Mining Waste in the Manufacture of Bricks

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Abstract

In mining, the process of excavation and beneficiation, huge amount of waste is produced. The disposals of wastes are done in the mining lease or outside the area. These wastes occupy vast area, degrade surrounding land and also deteriorate the environment. In this paper a masonry units made of iron slag in Stabilized Mud Block (SMB) is studied. Based on the gradation and requirement, optimum mix proportion of soil, sand and cement was fixed and the sand fraction was replaced by mineral wastes with a fixed proportions. The block characteristics like compressive strength, water absorption and shrinkage are examined and compared with that of the conventional bricks. From the experimental results it is found that considerable amount of natural aggregates can be replaced by iron slag with negligible compromise in desirable characteristics of bricks used for masonry thus helping in the reuse of mining waste. By cost analysis, it is found that the modified bricks are more economical than that of conventional ones.

Keywords: *Compressive Strength, iron slag, Mineral Waste, Stabilized mud block*

1. Introduction

Generally mud bricks are made of mud, sand, water and binding material (rice husk, straw, cement, bitumen). Stabilized Mud Bricks are alternative to burnt clay bricks. Stabilized Mud Bricks are manufactured by mixing soil, sand and stabilizer with optimum water content, compacted into a high density-block. Natural river sand is commonly used to achieve an optimum clay and sand content in the mix for production of good quality SMB. These are cured for up to 28 days and can be used in the construction of masonry elements. Mud bricks perform considerably better, in environmental terms, then fired bricks. They have significantly less embodied energy, contribute fewer CO_2 emissions and help to promote the local economy and local labor. But the drawback of SMB is that they are less durable and are susceptible to water damage when compared to the fired bricks.

In this project, sand and clay are replaced with iron slag in the manufacture of Stabilized Mud Brick. The bricks casted are then cured for 28 days and tests are conducted to show the properties of brick which uses slag as an alternative material.

Following were the objectives of the undertaken project:

- To study the properties of iron slag used in the manufacture of brick.
- To find the best mix proportion for the manufacture of brick which can replace sand by slag and its comparison
- Evaluate the cost of SMB which uses slag and its comparison with conventional brick to find the economic feasibility of alternate brick-SMB.

2. Literature Survey

Earlier research on SMB has examined in detail the role of clay and its optimum content in the soil for better performance of SMB both with respect to strength and durability. These studies recommend optimum clay content to be in the range of 12% to 16%. Hence, in order to bring the clay content of the soil within desirable limits, ratio of soil to sand was kept as 1:1 by weight. It is also brought out in earlier research that about 7% of stabilizer is sufficient for three storey load bearing masonry of moderate span residential buildings. Hence 7% cement by weight of soil and sand was used to stabilize the soil. In general, water content of about 10% of dry materials by weight is commonly used to make SMB. However, as the river sand is being replaced by both fine and coarse slag, demand for increased moulding water content was expected. Also, it is found that for a given mix, water content to the moist side of OMC gives better strength [5]. Hence, for all the mixes, water content was kept 10% more than the OMC of slag. The river sand fraction and clay was replaced by iron slag at 25%, 50% and 100%, compared with results for mix containing 100% clay (Reference mix-I) and 50% river sand (Reference mix-II). The bricks made out of the mix with sand to iron slag ratios of (1: 0), (0.75: 0.25), (0.5: 0.5) and (0: 1) are designated as A, B, C and D respectively. The target dry density was kept at 1.8 g/cc, which is again based on the recommendations by earlier research on SMB technology. [8] [9]

3. Mix-Proportions

Table 1: Mix Proportion of Conventional Brick

Mix type (Soil:Sand:Slag)	Mix proportion by weight			Cement content (%)	Water content (%)
	Soil (%)	Sand (%)	Slag (%)		
Regular Mix-I (R-I)	100	0	0	8	15
Regular Mix-II (R-II)	50	50	0	8	20

Table 2: Mix Proportion of Modified Brick

Mix type	Mix proportion by weight (kg)			Cement content (%)	Moulding water content (%)
	Soil (%)	Sand (%)	Slag (%)		
Fine-1(F-1) (50:0:50)	50	0	50	8	15
Fine-2(F-2) (50:25:25)	50	25	25	8	15
Fine-3(F-3) (50:37:13)	50	37.5	12.5	8	15
Coarse-1(C-1) (50:0:50)	50	0	50	8	20
Coarse-2(C-2) (50:25:25)	50	25	25	8	20
Coarse-3(C-3) (50:37:13)	50	37.5	12.5	8	20

4. Casting Mould

Mould is a rectangular, hollow object made to duplicate the required material in the prefixed shape. Steel moulds of size 230 x 110 x 70 are used in the casting method adopted as per IS 1077:1992.

