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K. P. Kacker & Dinesh Chandra
Central Building Research Institute, Roorkee

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ABSTRACT

The huge reserves of bauxite, large scale industrialisation and good export potentiality has made aluminium industry a growing industry in India. The present investigation carried out in the Institute has shown that large quantity of red mud that is obtained as a waste material from aluminium plants can be exploited by the heavy clay industry to produce bricks, tiles and allied products. It also suggests the utilization of less plastic clays with red mud for the development of good quality bricks.

Introduction

During production of aluminium, bauxite is digested with caustic soda when aluminium passes into solution as sodium aluminate. The red colour residue, which is left over is called alumina red mud. This is pumped into disposal tanks where it settles down while the supernatant liquid containing caustic soda is pumped back for reutilization.

Alumina red mud or bauxite reject is one of important inorganic wastes which presents storage, pollution and disposal problems on account of large accumulation. During 1973-74, about 0. 45 million tonnes of red mud was obtained against a production of about 0.2 million tonnes of aluminium. The availability of waste material during 1974-75 is expected to be 0.6 million tonnes. The total capacity for the production of aluminium shall go up to 0.43 million tonnes by the end of fifth plan (1978-79) when about 0.99 million tonnes of red mud is expected to be available as a waste material. This is likely to create similar problems which are presented by fly ash on account of pollution resulting from indiscriminate disposal. The huge reserves of about 250 million tonnes of bauxite in India suggest a manifold expansion of aluminium industry. Hence a worthwhile solution for the utilization of red mud has to be evolved both in the interest of aluminium plant as well as possible entrepreneur who may like to exploit it. Table I gives the availability of red mud in various aluminium plants[1].

Nakamura et al.[2] have suggested that the waste material could be utilized for the development of lightweight building units by foaming technique. Recently Nagata[3] of Japan suggested that red mud along with waste thermoplastics can be used for the development of construction materials, artificial reefs for fisheries and sea weed beds while Wargalla[4] advised its utilisation in portland cement as well as for the development of lightweight aggregates. However, the most important suggestion came from Tauber et al.[5] for its use in the development of heavy clay products as these involve high tonnage. The present production of bricks in India is 24,000 millions per year. It is expected that during the fifth plan it will go as high as 37,500 millions[6]. Hence it is worthwhile to consider the utilization of red mud for the development of bricks. This paper gives the results of laboratory and field investigation carried out in this connection.

Procedure

Samples of red muds for the present investigation were collected from Hindustan Aluminium Corporation (HINDALCO), Indian Aluminium Company (INDALCO) and Aluminium Corporation of India (ALCORPON).

TABLE I

Production of aluminium and red mud in different plants (Million Tonnes per annum)

Name of plant	Location	Aluminium Existing capacity 1973-74	Aluminium Expansion approved 1974-79	Red mud available (Approx.) 1973-74	Red mud available (Approx.) 1979
1. Aluminium Corporation of India.	(a) Asansol (W.B) (b) Koraput (Orissa)	0.009	0.030	0.021	0.090
2. Hindustan Aluminium Corporation	Renukoot (U.P)	0.095	0.025	0.218	0.276
3. Indian Aluminium Company	(a) Hirakud (Orissa) (b) Alwaye (Kerala) (c) Belgaum (Karnataka)	0.076	0.020	0.174	0.220
4. Madras Aluminium Company	Mettur (T.N.)	0.015	0.010	0.034	0.057
5. Bharat Aluminium Company	(a) Korba (M.P.)	—	0.100	—	0.230
	(b) Ratnagiri (Maharashtra)	—	0.050	—	0.115
Total :		0.195	0.235	0.447	0.988

TABLE II

Chemical analysis of red muds obtained from different Plants.

