Building Bricks From Iron Tailings

Mohan Rai & Dinesh Chandra
Central Building Research Institute, Roorkee

Abstract

Iron tailings, a waste material available at the iron ore mines where iron ore is extracted and concentrated pose great problems of disposal. Not much attention has been paid towards finding any worthwhile use of this waste as a building material. Possibilities exist to use it as an admixture to common soils for making building bricks and tiles. The present paper describes the experimental results of the use of Kudremukh (Karnataka) iron ore tailings in making building bricks.

Introduction

India has extreme reserves of iron ore of different categories amounting to about 10,269 million tonnes comprising 8,244 million tonnes of hematite and 2,025 million tonnes of magnetite variety[1]. The Kudremukh quartz-magnetite-hematite deposits of Aroli in Chikmagalur district of Karnataka State are estimated at about 610 million tonnes of weathered magnetite-hematite ore plus 520 million tonnes of underlying primary magnetite formation. The project at Kudremukh itself is expected to produce 7.5 million tonnes of concentrate per annum for which mining of 18.75 million tonnes of crude feed per annum will be required and the rest 11.25 million tonnes per annum residual tailings will go as a waste. This enormous quantity would be creating big problems for the project administration inspite of arrangements made for dumping it in the valley by constructing an earthendam.

It has been shown[2] that these tailings consisting of quartz, felspar, amphibole, mica, magnetite and pyrite can be shaped into bricks by using calcium lignoulphide as binder and followed by firing at high temperature (1200°c). Compressive strength of these bricks are given around 350 kg/cm^2. The author[2] has examined similar tailings from gold, nickel, copper uranium and molybedenum benefication industries also for use as pozzolanic material. Richard et al[3] have also found the utilisation of copper tailings in the production of red brick using clay as an admixture to tailings and followed by firing at 900-1100°c. Other tailings from waste water purifications plant[4] and gold beneficiation[5] have also been used for the development of cellular concrete. Ceramics from coal beneficiation tailings containing 7.69-22.26 per cent carbon have also been produced by Petrova[6]. Besides this, zinc tailings can also be used for the manufacture of masonry cement[7] and cellular concrete[8]. It appears however that no attention has been paid to the use of iron tailings directly as an admixture to the soil for making bricks.

A sample of iron tailings received from Kudremukh was used in the present investigation to make stabilised as well as burnt clay building bricks.

Experimental Procedure

Differential thermal analysis (DTA) of the powdered iron tailings sample (-150 micron) was carried out using Stanton- Red croft Differential thermal Analyser 674, keeping heating rate at 10°C per minute and Pt-Pt/Rh thermocouples. The thermogram obtained has been given in Fig. 1. The X-ray diffraction pattern of the powdered sample was also obtained by using a MoK α radiation with a zirconium filter in a general purpose Debye-Scherror Camera of 114.6 cm diameter. The petrographic examination of the sample of the tailings was carried out with the help of a Leitz Panphot microscope.

The chemical analysis of iron tailings and the lateritic soil of Kudremukh area are given in Table 1.

Table 1

Chemical Analysis of Iron Tailings, Red and Lateritic Soils

Constituents %	Tailings	Red Soil	Lateritic Soil
L. O. I.	3.58	8.77	10.82
SiO_2	58.53	53.50	31.82
Al_2O_3	9.21	16.31	31.59
Fe_2O_3	21.08	18.03	24.48
CaO	4.08	1.22	1.03
MgO	2.76	0.95	0.22
Alkali	—	1.16	—

The tailings appear to be siliceous and ferruginous containing sand size particles(>0.2) upto 92 percent. The particle size analysis and Atterberg limits given in Table 2 show that the soils used are clayey in nature and possess good plastic properties.

Table 2

Particle Size Analysis and Atterberg Limits of Red and Lateritic Soils

Properties	Red Soil	Lateritic Soil
Mechanical Analysis		
Clay (%)	60.08	42.6
Silt (%)	15.10	19.1
Sand (%)	24.82	38.3
Atterberg Limits		
Liquid Limit (%)	53.7	40.4
Plastic Limit (%)	19.3	25.6
Plastic Index	34.4	14.8

The DTA of the iron tailings sample shows two endothermic peaks at 380° and 570°C with a minor dent at 320°C. The peak at 380° may be attributed to the presence of goethite and the second peak at 570°C for quartz. The small dent at 320°C may be accounted for magnetite.

