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Utilization of Sugarcane Bagasse Ash and Red Mud in the Manufacture of Compressed Earth Blocks

Thomas Mathew[1], Sujatha Unnikrishnan[2]

Structural Design Engineer, Gravity + Elementz, Kottayam, India [1]

Associate Professor, Department of Civil Engineering, Faculty of Engineering Christ University, Bangalore, India [2]

Abstract: **Sugarcane bagasse ash (SBA) and red mud (RM) are two principal waste materials derived from sugar industry and aluminium industry respectively. The objective of this study is to analyze the effect of using SBA and RM in the manufacture of blocks using the compressed earth block technology. Two sets of blocks were cast of which, the first set was manufactured using Red mud and bagasse ash with bagasse ash proportion varying from10%-40%. The second set of blocks was manufactured with bagasse ash, red mud, cement and slag sand. Compressive strength and water absorption tests were conducted. Scanning Electron Microscopy (SEM) was conducted to study the surface morphology of the blocks. The results showed that these waste materials can be successfully incorporated in the manufacture of compressed blocks.**

Keywords: Bagasse Ash, Red mud, blocks, Slag sand

I. INTRODUCTION

Though industrialization and urbanization are the two worldwide phenomena which are necessary for the progress of the society, one has to look into their negative impacts on the global environment and social life. The major ill effect of these global processes is the production of large quantities of industrial wastes and the problems related with their safe management and disposal [1]. Brickwork and block work are the basic methods used in the construction of buildings since time immemorial. The good performance of masonry units in terms of its strength, thermal and acoustic properties made this construction material recognized in the developing and developed countries and the origin of masonry dates back to around 8000BC [2]. The traditional masonry units comprised of components, for which the production methods are highly energy consuming, as in the case of fired clay bricks. Sustainability is not only dependent on environmental impacts but also on the social requirements and economic feasibility [14].

India is the second largest producer of sugarcane in the world, after Brazil [15]. The production of sugarcane in India accounts to about 300 million tons a year. Sugarcane bagasse is fed into a boiler, where it is burnt at a temperature varying from 240ºC to 600ºC, depending on the moisture content and feed of the bagasse. This leaves behind a residual ash in the boiler which is known as Sugarcane Bagasse Ash [12]. It is considered as a non-biodegradable solid waste and is mainly dumped in landfills. Bagasse ash being a particulate matter pollutes the surrounding air and can lead to breathing disorders to the people living nearby. [4]

Red Mud is produced during the process of alumina production. Depending on the raw material processed, 1–2.5 tons of red mud is generated per ton of alumina produced [1]. In India, about 4.71 million tons/annum of red mud is produced which is 6.25% of world's total produce [2]. Red mud is a mixture of compounds originally present in the parent mineral bauxite and of compounds formed or introduced during the Bayer process. It is disposed as slurry having a solid concentration in the range of 10-30%, pH in the range of 10-13 and high ionic strength [5].

Past researches in this field show the use of fly ash, sand, lime, gypsum and cement along with red mud in the manufacture of unsintered bricks [5]. When bagasse ash is used as a replacement of cement in the manufacture of bricks, the overall carbon dioxide emission is reduced. It also helps in bringing down the adiabatic temperature of structures constructed with it, in addition to improving the mechanical properties [11]. Bagasse ash being a particulate matter helps fill the voids thereby contributing to the overall

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strength as well as helps to reduce water absorption [13]. However not much research has been carried out by using bagasse ash and red mud as the major constituents for the manufacture of compressed earth blocks.

II. MATERIALS AND METHODS

A. Material Characterization

The principal raw material SBA was collected from M/s, NSL Sugars Ltd. Mandya, India. Samples were collected during the cleaning operation of the boilers in the factory. The SBA thus obtained was used for making building blocks by mixing Red mud, Slag sand and Cement in different proportions. Red mud was collected from M/s, HINDALCO, Belgaum, India and slag sand from M/s JSW steels, Bellary, India. The percentage compositions of oxides for these waste materials are shown in Table 1. Red mud and slag sand was tested according to IS 2386-Part III (1963) and bagasse ash was tested according to IS 4031-Part V (1988). The specific gravities of the constituent raw materials are shown in Table 2.