Content	Hindalco (per cent)	Indalco (per cent)	Alcorpon (per cent
SiO_2	6-10	6-8	6-8
Al_2O_3	19-26	25-29	24-26
Fe_2O_3	23-31	24-27	22-25
TiO_2	20-27	22-25	18-21
CaO	2-4	—	—
MgO	—	—	—
Na_2O	4-7	4-5	—
Loss on Ignition	8-11	10-12	10-13

TABLE IV

Atterberg's limits of red muds and Clays

	Liquid limit (per cent)	Plastic limit (per cent)	Plasticity Index
Red Muds			
Hindalco	28	22	6
Indalco	31	24	7
Alcorpon	30	23	7
Clays			
Hindalco clays	32	20	12
Hindalco shale	31	21	10
Indalco clay	23	13	10
Alcorpon clay	28	16	12
Red Mud-clay (50 : 50)			
Hindalco	31	22	9
Indalco	26	18	8

TABLE III

Particle size analysis of red muds and clays (per cent)

	>1 mm	1-0.25 mm	0.25-0.063 mm	0.063-0.02 mm	0.02-0.002 mm	<0.002 mm
Red Muds						
Hindalco	Nil	7	26	8	33	26
Indalco	Nil	7	15	5	34	39
Alcorpon	Nil	10	14	6	50	20
				>0.02 mm	0.02-0.002 mm	<0.002 mm
Clays						
Hindalco clay	—	—	—	27	49	24
Hindalco shale	—	—	—	34	42	24
Indalco clay	—	—	—	52	27	21
Alcorpon clay	—	—	—	40	35	25

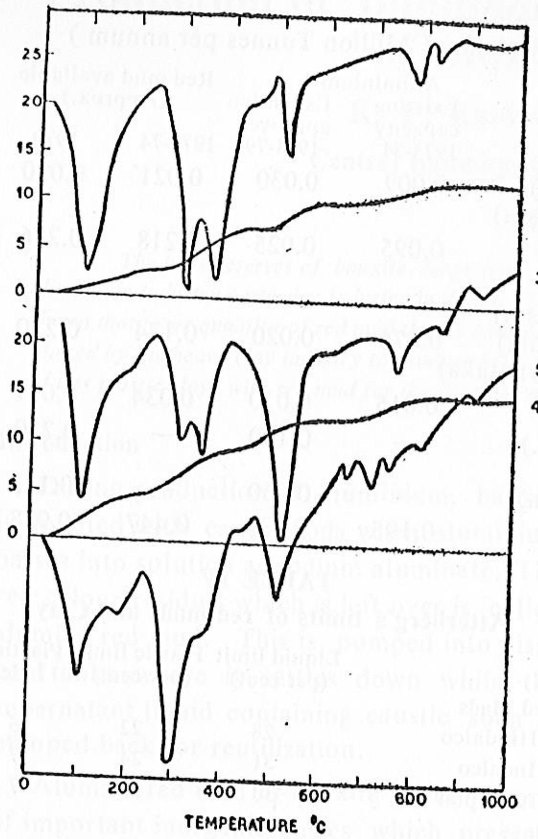

Fig. 1—DTA and TGA of Red Muds. Hindalco (1) DTA, (2) TGA. INDALCO (3) DTA, (4) TGA ALCORPON (5) DTA.