The X-ray results (Table 3) indicate that the tailings contain quartz, hematite, magnetite, orthoclase and goethite as the main constituents. Petrographic examination of these tailings also confirms the presence of quartz, hematite and magnetite in considerable quantity alongwith orthoclase and goethite.

Table 3

X-ray Powder Diffraction Data of Iron Tailings

Sl. No.	Values	Intensity	Possible Phases
I.	1.37	Strong	Quartz
2.	1.45	Weak	Magnetite
3.	1.56	Medium	Quartz
4.	1.68	Weak	Hematite
5.	1.80	Medium	Quartz, Orthoclase
6.	2.48	Medium	Hematite, Magnetite, Goethite
7.	3.28	Very Strong	Quartz, Orthoclase
8.	4.26	Strong	Quartz, Orthoclase, Geothite

Manufacture of Bricks from Iron Tailings

Iron tailings being sandy and non-plastic in nature could not be used like ordinary plastic soils for making burnt bricks. Therefore two sets of experiments were carried out to make (i) stabilised bricks using cement or hydrated lime and (ii) burnt bricks using some clayey additives such as red, lateritic or China clay and firing them at 900 - 1000°C temperature.

(i) Stabilisation of Tailings with Cement or Hydrated Lime

Stabilised bricks using portland cement or hydrated lime conforming to class C (I:712-1963) were made, the ratio of tailings/stabilizer being 95/5, 90/10 and 85/15 (by weight). Briquettes of size 10x 5x 3 cm of these mixes were cast by hand moulding or pressure moulding at the pressure of 160 or 320 kg/cm². These briquettes were cured at 90 percent relative humidity and 25-30°C temperature till the time of testing at 7 and 28 days. Some briquettes were autoclaved also under saturated steam (pressure 14 kg/cm²) and 180°C temperature for 5 hours. These autoclaved briquettes were tested after cooling to room temperature and saturation in water for 24 hours. Full size bricks of size 23.0x 11.7 x 7.5 cm were made to study the practical feasibility. Mixtures of the tailings and portland cement were made with 10 percent moisture content with the help of a Winget brick making machine (moulding pressure 70-100 kg/cm²). These bricks were put under wet gunny bags for 24 hours under a shed and then put in water until testing at 28 days. The test results have been given in Table 6.

The results in Table 4 show that the strength of briquettes increases from 41 to 106 and 59 to 132 kg/cm² with the increase in cement addition from 5 to 15 percent. Similar trend was seen with the addition of hydrated lime. The compressive strength of the lime

Table 4

Compressive Strength Data of Briquettes Made at Different Pressure with P. Cement

Composition (%by wt.)		7 and 28 days Compressive strengths (Kg/cm²) of briquettes cast at moulding pressure of					
Tailings	P' Cement	Hand		160Kg/cm²		320Kg/cm²	
		7d	28d	7d	28d	7d	28d
100	—	Crumbled at the Green Stage					
95	5	—	—	21	41	44	59
90	10	24	30	32	37	76	109
85	15	—	—	78	106	109	132

stabilised briquettes after 28 days' curing was found to be about 140kg/cm² (Table 5). On autoclaving, compressive strength of the briquettes goes up to 269 kg/cm² (Table 6) which may be due to the formation of the binding phase of calcium silicate hydrate.

Table 5

Compressive strength Data of Briquettes Made at Different Pressures with Hydrated Lime

Composition (% by wt.)		Compressive strength (Kg/cm²) of briquettes cast at moulding pressure of					
		Hand		160Kg/cm²		320Kg/cm²	
Tailings	Hydrated Lime	7d	28d	7d	28d	7d	28d
100	—	Crumbled		at	green	stage	
95	5	—	—	15	20	22	36
90	10	8	14	22	20	70	106
85	15	—	—	26	51	96	140

Table 6

Physical Properties of Briquettes Cured in Autoclave at the Steam Pressure of 14Kg/cm²

Composition (% by wt.)		Compressive Strength (Kg/cm²)	Water Absorption (%)	Bulk Density (Kg/cm²)
Tailings	Lime			
95	5	159	18.0	1910
90	10	220	17.0	1920
85	15	269	16.8	1980

Compressive strength data of full size bricks after wet curing for 7 and 28 days (Table 7) shows that bricks of 24 to 34 kg/cm² compressive strength could be made. Hence these bricks would cost much more than the burnt clay bricks. It is evident that high strength brick with 5 to 10 per cent cement or lime addition could be made if high moulding pressure and autoclaving techniques are adopted.