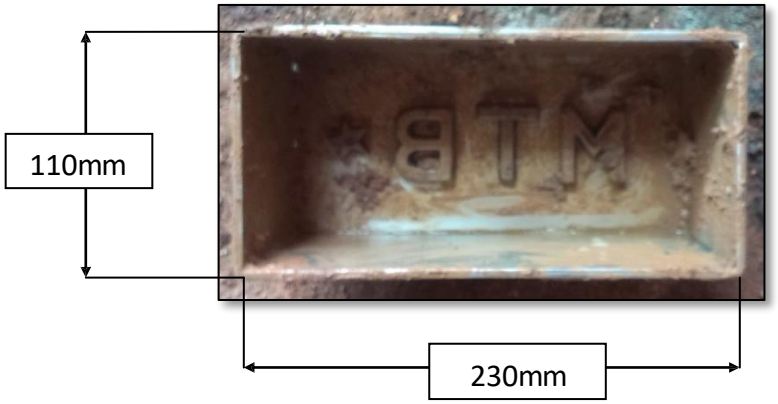

Fig 1: Steel Mould

5. Methodology

The following section deals with the method adopted to cast the Stabilized Mud Block:

- Locally available red clay soil and natural river sand were used to make SMB with Ordinary Portland Cement of 43 Grade as stabilizer.

- The raw materials were processed to characterize their properties. Relevant tests were conducted to determine their properties.
- Eight mix proportions are fixed to cast bricks. (2 conventional reference mixes and 6 slag replaced mixes). Volume batching method was used to mix the raw materials.
- Raw materials are dry mixed and after adding stabilizing agent, water is added as per decided proportions and mixed thoroughly.
- Mixed material is rammed into the mould, compacted manually at a compacting strength of 30 KN and top layer is skimmed off to give smooth finish.
- The casted bricks are cured for 28 days by membrane curing.
- Tests are conducted for 7, 14 and 28 days period to get compressive strength of dried brick.

6. Results

Table 3: Average Compressive Strength for Conventional Bricks

Reference Mix			
Mix Code	Compressive strength, Mpa		
	7 Days	14 Days	28 Days
R-I	4.94	13.24	15.08
R-II	3.96	9.55	14.23

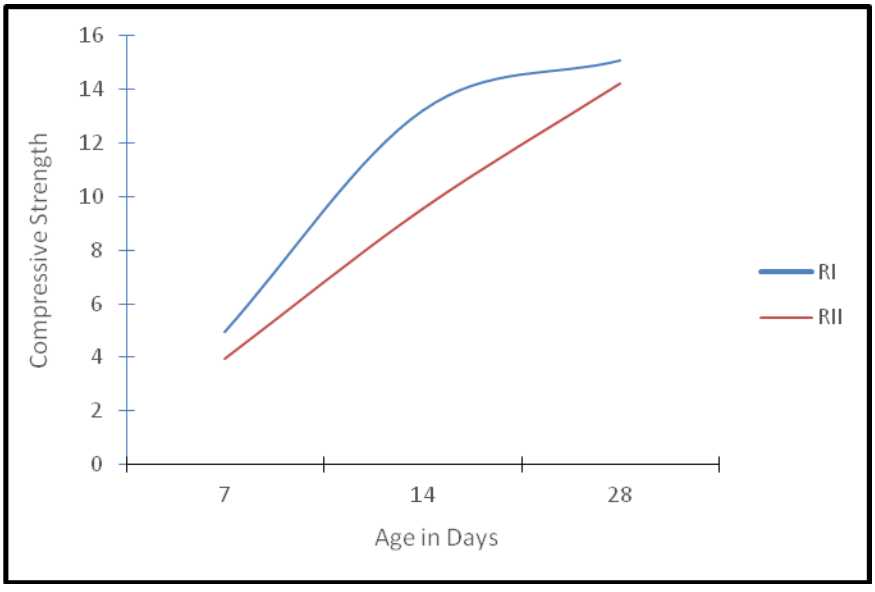

Fig 2: Compressive strength of Conventional Bricks

Table 4: Average Compressive Strength for Slag Bricks

Modified mix with fine slag				Modified mix with coarse slag			
Mix type	Compression strength, MPa			Mix type	Compression strength, MPa		
	7 Days	14 Days	28 Days		7 Days	14 days	28 Days
F-I (50:0:50)	3.4	10.86	13.89	C-I (50:0:50)	3.22	9.22	11.13
F-II (50:25:25)	3.68	9.88	12.05	C-II (50:25:25)	3.22	10.2	11.92
F-III (50:37:13)	4.14	9.54	11.16	C-III (50:37:13)	3.09	9.85	12.9