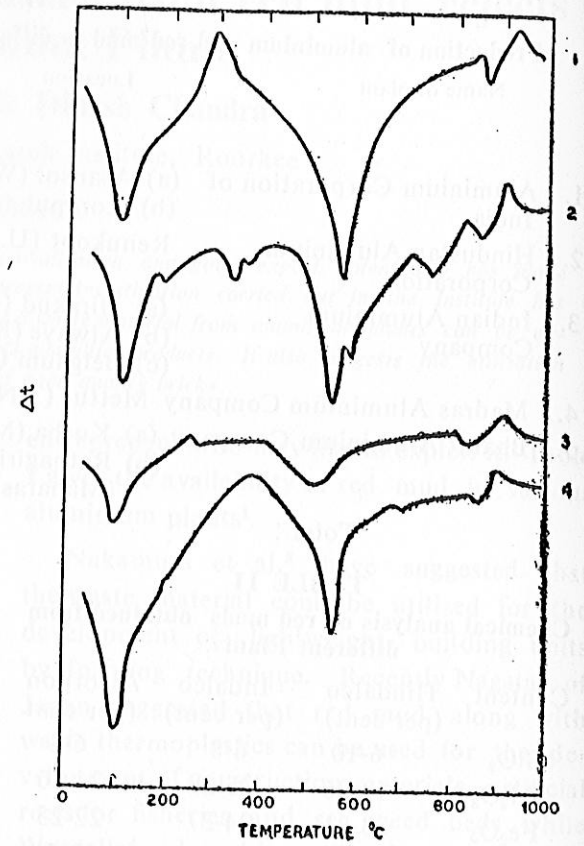

Fig. 2—DTA of Clays Near Aluminium Plants (1) HINDALCO CLAY and (2) SHALE, (3) INDALCO CLAY and (4) ALCORPON CLAY.

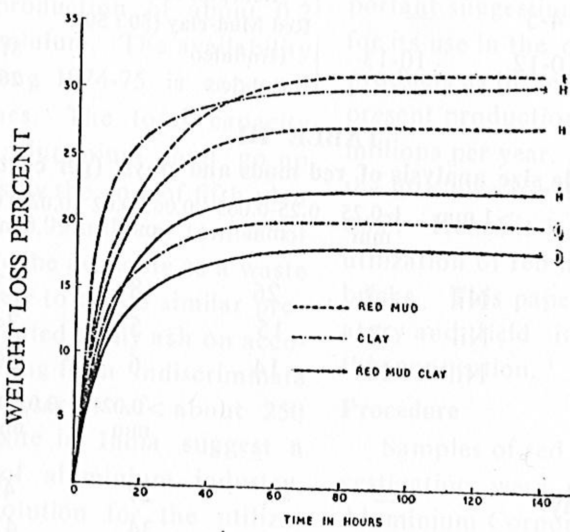

Fig. 3—Drying Characteristics of RED MUD, CLAY, RED MUD-CLAY BRICK (H) HINDALCO (I) INDALCO.

The clays were obtained from disposal tank sites. Samples of fly ash and fine river sand were also included to study their possible use as one of the raw materials with redmud.

Chemical analysis, particle size analysis, Atterberg's limits, pH, DTA, petrographic and X-ray examination of raw materials formed part of the present investigation.

For making briquettes, the powdered raw materials were mixed in a laboratory mixer. Briquettes of size 7.5 x 5 0 x 3.7 cms were made by hand moulding from different compositions of red mud and clay mixed by volume. These were fired at 980° and 1020°C with a soaking period of 3 hours. Normal bricks of size 22 x 11 x 7.5 cms were also made by hand moulding and fired at the above temperatures. Dimensional stability measurements of the fired materials were recorded by a length comparator fitted with a dial gauge. The values were compared with those of normal clay bricks. Observations were also taken on the drying time of the bricks made from red mud, clay and redmud-clay compositions. Extrudebility of these bricks was also studied in a laboratory extruder. The laboratory investigations were followed by a small scale field trial carried out at a local Bull's Trench kiln.

Discussion

(A) Analytical

Table II which gives the chemical composition of three red muds shows that the waste material predominates in Al_2O_3, Fe_2O_3 and TiO_2 contents. There is also presence of appreciable amount of alkali content which should act as a good flux. However, SiO_2 content in all the samples is quite low. The variation in the composition of the red muds may be due to variation in the composition of bauxites used from time to time. The only difference in the composition when compared to Australian red mud lies in SiO_2 and TiO_2 contents which are 14·18 and 7-10 per cent respectively in its case[5].

