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Autoclaved Calcium Silicate Bricks from Gold-ore Mine Tailings

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The potentiality of using gold-ore mine tailings as a raw material for making autoclaved calcium silicate (sand-lime) type bricks is explored.

India has an estimated reserve 4,467,940 tonnes of gold-ore. After beneficiation of the ore, 14.30 gm/tonne and 5.59-6.60 gm/tonne of pure metal is estimated to be recovered from payable and low grade ore respectively and the rest is thrown as waste. Therefore, this huge quantity of waste, called tailings, is creating a big problem of disposal and air pollution.

Autoclaved calcium silicate bricks are building bricks essentially made from siliceous sand and hydrated lime with just sufficient water to allow the bricks to be moulded under pressure. The bricks are cured in an autoclave under saturated steam. Under autoclaving conditions, lime reacts with the surface of the silica grains to form a cementing material known as calcium silicate hydrate. Steam is essential for the formation of the hydrate. Otherwise heating of CaO-SiO_2-H_2O mixture under dry conditions expels the small amount of water present in the mix and produces a weakly bonded material[1,2]. It has been shown[3] that tailings from copper mines can be shaped into bricks by using clay as an admixture and followed by firing them at 900-1000°C. Collings *et al.*[4] have examined similar tailings from gold, nickel, copper and molybdenum beneficiation industries also for use as pozzolanic material. Rai *et al.*[5] have found suitable methods for making building bricks from iron-ore mine tailings. Watanabe *et al.*[6] have also used gold mines waste as an admixture to make autoclaved concrete. Besides, zinc tailings can also be used for the manufacture of sand-lime type bricks[7], cellular concrete[8] and masonry cement[9]. It appears, however, that no attention has been paid to the use of gold-ore mine tailings for making autoclaved calcium-silicate type bricks.

Suitability of gold-ore mine tailings

A sample of gold-ore mine tailings was obtained from M/s Bharat Gold Mines Ltd, Kolar (Karnataka), for making various building materials, specifically autoclaved calcium silicate (sand-lime) typed bricks.

The chemical analysis of the tailings indicates the presence of SiO_2:61.32, Al_2O_3:11,63, Fe_2O_3:9.85, CaO:10.36, MgO:2.32, SO_3:0.58 and loss on ignition: 2.31%, which shows that the tailings are mainly siliceous in nature. Sieve analysis indicates that the fineness modulus of tailings is 0.10. The specific gravity of the material is 2.85 and the colour greyish white.

Experimental procedure

Briquettes of dimensions $10 \times 5 \times 3.5$ cm, prepared from the tailings and hydrated lime, were cast at 300 kg/cm^2 moulding pressure and

7-8% water content in a specially fabricated mould by hydraulic press in the Laboratory. The mix contained 5-20% hydrated lime conforming to class C of IS-712:1963. The pressed briquettes were autoclaved at a saturated steam pressure of 14 kg/cm² and a temperature of 170-180°C for 5 hr in an autoclave. These autoclaved briquettes were tested for compressive strength and water absorption after cooling to room temperature and saturation in water for 24 hr. The test results are given in Table 1.

Table 1—Physical Properties of Briquettes Made from Gold Tailings and Hydrated Lime

Mix proportion (% by wt)		Wet compressive strength	Water absorption	Dry bulk density
Tailings	Lime	(kg/cm²)	(%)	(kg/m³)
95	5	155.0	16.4	1980
90	10	205.0	15.8	1990
85	15	306.0	15.4	2020
80	20	301.0	15.7	2020

The results in Table 1 show that the strength of briquettes increases from 155 to 306 kg/cm² with the increase of hydrated lime addition from 5 to 15% thereafter a slight decrease in strength is observed. The conversion factor of briquette to brick strength is 0.8 to 0.9. On the basis of this conversion factor, full size bricks from 120-240 kg/cm² strength could be made with 5-15% addition. These bricks can be classified according to IS-4139:1976.

Gold tailings being a very fine material were replaced with 10 and 20% coarse sand (a locally available river sand passing No.60 IS sieve) and standard ennore sand (−1, +0.5 mm sieve).

Table 2—Physical Properties of Autoclaved Briquettes with Tailings, Coarse (river) Sand and Hydrated Lime

	Mix proportion (% by wt)		Wet compressive strength	Water absorption	Dry bulk density
Tailings	Sand	Lime	(kg/cm²)	(%)	(kg/m³)
(a) 85	10	5	164.0	15.4	2000
80	10	10	238.6	15.1	2010
75	10	15	366.0	14.3	2020
70	10	20	288.0	14.6	2020
(b) 75	20	5	165.3	15.2	2000
70	20	10	238.6	15.0	2010
65	20	15	355.0	14.6	2030
60	20	20	280.0	14.8	2020

Table 3—Physical Properties of Autoclaved Briquettes with Tailings, Coarse (standard) Sand and Hydrated Lime

	Mix proportion (% by wt)		Wet compressive strength	Water absorption	Dry bulk density
Tailings	Sand	Lime	(kg/cm²)	(%)	(kg/m³)
(a) 85	10	5	167.0	14.9	2010
80	10	10	250.5	14.4	2020
75	10	15	351.0	14.1	2040
70	10	20	318.6	14.3	2030
(b) 75	20	5	208.0	13.6	2010
70	20	10	254.5	13.4	2020
65	20	15	328.0	12.9	2030
60	20	20	292.6	13.3	2020

Table 4—Physical Properties of Autoclaved Briquettes made from Tailings and Hydraulic Lime

Mix proportion (% by wt)		Wet compressive strength (kg/cm^2)	Water absorption (%)	Dry bulk density (kg/m^3)
Tailings	Hydraulic lime			
95	5	105.3	17.8	1960
90	10	188.0	16.5	1960
85	15	229.3	16.4	1960

Hydrated lime 5 to 20% was mixed to the above composition. Briquettes were cast under pressure and then cured and tested. The results given in Tables 2 and 3 show that the addition of coarse sand with tailings to improve the compressive strength of bricks is not advantageous as the strength of briquettes with and without the addition of sand is almost equal.

To know the suitability of hydraulic lime another set of experiments was carried out by preparing a hydraulic lime in the Laboratory by firing 80% analar calcium carbonate with 20% kaolin (by wt) in an electric muffle furnace at 1000°C for 4 hr. The above lime was then hydrated, dried and passed through IS sieve No.15. The hydraulic lime thus prepared was mixed with tailings to the extent of 5-15% by wt and briquettes were cast under pressure, cured and tested as described earlier. The test results are given in Table 4.

The results given in Table 4 show that the briquettes of strength ranging from 105 to 229 kg/cm^2 can also be made by using 5-15% hydraulic lime.

Conclusions

Gold tailings can be utilized for making autoclaved calcium silicate bricks by pressing a mixture of the tailings and hydrated lime in 9:1 ratio and autoclaving for 5 hr under saturated steam pressure. Good quality hydraulic lime can also be used in place of hydrated lime for making these bricks. The properties of all the bricks conform to the relevant Indian Standard Specification, 4139-1976.

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