# Building Bricks From Copper Mine Tailings

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**Abstract**

*Copper mine tailings, a waste material available at the copper ore mines where copper ore is extracted and concentrated, poses 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. The present paper describes the experimental results for the use of Khetri (Rajasthan) Copper ore tailings in making building bricks.*

**Introduction**

India has total reserve of copper ore of about 400 million tonnes. Out of which 5.02 million tonnes of copper metal is estimated to recover and the rest to go as waste[1]. The annual production of copper mine tailing is about 0.55 million tonne which is expected to about 1.00 million tonne per annum at the end of this century. Hindustan Copper Limited has two major complexes, one Khetri Copper Complex at Khetrinagar district Jhunjhunu in Rajasthan state and the other at Indian Copper Complex at Ghatsilla, Singhbhum district in Bihar. The Khetri Copper Complex in Rajasthan is expected to produce 1.00 million tonne metal concentrate out of total reserve 93.44 million tonnes copper ore. Hence this huge quantity of waste would be creating big disposal problem for the project administration.

Richard et. al[2] have found use of copper mine tailings in the production of bricks by using clay as an admixture to tailings and followed by firing at 900-1000°C. Collings et. al[3] have examined similar tailings from nickel, uranium, gold, copper and molybdenum beneficiation industries also for use as pozzolanic material. Petrova[4] has produced ceramic products from coal beneficiation tailings containing 7.69-22.2 percent carbon. Mohan Rai et. al[5] have also found iron ore tailings suitable for making bricks. Beside this, zinc tailings can be used for manufacture of sand-lime type auto-claved bricks[6], cellular concrete[7] and masonry cement[8].

A sample of copper mine tailings received from Khetri Copper Complex, Khetrinagar (Rajasthan) was used in the present investigation to make building bricks by firing, stabilization as well as auto-claving techniques.

**Experimental Procedure**

The chemical analysis of copper mine tailings and local plastic soil and the yellow lateritic soil used are given in Table 1.

**Table 1 Chemical analysis of copper tailings, local plastic and yellow lateritic soils**

| Composition % | Tailings | Plastic Soil | Lateritic Soil |
|---|---|---|---|
| $SiO_2$ | 59.42 | 44.28 | 60.15 |
| $Al_2O_3$ | 7.79 | 26.46 | 12.80 |
| $Fe_2O_3$ | 23.91 | 10.17 | 15.36 |
| CaO | 2.11 | 4.06 | |
| MgO | 1.86 | 3.05 | — |
| L.O.I | 2.24 | 10.70 | 10.82 |

Sieve analysis of tailings indicates that the fineness modulus is 0.638. The tailings appear to be siliceous and ferruginous in nature. The specific gravity of the tailings is about 2.95 and the colour is blackish-grey.

The mechanical analysis and Atterberg limits given in Table 2 show that the soils used are clayey in nature and possess good plastic properties.

Differential thermal analysis (DTA) of the powdered copper tailings sample (-IS No. 15 sieve) was carried out using Leeds and Northrup programme controller, keeping heating rate at 10°C per minute and chromel-Alumel Thermocouple. The DTA of the copper tailings shows endothermic peaks at 90°, 260°, 570°, 720°, 800° and 920°C. These peaks may be attributed to the presence of chlorite, cristobilite, quartz, biotite and aragonite ($CaCO_3$).

The petrographic examination of the sample of the tailings was carried out with the help of a Leitz-Panphot microscope. Petrographic examination of these tailings shows the presence of quartz, hematite, ilmenite and biotite. These results of DTA and petrographic analysis of the tailings also confirmed by X-ray analysis.

**Bricks from copper mine tailings**

Copper mine tailings being sandy and non-plastic in nature could not be used like ordinary plastic soils for making burnt bricks. Therefore three sets of experiments were carried out to make (a) burnt bricks using some clayey additives such as plastic, lateritic or china clay and firing them at 900°, 1000° and 1050°C temperature, (b) stabilized bricks using portland cement and (c) autoclaved calcium silicate type bricks using hydrated lime as binder.

**(a) Clay bonded copper mine tailings bricks**

Local plastic soil (Khetri region) of illitic group, yellow lateritic soil and China clay (Jhunjhunu district) possessing kaolinitic group of clay minerals were used as binder to make burnt bricks from tailings. Copper tailings were mixed with different percentages of local plastic and lateritic soils (20-50 %) of and the briquettes of size 7 x 5 x 3.5 cms with 10-12 % moisture were prepared by hand moulding. These briquettes were fired at 900°, 1000° and 1050°C with 5 hours soaking in an electric furnace. The test results are given in Tables 3 and 4.

