces.

D. Fly Ash

Class F fly ash was collected from Raichur thermal power Specific gravity of Fly ash is found to be 2.10

Fig. 4: Fly Ash

E. Lime

Lime is obtained from lime stone, lime collected from Dharwad local dealer. Specific gravity of Lime is found to be 2.3

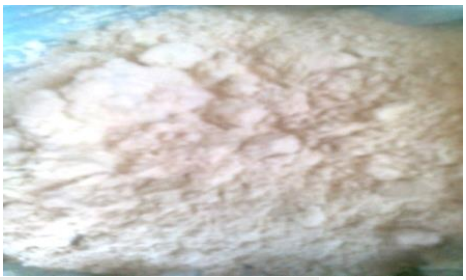

Fig. 5: Lime

F. Methodology for Bricks

In present research work three different types of bricks were prepared with various proportions, with size of brick as 190x90x90 mm, and weight of each brick as 3.0 kg,

For First brick, with granite waste powder, corn cob was partially added to the clay, by the weight of the clay. With granite waste powder was used between 6 to 30 %, with interval of 6%, corn cob was used in between 2 to 10 %, with interval 2%

For second brick granite waste powder was partially added to clay, with granite waste powder was used in between 6 to 30 %, with interval of 6%.

For third brick, with corn cob was partially added to the clay, with corn cob was used in between 6 to 24 % with interval of 6%.

Fly ash bricks were prepared with, fly ash, granite waste powder, and lime as raw material, with the size of brick as 230x115x75 mm and weight of brick as 3.5 kg. Granite waste powder was used in between 6 to 30 % with interval as 6%, lime 10% constant, in the fly ash by the weight of fly ash.

G. Test carried out on the Bricks

1) Compressive Strength Test

Compressive test for the bricks was carried out as per procedure given in IS 3495 part 1 (1992) with CTM. Compressive strength of the brick was calculated by Eq'n 3.1

$$\frac{\text{Maximum load at which brick fail (N)}}{\text{Area of the brick (mm}^2\text{)}} \qquad \text{Eq'n 2.1}$$

2) Water Absorption Test

Water absorption test was carried out for the brick as per IS 3495 part 2 (1992), weight of brick in dry condition (S_1) is taken, then weight of brick taken after brick completely immersed in the cold water 24 hrs (S_2). And percentage of water absorption was determined by Eq'n 3.2

$$\frac{(S_2 - S_1)}{(S_1)} \qquad \text{Eq'n 2.2}$$

III. Results and Discussion

A. Specific Gravity Test

Pycnometer apparatus is used to determine the specific gravity of the material, after passing through 4.75 mm IS sieve.

Sl. No	Materials	Specific Gravity
1	Clay	2.31
2	Corn cob	0.64
3	Fly ash	2.10
4	Granite waste powder	2.5
5	Lime	2.3

Table 1: Material and there Specific Gravity

Fig. 6: Brick Place in CTM

B. Compressive Strength Test Results and Water Absorption Test Results

Sl. No	Materials	Proportions	Compressive Strength(N/mm^2)
1	Clay + GWP	94% + 6%	3.74
2		88% + 12%	4.18
3		82% + 18%	4.95
4		76% + 24%	4.78
5		70% +30%	4.62

Table 2: Compressive Strength of Clay Bricks with Varying Combinations of GWP

Sl. No	Materials	Proportions	Water Absorption (%)
1	Clay + GWP	94% + 6%	11.4
2		88% + 12%	13.16
3		82% + 18%	15.34
4		76% + 24%	16.37
5		70% +30%	17.56

Table 3: Water Absorption of the Clay Brick with Varying Combinations of GWP

Sl. No	Materials	Proportions	Water Absorption (%)
1	Clay	94% + 6%	10.56

2	+ CC	88% + 12%	11.95
3		82% + 18%	14.42
4		76% + 24%	16.73

Table 4: Compressive Strength of Clay Bricks with Varying Combinations of CC

Sl. No	Materials	Proportions	Compressive Strength (N/mm^2)
1	Clay + CC	94% + 6%	3.61
2		88% + 12%	3.52
3		82% + 18%	3.40
4		76% + 24%	3.24

Table 5: Water Absorption of Clay Bricks with Varying Combinations of CC

SL No	Materials	Proportions	Compressive Strength (N/mm^2)
1	Clay + GWP + CC	88% + 6% + 6%	3.72
2		82% + 12% + 6%	4.10
3		76% + 18% + 6%	4.91
4		70% + 24% +6%	4.80
5		64% +30% + 6%	4.42

Table 6: Compressive Strength of Clay Bricks with Varying Combinations of GWP and CC

Sl. No	Materials	Proportions	Water Absorption (%)
1	Clay + GWP + CC	88% + 6% + 6%	12.80
2		82% + 12% + 6%	14.68
3		76% + 18% + 6%	15.81
4		70% + 24% + 6%	17.68
5		64% +30% + 6%	18.22

Table 7: Water Absorption for the Clay Bricks with Varying Combinations of GWP and CC

Sl. No	Materials	Proportions	Compressive Strength (N/mm^2)		
			7	14	21
1	Fly Ash + GWP + Lime	84% + 6% + 10%	1.25	2.85	5.98
2		78% + 12% +10%	1.61	3.38	6.28
3		72% + 18% + 10%	1.92	3.72	6.85
4		66% + 24% + 10%	1.96	3.76	7.83
5		60% +30% + 10%	1.78	3.55	7.68

Table 8: Compressive Strength of Fly ash Bricks for 7, 14, 21 day with Varying Combinations of GWP and Lime

SL No	Materials	Proportions	Water Absorption (%)
1	Fly Ash + GWP + Lime	84% + 6% + 10%	8.5
2		78% + 12% +10%	9.4
3		72% + 18% +10%	11.1
4		66% + 24% +10%	12.68
5		60% +30% +10%	15.16

Table 9: Water Absorption for the Fly ash bricks with varying combinations of GWP and Lime.