TABLE I
PERCENTAGE COMPOSITION OF OXIDES

Constituents	Red mud (%)	SBA (%)
SiO_2	11.14	42.22
Al_2O_3	22.94	6.88
Fe_2O_3	35.53	2.32
CaO	2.07	18.79
MgO	1.41	3.83
SO_3	0.21	4.33
Na_2O	5.96	1.20
K_2O	0.18	2.75

TABLE II
SPECIFIC GRAVITY OF RAW MATERIALS

Materials	Specific Gravity
Red mud	2.50
SBA	1.35
Slag sand	3

Considerable research and development work for the storage, disposal and utilization of red mud is being carried out all over the world [3]. Manufacturing and testing of Compressed Earth Blocks using these waste materials was attempted in this study. The aim is to provide some valuable information to further address the comprehensive utilization of these waste materials.

B. Development of Composite Blocks

A manual block press called the Mardini Press developed at IISC Bangalore was used to make building blocks of dimensions 230 × 110 × 100 mm^3. The first set of blocks was manufactured using red mud and bagasse ash with bagasse ash proportion varying from10%-40%. The second set of blocks was manufactured with bagasse ash, red mud, cement and slag sand. Fig.1 shows the steps involved in the manufacture of blocks. The different proportions adopted are shown in Table 3. Water content was fixed at 15% based on trials for consistency.

TABLE III
MIX PROPORTIONS

SI NO	Denotation	Red mud %	Bagasse ash %	Slag sand %	Cement %
1	90RM 10BA	90	10	Nil	Nil
2	80RM 20BA	80	20	Nil	Nil
3	70RM 30BA	70	30	Nil	Nil
4	60RM 40BA	60	40	Nil	Nil
5	M1	70	15	10	5
6	M2	70	10	10	10
7	M3	60	15	20	5
8	M4	60	10	20	10

Fig. 1. Steps involved in the manufacture of blocks

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A series of Physico mechanical tests were carried out in accordance with the recommended Indian. The Scanning Electron Microscopy (SEM) was conducted to gather information about the surface morphology of the blocks. [10] discussed about amplifier power relation, impedance , T π and microstripline matching networks.

III. RESULTS & DISCUSSIONS

A. Block Density

Table 4 shows the density of blocks tested. Density of Red mud – SBA blocks were noted to have reduced with increase in percentage of SBA.

TABLE IV
DENSITY OF BLOCKS

Mix Designation	Density (kg/m^3)
90RM10BA	1495
80RM20BA	1478
70RM30BA	1136
60RM40BA	1080
M1	1453
M2	1508
M3	1406
M4	1522

B. Dry Compressive Strength

The dry compressive strength test of blocks was conducted as per IS 3495 part I. The blocks were tested in dry condition after 28 days of curing in ambient temperature. The failure load was noted and compressive strength was determined.

C. Wet Compressive Strength

The wet compressive strength test of blocks was conducted according to IS 3495 part I. After 28 days of curing in ambient temperature conditions, the blocks were immersed in water for 24 hours. The specimens were taken out of water and the surface was dried before testing. The compressive strengths of blocks tested are shown in Table 5.