**Table 2 Mechanical analysis and Atterberg limits of local plastic and lateritic soils**

| Properties | Plastic soil | Lateritic soil |
|---|---|---|
| **Mechanical analysis** | | |
| Clay % | 22.0 | 43.6 |
| Silt % | 25.6 | 37.7 |
| Sand % | 52.4 | 18.7 |
| **Atterberg Limits** | | |
| Liquid Limit % | 29.0 | 42.9 |
| Plastic Limit % | 16.0 | 19.5 |
| Plasticity Index | 13.0 | 23.4 |

**Table 3 Physical properties of briquettes made by the addition of local plastic soil**

| Mix proportion (% by weight) Tailings | Soil | 900°C CS | WA | 1000°C CS | WA | 1050°C CS | WA |
|---|---|---|---|---|---|---|---|
| 80 | 20 | 63.6 | 12.5 | 84.6 | 12.2 | 138.5 | 11.6 |
| 70 | 30 | 112.4 | 12.4 | 112.8 | 8.1 | 189.1 | 10.6 |
| 60 | 40 | 150.4 | 11.9 | 176.7 | 7.9 | 275.4 | 10.0 |
| 50 | 50 | 165.6 | 11.5 | 238.7 | 7.7 | 333.3 | 8.6 |

Table 3 show that the briquettes of wet compressive strength from 112-238 kg/cm² can be made with the addition of 30-50 % local plastic soil at 1000°C temperature. The briquettes strength can be improved by increasing the temperature (1050°C). Therefore full size bricks of compressive strength from 60—130 kg/cm² can be manufactured by the addition of plastic soil to tailings at temp. 1000±20°C with 5 hours soaking.

The data Table 4 show that the briquettes made of tailings with 40 % lateritic soil could be manufactured giving compressive strength from 122—206 kg/cm² depending upon the firing temperature. It is also seen that the briquettes made with equal proportion of tailings and soil giving less compressive strength at all the firing temperature. Therefore full size bricks of about 110 kg/cm² can be manufactured with 40 % lateritic soil addition to tailings and fired at 1050°C with 5 hours soaking.

**Table 4 Physical properties of briquettes made by the addition of lateritic soil**

| Mix proportion (% by weight) Tailings | Soil | 900°C CS | WA | 1000°C CS | WA | 1050°C CS | WA |
|---|---|---|---|---|---|---|---|
| 80 | 20 | — | — | — | — | — | — |
| 70 | 30 | 59.5 | 15.9 | 62.9 | 14.9 | 98.0 | 13.6 |
| 60 | 40 | 122.3 | 14.0 | 135.8 | 13.2 | 206.5 | 12.5 |
| 50 | 50 | 112.5 | 14.8 | 117.8 | 13.4 | 174.9 | 13.0 |

The test results (Table 5) show the briquettes of good compressive strength (274—312 kg/cm²) can be made with the addition of 10-30% China clay to the tailings by moulding at 320 kg/cm² pressure by hydraulic machine and then fired at 1000°C with 3 hours soaking. The briquettes were of sixe 10 x 5 x 3.5 cm with 6-7 % moulding moisture.

**Table 5 Physical properties of briquettes made by the addition of China clay**

| Mix proportion (% by weight) Tailings | China clay | 800°C CS | WA | 900°C CS | WA | 1000°C CS | WA |
|---|---|---|---|---|---|---|---|
| 90 | 10 | 163.0 | 12.9 | 185.0 | 13.3 | 274.0 | 7.9 |
| 80 | 20 | 213.0 | 12.2 | 204.0 | 12.6 | 294.0 | 7.8 |
| 70 | 30 | 236.0 | 11.5 | 205.0 | 12.6 | 312.0 | 7.6 |

**(b) Stabilization of copper tailings with portland cement**

Stabilized bricks using portland cement conforming to IS 269/1967 were made, the ratio of tailings/cement being 95/5, 90/10 and 85/15 (%by weight). Briquettes of size 10×5×3.5 cm with 7-8% moisture of these mixes were pressure cast at 160 and 320 kg/cm² pressure. These briquettes were cured at 90 percent relative humidity at 27 ± 2°C temperature till the time of testing at 7 and 28 days. Bricks from mixture of the tailings and portland cement with 10 percent moisture content with the help of a Winget brick making machine (Moulding pressure 50-70 kg/cm²) were made. These bricks were put under wet gunny bags for 24 hours in a shed and then put in water until testing at 28 days. The test results are given in Table 6 and 7.

The results in Table 6 show that the strength of stabilized briquettes after 28 days curing increases from 52-114 and 104-203 kg/cm² with the increased addition of cement (5-15 percent) and also with the increased moulding pressure. Table 7 show that the compressive strength of full size bricks 31 kg/cm² could be made with addition of 15% cement. Hence these bricks having poor strength would cost much more than the burnt bricks.