C. Computation of Embodied Energy for the Bricks

The embodied energy was calculated for the bricks which are giving maximum compressive strength with specific proportion.

Embodied energy= (Quantity of material in kg) X (Embodied energy value in MJ/kg)..... Eq'n (3.1)

CO_2 emission= (Quantity of material in kg) X (CO_2 Emission Value per kg)....Eq'n (3.2)

Coal is used as external fuel for clay bricks. Embodied energy and CO_2 emission is calculated by Eq'n (3.1) and Eq'n (3.2) respectivity.

Embodied Energy				
Sl. No	**Material**	**Quantity of Materials in kg for 1000 Bricks**	**Embodied Energy value MJ/kg**	**Embodied Energy in MJ**
1	Clay	2460	0	0
2	GWP	540	0.79	426.6
3	Coal (External Fuel)	140	27.5	3850
Total Embodied Energy per 1000 Bricks				4276.6MJ
Embodied Energy per Brick				4.276MJ
CO_2 emission				
Sl. No	**Material**	**Quantity of Materials in kg for 1000 Bricks**	**CO_2 per kg value**	**CO_2 Emission (in kg)**
1	Clay	2460	0	0
2	GWP	540	0.2	108
3	Coal (External Fuel)	140	2.42	338.8
CO_2 Emission per 1000 bricks				446.8kg
CO_2 Emission per Brick				0.44kg

Table 3.10: Computation of Embodied Energy and CO_2emission for Clay Brick with GWP.

Embodied Energy				
Sl. No	**Material**	**Quantity of Materials in kg for 1000 Bricks**	**Embodied Energy value MJ/kg**	**Embodied Energy in MJ**
1	Fly ash	2310	0	0
2	GWP	840	0.79	663.6
3	Lime	350	5.63	1970.5
Total Embodied Energy per 1000 Bricks				2634.1MJ
Embodied Energy per Brick				2.634 MJ

CO_2 emission				
Sl. No	**Materials**	**Quantity of Materials in kg for 1000 Bricks**	**CO_2 per Kg value**	**CO_2 Emission (in kg)**
1	Fly ash	2310	0.004	9.24
2	GWP	840	0.2	168
3	Lime	350	0.55	192.5
CO_2 Emission per 1000 Bricks				369.74 kg
CO_2 Emission per Brick				0.369 kg

Table 3.11 Computation of Embodied Energy in MJ and CO_2 Emission for Fly ash Bricks with GWP and Lime.

IV. CONCLUSION

Present research work gives following conclusion

1) The three different types of clay brick and one fly ash brick, were casted,
   - Brick-1 = (Clay + GWP), Brick-2 = (Clay + CC), Brick-3 = (Clay + GWP + CC) Brick-4 = (FA + GWP +L)
   - Brick-1 (4.95 N/mm^2) is having Maximum compressive strength than Brick-2 (3.61 N/mm^2) and Brick-3 (4.91 N/mm^2).
   - Brick-1 (15.34 %) is having water absorption higher than Brick-2 (10.56 %) and lower than Brick-3 (15.81 %) but it is within the prescribed maximum limit as per IS code.
   - Brick-1 (4.27 MJ and 0.44 kg) is having embodied energy and CO_2 emission lesser than Brick-2 (7.13 MJ and 0.66 kg) and Brick-3 (7.56 MJ and 0.76 kg)
   - Brick-4 (2.63MJ and 0.369 kg) is having embodied energy and CO_2 emission lesser than Brick-1(4.27MJ and 0.44 kg) , Brick-2 (7.13 MJ and 0.66 kg) , Brick-3 (7.56 MJ and 0.76 kg)
2) Fly ash can be partially replaced by granite waste powder and lime combination, with granite waste powder upto 30% and lime upto 10%, for 24% of granite waste powder and 10% of lime, the maximum compressive strength as 7.83 N/mm2, which is greater than minimum compressive strength as per IS code and water absorption as 12.68 %, which is within the prescribed maximum limit as per NTCP guide line.

V. SCOPE FOR FUTURE STUDY

In present study bricks were prepared manually, same bricks can be prepared by machine and there compressive strength, water absorption property can be studied.

Corn cob can be added to coal with certain percentage as external fuel for the bricks can be studied.

REFERENCE

[1] Prepared for UNDP-GEF project on Energy efficiency improvements in Indian brick industry - "Approach paper on Market for Resource Efficient Brick products", June 2011.
[2] Venkatesan A, Anand G, Fernandez George, Thillai N, Alex A, "A Compressive Strength and Water Absorption Test on Brick Made of Wood Ash, Charcoal with Clay Bricks: A Comparative Study", The International Journal Of Science &Technology ,ISSN 2321 – 919X, 81 Vol 3 Issue 3 March, 2015.
[3] Sekar T, "Utilization of Industrial Wastes for Production of Black Cotton Soil Bricks", International Research Journal of Engineering and Technology (IRJET),e-ISSN: 2395 -0056 ,Volume: 02 Issue: 05 | Aug-2015.
[4] Kumar J, Jain S and Salgude R R, " Comparison of Carbon Emission & Embodied Energy between Brickwork & Waffle wall method for Industrial Building" ,International Journal of Innovative and Emerging Research in Engineering, ISSN (Online): 2319-7064 Volume 2, Issue 6, 2015.