TABLE V
COMPRESSIVE STRENGTHS OF BLOCKS TESTED

Mix designation	Dry compressive strength (N/mm^2)	Average dry Compressive strength (N/mm^2)	Wet compressive strength (N/mm^2)	Average wet Compressive strength (N/mm^2)
90RM 10BA	0.80 0.83 0.86 0.83 0.90	0.84	Nil Nil Nil Nil Nil	Nil
80RM 20BA	2.33 2.45 2.52 2.72 2.80	2.57	1.54 1.30 1.30 1.73 1.62	1.50
70RM 30BA	1.74 2.25 1.97 1.90 1.86	1.94	0.95 1.10 0.83 1.15 1.22	1.06
60RM 40BA	1.72 1.39 1.62 1.72 1.78	1.50	0.85 0.95 1.22 0.99 1.10	1.01
M1	3.84 3.43 3.75 3.75 4	3.75	2.49 2.56 2.33 2.41 2.37	2.43
M2	4.78 4.40 4.90 5.10 4.86	4.80	3.87 4.01 3.71 3.83 3.79	3.85
M3	2.52 2.88 3.20 3.24 3.12	3.0	2.29 2.09 1.77 2.01 2.21	2.07
M4	4.30 4.34 4.27 4.46 4.30	4.33	3.20 3.12 3.47 3.32 3.20	3.26

D. Water Absorption Test

The water absorption test on blocks was performed according to IS: 3495 Part-II. Results of water absorption test on block specimens of different mix proportions are shown in Table 6

TABLE VI
WATER ABSORPTION TEST RESULTS

Mix designation	Water absorption (%)
90RM10BA	Nil
80RM20BA	27.26
70RM30BA	36.67
60RM40BA	31.00
M1	19.00
M2	15.00
M3	22.10
M4	19.40

E. Scanning Electron Microscopy

Scanning Electron Microscopy was conducted to study the surface morphology of blocks. SEM images of a few blocks tested are shown in Fig 2. The SEM results of blocks cured for 28 days show ettringite formation with needle like structures in compositions 80RM20BA and M1. It can be seen that the ettringites filled the interstitial spaces accompanied with some hydrated C-S-H gel. It can thus be inferred that ettringite and C-S-H gel are the major contributors in the strength of the blocks.

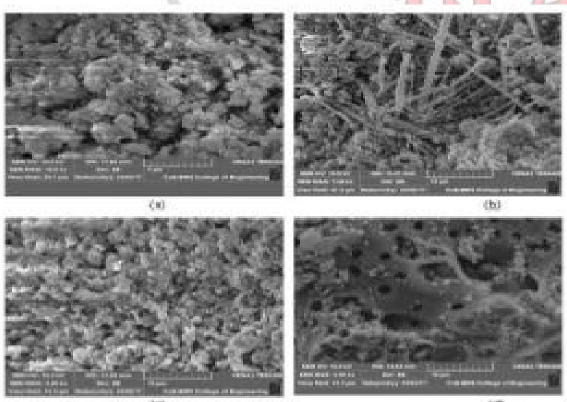

Fig.2. SEM analysis of block made of (a) 80RM20BA mix (b) M1 mix (c) M2 mix and (d) M3 mix

IV. CONCLUSION

The following conclusions were drawn based on the experimental study

1. This research study shows that the industrial waste materials- Red mud, Bagasse ash and Slag sand can be used for the manufacture of compressed blocks.

2. The dry compressive strength and wet compressive strength of the blocks with 20% bagasse ash and 80% Red mud was 2.57MPa and 1.5MPa respectively. These values satisfy the criterion for Class B Compressed Earth Blocks. The water absorption of these blocks was higher than stipulated limits.

3. All the blocks incorporated with slag sand and cement in addition to red mud and bagasse ash satisfied the criterion for Class A Compressed Earth Blocks. Water absorption of these blocks met the values stipulated by Indian standards.

4. This experimental study is an attempt on energy efficient building blocks.

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BIOGRAPHY

Thomas Mathew obtained his Master's Degree in Structural Engineering from Christ University, Bangalore and currently plays the role of Design Manager-Structural Design in a multi-disciplinary design consultancy, Gravity + Elementz, Kottayam, Kerala. His research interests include sustainable building materials and sustainable architecture.

Dr Sujatha Unnikrishnan obtained her PhD degree from National Institute of Technology Karnataka, Surathkal, India. She is currently Associate Professor in Faculty of Engineering, Christ University, Bangalore. Her research interests include sustainable building materials, structural masonry and seismic response of structures. She has published papers in national and international journals and presented papers in conferences.