**Table 6 Compressive strength data of briquettes made at 160 and 320 kg/cm² pressure with portland cement**

| Mix proportion (% by wt.) | | Comp. strength (kg/cm²) at pressure | | | |
|---|---|---|---|---|---|
| Tailings | Cement | 160 kg/cm² | | 320 kg/cm² | |
| | | 7d | 28d | 7d | 28d |
| 95 | 5 | 43.3 | 52.2 | 82.6 | 104.6 |
| 90 | 10 | 62.6 | 72.0 | 134.6 | 156.6 |
| 85 | 15 | 101.3 | 114.6 | 184.6 | 203.3 |

**(c) Auto-claved calcium silicate type bricks**

Auto-claved calcium silicate (sand-lime) 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 pressed bricks are then cured in an auto-clave under saturated steam at 14 kg/cm² pressnre corresponding to 190°C temperature

The briquettes of size 10 x 5 x 3.5 cm with 5-15% hydrated lime to tailings and 8-10 percent moisture content were formed at 320 kg/cm² moulding pressure by a mechanical press in a specially fabricated mould. These pressure cast briquettes were autoclaved at 14 kg/cm² saturated steam pressure in an auto-clave for 5 hours. These auto-claved briquettes were tested after cooling to room temperature and saturation in water for 24 hours. The test results (Table 8) show that the compressive strength of briquettes from 196-438 kg/cm² with 5-15 percent hydrated lime to the tailings can be made. Hence by this auto-claving technique, the full size bricks of compressive strength of 160-340 kg/cm² can be manufactured with 5-15 percent hydrated lime addition.

**Table 7 Compressive strength data of bricks with cement under normal water curing at 28 days**

| Mix proportion (% by weight) | | Compressive strength (kg/cm²) |
|---|---|---|
| Tailings | Cement | |
| 90 | 10 | 16.6 |
| 85 | 15 | 31.1 |

**Table 8 Physical properties of auto-claved briquettes cured at 14 kg/cm² steam pressure in an auto-clave**

| Mix proportion (% by Wt.) | | Comp. strength | water absorption | Dry bulk density |
|---|---|---|---|---|
| Tailings | Lime | (kg/cm²) | (%) | (gm/cc) |
| 95 | 5 | 196.0 | 12.5 | 2.26 |
| 90 | 10 | 379.0 | 12.2 | 2.29 |
| 85 | 15 | 438.0 | 12.1 | 2.30 |

**Conclusions**

Copper mine tailings can be utilized for making building bricks with clayey additive such as plastic or lateritic soil by usual hand pressing and firing. 15 percent cement could be used for making stabilized bricks of strength good enough for single storey construction. The strength of stabilized bricks could be improved if the moulding pressure is increased. High strength bricks with 10% hydrated lime as binder can be made when pressing and auto-claving techniques are adopted.

The cost of production of auto-claved bricks has been estimated and it is in the range of Rs.300-325 per 1000 bricks depending upon the source of lime. This cost of production is quite comparable with the normal fired clay bricks in the area. The addition of local plastic soil to be the mining waste is also economical because the plastic soils are available in the vicinity of Khetri region (around the mine area). However the addition of China clay and lateritic clay to the tailings is not economical as compared to auto-claved bricks.

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# Rs. 70-cr Exchange Saving From MP Copper Project

The Rs- 120 crore Malanjkhand copper project, to be inaugurated by prime Minister Indira Gandhi on Friday next, will double India's copper production to 60,000 tonnes, effecting a foreign exchange saving of Rs 70 crore a year at current prices.

The project, being implemented by the public sector Hindustan Copper Limited (HCL), will be the most sophisticated of its kind in India and strict efforts have been made to adhere to anti-pollution and ecological preservation standards,

Sanctioned in 1977, the project kept to construction schedules throughout to begin trial production in May last. By 1985, when the second stage of its ore concentration plants is expected to stabilise, Malanjkhand would produce concentrated ore for making 23,000 tonnes of copper.

The project, being put up to exploit the new-found Malanjkhand copper deposits, will have the biggest base metal open-pit mine, containing a mineable crusher-grade ore reserve estimated at 58.8 millon tonnes with a metal content of 1.2 percent.

Though the existence of copper in Malanjkhand forest area was reported over a 100 years ago by the then British collector of Balaghat district, systmatic surveys were done by the Geological Survey of India and HCL only in the 1960s. The local Baiga and Gond tribals always believed that hidden treasure could be found below the seven hillocks.

According to the tribal folklore, the treasure was guarded by a cruel demon (Asura) in the from of a giant fish called "Kilkila" Bhima, one of the Pandava brothers, fought the demon guard and cut it into seven pieces which he scattered around. The place gets its name from "malanj" (fish) and "khand" (piece).

The Malanjkhand unit will process the ore deposits into concentrates containing 25 percent copper and send it to HCL's Khetri unit in Rajasthan by road for smelting.

For obtaining 1.1 tonne of copper, about 700 tonnes of rock will have to be processed into 100 tonnes of ore concentrate. The Malanjkhand ores are expected to last for more than 30 years at the planned level of two million tonnes of ore extracted every year.

Mr J.D. Taneja, the project general manager, said two diesel generating units of 4 mw capacity were being added to offset power cut imposed on the unit by the Madhya Pradesh electricity board. This would add futher to the production cost, he said.

He said only four trees were felled in the entire project area to maintain the tree cover. The waste storage and effluent treatment had been so planned as to prevent the waste water from flowing into the adjoining Narmada and Godavari river catchment area.

Mr Taneja said he was persuading the state government to set up ancillary units in the project area to ensure achievement of full job potential.