Table III presents the particle size data of red muds and clays. It shows that like clays, red muds also contain sufficient quantity of fines (less than 0.02mm). This suggests their profitable utilization by heavy clay industry. The Atterberg's limits for the raw materials given in Table IV suggest that like clays red muds also possess plastic properties though their plasticity index values are slightly lower than clays. Care has therefore to be taken during addition of water in the red mud. Any excess amount is likely to create difficulty during moulding due to development of sticky conditions. Addition of clay with red mud improves the plasticity index values. As will be seen later, this addition is also necessary for the strength development in the bricks.

Differential thermal analysis and thermogravimetric analysis curves for red muds are given in Figure 1. Three endothermal peaks at 100°, 300-370° and 520°C are attributed to water, gibbsite and boehmite respectively. The size of peaks gives indication of the proportion of these phases in the three samples. Small endothermal peaks between 700-850°C may be due to presence of Ca, Mg or Na carbonates. A high temperature recrystallization is indicated by an exothermal inflexion at about 900°C. It is seen that Indalco sample which has maximum amount of fines gives larger endothermal peak at 100° C due to release of water. TGA curves show total weight losses of 12.5 and 15.5 per cent for Hindalco and Indalco red muds respectively. The DTA of clays given in Figures 2 suggests that in general these are illitic. Hindalco clay and shale, however, seem to be associated with small quantities of kaolinite which is quite usual for this region. The X-ray diffraction comfirm the four important phases in the red mud as gibbsite, boehmite, anatase and hematite with small amounts of calcite, quartz and sodium aluminium silicate ($NaAlSi_3O_8$).

(B) Properties of Bricks

Table V shows that the briquettes made with red mud alone give compressive strengths of 12-59 kg/cm^2 when fired at 980-1020°C. In case of Indalco red mud the strength was highest which may be the result of larger quantities of fines present in it. The higher strength obtained by Australian workers[5] can be attributed to higher percentage of SiO_2 (required for the development of glassy phases) and lower proportion of TiO_2 (which acts as a refractory material at these firing temperatures).

Addition of sand (passing 0.5mm) in the proportion of 30,50 and 70 per cent by volume in Hindalco red mud gives briquettes of compressive strength 31,23 and 13kg/cm^2 respectively. Sand passing 0.15 mm improved compressive strength values to 150,78 and 45kg/cm^2 respectively. Addition of fly ash showed better strength development, the values obtained with 30,50 and 70 per cent addition were 85, 147 aud 100 kg/cm^3. From these observations it follows that presence of fine silica is an important requirement for the development of strength. However, its larger addition brings down the percentage of Al_2O_3 resulting into lower strength. Fly ash which contains both SiO_2 and Al_2O_3 in fine state gives better results. It is expected, therefore, that clays which contain both Al_2O_3 and SiO_2 as alumino-silicates in very fine form should give still better compressive strengths with red mud. The optimum amounts of two raw materials for the development of maximum strength will depend upon their chemical composition and particle size distribution.

The results with clay as one of the raw materials have been given in details under Table V. With Hindalco red mud and clay, maximum strengths are obtained by mixing 30 per cent red mud, the values obtained at 980-1020° C vary between 506-674 kg/cm^2. With 50 per cent addition the strength is slightly lower, the values being 412-472 kg/cm^2. The strengths, in general, are higher at 1020°C than at 980°C. No appreciable difference in strength is observed with materials passing O.5 mm or 1 mm. In general, there is gradual decrease in the drying shrinkage with increase in red mud proportions. It is because the clay is more plastic than red mud. The higher values of firing shrinkage correspond to higher strengths. The strength with Hindalco shale is lower as this material seems to be more refractory than clays. It gives compressive strength values of only 61-106 kg/cm^2 when fired at 98°C (Table V(C).