Table 7

Compressive Strength Data of Full Size Bricks Stablized With Cement and Cured Under Wet Conditions

Composition (% by wt.)		Compressive Strength (Kg/cm²)	
Tailings	Cement	7 days	28 days
90	10	16	24
85	15	25	34

Clay Bonded Iron Tailings Bricks

A locally available clay was used as a binder to make burnt bricks from the tailings. The soils available around Kudremukh mines red or lateritic possessing kaolinitic group of clay minerals were used as a binder. Iron tailings were mixed with different percentages of the clays (10-15 percent) and briquettes were prepared by hand moulding. Briquettes on the application of 160 or 320 kg/cm² moulding pressure with 10% water content were also prepared. The briquettes were fired at different temperatures (800-1050°C) with 5 hours soaking. The results of the tests have been given in Tables 8 to 11.

Full size bricks of size 23.5x11.7x7.5 cm were also made by hand moulding at 25% moisture content as well as by pressure moulding also at 10% moisture content with the mix containing 70 percent iron tailings and 30 percent red soil. These bricks were dried in the sun and fired at 1000±20°C with 5 hours soaking period in an electric furnace. The test results of these bricks are given in Table 12.

The test results (Table 8) show that the briquettes of good compressive strength (210-225 kg/cm²) can be manufactured with the addition of 15 per cent China clay to the tailings and firing at 1000°C. The data given in Table 9 show that the briquettes made of iron tailings and red soil could be manufactured giving compressive strength 110-190 kg/cm², depending upon the moulding pressure. It is also seen that the briquettes made of equal proportions of the tailings and lateritic soil give compressive strength ranging from 100 to 354 kg/cm², with the application of different moulding conditions (Table 11).

Bricks of size 23.5x11.7x7.5 cm of two compositions viz 70:30 and 50 :50 (tailings:red soil) by weight were made by hand moulding and pressure moulding using Landcrete brick making machine. It was found during drying that the bricks having equal proportions of the two materials get cracked. The bricks of other compositions i.e. 70:30 were fired in an electric furnace at 1000±20°C with 5 hours soaking.

The results obtained (Table 12) show that bricks having compressive strength 26-52 kg/cm² could be manufactured by ordinary pressing and firing at about 1000°C. The strength of these bricks can be improved

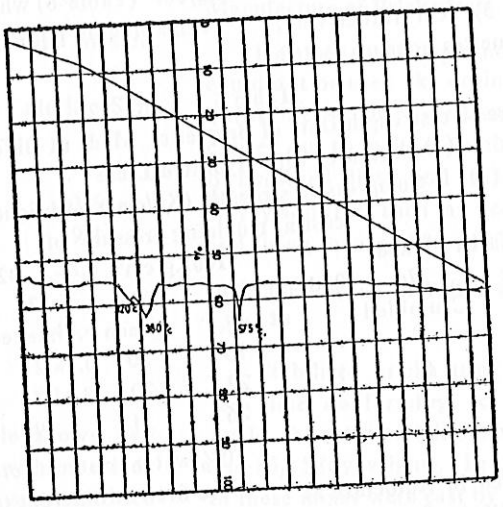

FIG. I - THERMOGRAM OF IRON TAILINGS SAMPLE

Table 8

Physical Properties of Briquettes Made by the Addition of China Clay.

Composition (% by wt.)		Physical properties of briquettes moulded at the pressure of 320 Kg/cm² and fired at								
		800°C			900°C			1000°C		
Tailings	China Clay	C. S. Kg/cm²	W. A. %	B, D. Kg/cm³	C. S. Kg/cm²	W. A. %	B. D. Kg/cm³	C. S. Kgcm²	W. A. %	B. D. Kg/cm³
90	10	69.4	16.0	1840	107.3	16.4	1860	115.0	17.4	1863
80	20	156.3	15.4	1941	177.0	15.3	1944	181.0	15.6	1948
70	30	186.0	14.3	1965	211.8	14.6	1976	221.0	15.2	1978

Table 9

Physical Properties oft Briquetes Made by the Addition of Red Soil and Fired at 1000°C

Composition (% by wt.)		Physical properties of briquettes moulded at the pressure of								
		Hand Compaction			160 Kg/cm²			320 Kg/cm²		
Tailings	Red Soil	C. S. Kg/cm²	WA. %	B. D. Kg/cm³	C. S. Kg/cm²	W.A. %	B. D. Kg/cm³	C.S. Kg/cm²	W. A. %	B. D. Kg/cm³
100	—	Crumbled during green stage						56	18.7	1770
90	10	—	—	—	—	—	—	124	17.1	1880
80	20	—	—	—	—	—	—	18A	15.8	1915
70	30	37	18.4	1801	127	17.5	1814		—	—
60	40	77	17.6	1836	—	—	—	192	14.9	1965
05	50	112	16.7	1843	154	16.4	1860	—	—	—
—	100	—	—	—	363	6.9	2176			