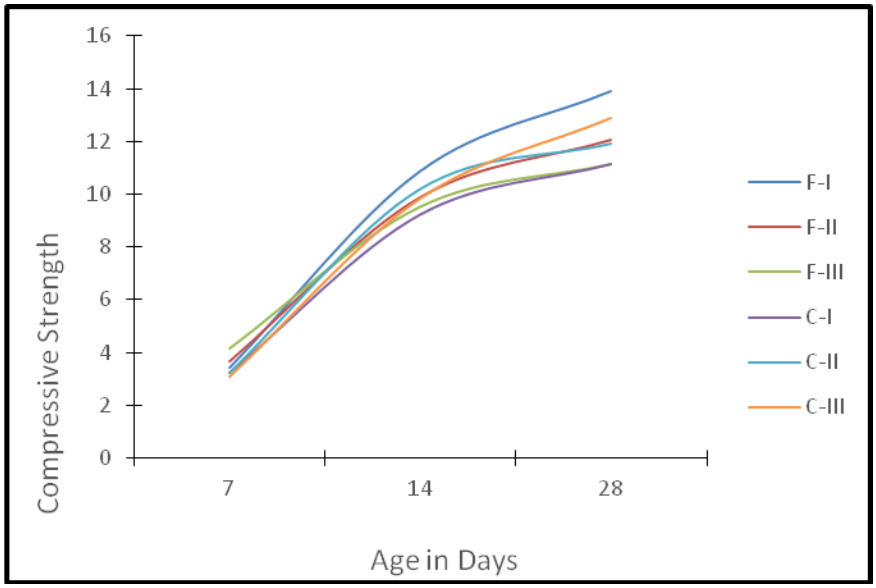

Fig 3: Compressive strength of Slag Bricks

It is observed that compressive strength of bricks using fine slag increases with the increase in percentage of fine slag used. In case of coarse slag bricks, compressive strength decreases with the increase in coarse slag percentage. The graph shows that Brick which replaces fine slag with highest replacement of sand (F-1) gives highest compressive strength when compared to all other modified bricks. In F-1, F-2, F-3 bricks, compressive strength increases non-linearly with increase in slag content. When percentage of Coarse slag is at 50% (C-3), the compression strength is lowest among all the other blocks.

7. Conclusion

Bricks manufactured using iron ore slag was proved to be eco friendly as it utilizes mining wastes to reduce adverse effect of mining on environment. Shrinkage of modified bricks is less when compared with shrinkage of conventional bricks. Compressive strength of bricks manufactured using slag is less when compared to that of conventional bricks so these bricks can be categorized under class 2 bricks. The compressive strength of bricks which uses fine slag is more when compared to that of coarse slag bricks.

Mass production of these bricks will prove to be eco friendly as stabilized mud bricks emit lesser CO_2. It can be concluded that these modified bricks are proved to be eco friendly, economical and efficient.

8. Reference

[1] *"Utilization and Stabilization of Mineral Waste", 1986*, K. C. Dean, L. J Froisland, and M. B. Shirts.

[2] *" Utilization of Fe-Bearing Steel Plant Fines in Primary Operations"*, Landowet et. al., (1997)

[3] *"Trash to Treasure Turning Steel-Mill Waste into Bricks", Erikssonet et. al.,(1999)*

[4] *"Bricks by Using of Coal Fly-Ash"*, Freidin and Erell (2005)

[5] *"An Overview of Utilization of Slag and Sludge from Steel Industries"*, 2006 B. Das, S. Prakash, P.S.R. Reddy, V.N. Misra.

[6] *Indian Mineral Yearbook 2011*, Slag-Iron and steel, Indian Bureau of Mines.

[7] *"Alternative Methods of Stabilization of Unfired Mud Bricks", 2011*, Doug Harper.

[8] *"Characteristics of Masonary Units from Iron Ore Tailings"*, Ullas S. N, B. V. Venkatarama Reddy and K. S. Nanjunda Rao.

[9] *"Utilization of Hematite Tailings in Manufacturing of Non-Fired Bricks"*, Yongliang et al., (2011)