In case of Indalco red mud and clay, best results are obtained with 50 per cent red mud, the compressive strengths being 383-586 kg/cm^2. While this red mud is more plastic, the clay is coarser and less plastic as compared to Hindalco red mud and clay. Addition of Indalco red mud in clay therefore, results into vast improvement in compressive strength values. Red mud addition is, therefore, of advantage in clays which contain lower amount of fines and give bricks of poor strength. Alcorpon red mud and clay also give highest compressive strength with 50 per cent addition of red mud, though the value obtained with 30 per cent addition is also quite close. The briquettes prepared however show high firing shrinkage at 980°C. At 1020°C, the briquettes show fusion and slight bloating. This is due to lower fusion temperature of the clay as was noticed in case of Durgapur clays[7]. Table V(G) also shows high firing shrinkage characteristic of this clay. With such compositions a lower firing temperature (950°-980°C) should be recommended.

TABLE V

Physical Properties of red mud Briquettes

Composition by volume (Per cent)		Drying shrinkage	Firing shrinkage	Total shrinkage	Bulk density	Water absorption	Compressive strength	Colour of fired Meterial.
Red Mud	Clay	Per cent	Per cent	Per cent	kg/m³	per cent	kg/cm²	
1	2	3	4	5	6	7	8	9
A. Hindalco Red Mud and Clay								Firing temperature 980°C
—	100	16.5	4.2	20.7	1830	12.6	309	Brick red
30	70	11.8	13.1	24.9	2011	9.6	506	Light chocolate
* 50	50	9.3	14.1	23.4	1989	12.3	435	Light brown
70	30	7.9	10.9	18.8	1849	18.8	203	Dark yellow
100	—	6.2	5.5	11.7	1648	29.9	12	Brownish yellow
—	100	16.4	3.4	19.8	1844	13.6	295	Brick red
30	70	11.3	12.2	23.5	2012	10.7	544	Light chocolate
** 50	50	9.0	12.6	21.6	1968	13.8	418	Light brown
70	30	7.8	8.4	16.2	1867	19.1	201	Drak yellow
100	—	6.2	4.5	10.7	1669	29.3	14	Brownish yellow
B. Hindalco Red Mud and Clay								Firing temperature 1020°C
—	100	16.5	8.5	25.0	1916	9.5	469	Brownish red
30	70	11.8	21.6	33.4	2180	5.2	660	Light chocolate
* 50	50	9.3	16.6	25.9	2046	5.5	472	Buff
70	30	7.9	15.7	23.6	1956	14.0	325	Dark yellow
100	—	6.2	7.8	14.0	1689	27.2	13	Brownish yellow
—	100	16.4	10.1	26.5	1968	8.5	419	Brownish red
30	70	11.3	19.4	30.7	2191	4.9	674	Light chocolate
** 50	50	9.0	16.1	25.1	2035	10.7	412	Buff
70	30	7.8	15.2	23.0	2007	12.8	291	Dark yellow
100	—	6.2	7.7	13.9	1731	26.6	16	Brownish yellow
C. Hindalco Red Mud and Shale								Firing temperature 980°C
—	100	7.5	4.6	12.1	1517	24.6	106	Light red
30	70	6.7	18.3	25.0	1813	16.9	286	Brown
* 50	50	5.5	13.6	19.1	1783	19.5	248	Buff
70	30	4.9	5.0	9.9	1756	28.7	58	Yellow
100	—	6.2	5.5	11.7	1648	29.9	12	Brownish yellow
—	100	9.0	1.1	10.1	1488	26.8	61	Light red
30	70	7.4	16.3	23.7	1797	18.7	264	Brown
** 50	50	6.4	11.5	17.9	1744	21.8	196	Buff
70	30	5.0	3.6	8.6	1628	27.9	64	Yellow
100	—	6.2	4.5	10.7	1669	29.3	14	Brownish yellow
D. Hindalco Red Mud and Shale								Firing temperature 1020°C
—	100	7.5	11.7	19.2	1670	18.0	253	Light red
30	70	6.7	28.2	34.9	2149	7.3	423	Light brown
* 50	50	5.5	24.6	30.1	1995	14.6	346	Dark yellow
70	30	4.9	15.8	20.7	1807	20.1	130	Yellow
100	—	6.2	7.8	14.0	1689	27.2	13	Brownish yellow
—	100	9.0	11.4	20.4	1670	18.3	250	Light red
30	70	7.4	30.7	38.1	2180	7.9	536	Light brown
** 50	50	6.4	23.3	29.7	1998	13.8	328	Dark yellow
70	30	5.0	15.0	20.0	1848	20.3	150	Yellow
100	—	6.2	7.7	13.9	1731	26.6	16	Brownish yellow