Table 10

Physical Properties of Briquettes Made by the Addition of Red Soil and Mouldeds at the Pressure- of 320 Kg/cm²

(10% moisture Content) and fired at different Temperatures

Composition (% by wt.)		Physical Properties of Fired Briquettes Temperature of Firing								
		950°C			1000°C			1050°C		
Tailings	Red Soil	C.S. Kg/cm²	W.A. %	B.D. Kg/m³	C.S. Kg/cm²	W.A %	B.D. Kg/cm³	C.S. Kg/cm²	W.A. %	B.D. Kg/cm
90	10	51.4	18.8	1756	56.0	17.7	1770	61.5	18.1	1775
80	20	117.0	16.3	1859	124.0	17.1	1880	133.0	16.7	1892
70	30	168.0	14.9	1900	184.0	15.8	1915	206.0	14.6	1922

Table 11

Physical Characteristics of Briquettes Made by the Addition of Lateritic Soil

Composition (% by wt.)		Physical Properties of Briquettes Moulded at the Pressure and Moisture Content of.								
Tailings	Leteritic Soil	Hand Compaction (30% moisture content)			160 Kg/cm² (12% moisture content)			320 Kg/cm² (10% Moisture Content)		
		C.S. Kg/cm²	W.A. %	B.D. Kg/cm³	C.S. Kg/cm²	W.A. %	B.D. Kg/cm³	C.S. Kg/cm²	W.A. %	B. D. Kg/cm³
100	—	Crumbled	during	green				stage		
70	30	56	21.4	1730	143	21.3	1780	185	17.9	1866
60	50	100	21.1	1747	176	20.9	1786	354	17.7	1916
—	100	198	20.7	1815	293	20.1	1877	409	13.4	2100

Table 12

Physical Properties of Full Size Bricks Made by the Addition of Red Soil and Fired at 1000°C

Composition (% by wt.)		Properties of Bricks Moulded by					
Tailings	Red Soil	Hand moulding			Machine moulding		
		C.S. Kg/cm²	W.A. %	B.D. Kg/m³	C.S. Kg/cm²	W.A %	B.D. Kg/cm³
70	30	29.4	17.4	1686	36	16.1	1715
50	50	Cracked during drying			52	15.0	1810

by slightly increasing the temperature over 1000°C.

Conclusions

Iron tailings can be utilised for making building bricks by usual hand pressing and firing. Such bricks show compressive strength upto 50kg/cm² by the addition of 30-35 percent lateritic or red soil. Cement or lime could also be used for making stabilized bricks of strength good enough for single storey constructions. High strength bricks can be made by pressing a mixture of the tailings and lime in 90:10 ratio and autoclaving for 5 hours under the saturated steam pressure.

Acknowledgement

This paper is published with the permission of the Director, Central Building Research Institute, Roorkee (UP).

Reference

1. Indian Minerals Year Book. Indian Bureau of Mines, Nagpur, 1970, P. 382.
2. Collings, R.K., Winder, A. A. and Feasby, D. G.-The Utilisation of mineral wastes - Journal of Canadian Ceramic Society, 42, 1973, pp. 61-7.
3. Richard, C. Lowrie, Patrick, S. Nicholson and Ivan, B. Cutler-Utilisation of Copper tailings in Red Brick Production - Am. Ceram. Soc. Bull. 48 (12), 1969. pp. 1138-39.
4. Charnousov, Yu. I - Use of Tailings from weste water Purification - Tsellyul, Bum. Karton, 21, 1978, p. 11.
5 Watanabe. A., Kamino, R. and Takakura, A. - Utilisation of waste Materials from Gold Mines as an Admixture for Autoclaved Concrete - Semento Gijutsu Nempo. 31, 1977, pp. 180-3.
6. Petrova, G. P. - production of A Ceramic from Coal Benefeciation Tailings- Stroit, Mater, 10, 1978 pp. 13-15.
7. Rai, M. and Jain, V . K. - Utilisation of zinc tailings for making Masonry Cement - Cement XIII (I), 1979, pp. 6-8.
8 Rai, M. and Srivastava, R. S. -Utilisation of waste Zinc Tailings in Making Cellualr Concrete - Research and Industry 24, Dec. 1979, pp. 226-228.