E. Indalco Red Mud and Clay — Firing temperature 980°C

1	2	3	4	5	6	7	8	9
—	100	8.6	1.6	10.2	1852	12.7	189	Brick red
30	70	7.2	4.5	11.7	2033	10.2	405	Yellowish brown
* 50	50	7.4	8.6	16.0	2017	12.3	383	Dark yellow
70	30	7.2	8.5	15.7	1914	16.9	241	Medium yellow
100	—	8.4	6.4	14.8	1618	30.9	43	Light yellow
—	100	9.0	1.6	10.6	1842	12.8	208	Brick red
30	70	7.3	4.1	11.4	2026	10.1	433	Yellowish brown
** 50	50	7.8	8.9	16.7	2078	10.7	500	Dark yellow
70	30	8.0	10.8	18.8	1998	14.7	285	Medium yellow
100	—	8.4	4.9	13.3	1670	29.4	56	Light yellow

F. Indalco Red Mud and Clay — Firing temperature 1020°C

1	2	3	4	5	6	7	8	9
—	100	8.6	2.0	10.6	1893	11.2	224	Brownish red
30	70	7.2	6.1	13.3	2069	9.0	432	Dark yellow
* 50	50	7.4	10.8	18.2	2066	10.2	450	Medium yellow
70	30	7.2	17.2	24.4	2012	10.2	418	Medium yellow
100	—	8.4	11.7	20.1	1726	26.8	50	Yellow
—	100	9.0	2.4	11.4	1885	11.4	258	Brownish red
30	70	7.3	7.8	15.1	2114	8.0	492	Dark yellow
** 50	50	7.8	11.9	19.7	2143	8.9	586	Medium yellow
70	30	8.0	17.0	25.0	2147	8.4	529	Medium yellow
100		8.4	8.1	16.5	1708	27.2	59	Light yellow

G. Alcorpon Red Mud and Clay — Firing temperature 980°C

1	2	3	4	5	6	7	8	9
	100	11.9	22.3	34.2	1862	10.8	238	Brick red
30	70	13.0	17.4	30.7	1923	10.3	462	Dark yellow
* 50	50	13.9	27.2	41.1	2103	8.5	479	Yellow
70	30	15.3	19.6	34.9	1698	19.2	201	Yellow
100	—	17.9	18.6	36.5	1476	35.5	185	Light yellow

* Red-mud and clay passing 1 mm
** Red-mud and clay passing 0.5 mm

TABLE VI
Physical Properties of Normal Size Bricks

	Drying shrinkage per cent	Firing shrinkage per cent	Total shrinkage per cent	Bulk density kg/m³	Water absorption per cent	Compressive strength kg/cm²	Colour of brick
(A) Red Mud* : Clay* (50 : 50) — Firing Temperature 980°C							
Hindalco	9.4	*12.2*	*21.6*	*1911*	*12.9*	287	Yellow
Indalco	7.5	9.6	*17.1*	*1927*	*11.4*	288	Yellow
Alcorpon	*12.6*	*17.9*	30.5	*1876*	*11.8*	240	Yellow
(B) Red Mud* : Clay* (50 : 50) — Firing Temperature 1020°C							
Hindalco	9.4	*14.8*	24.2	*1945*	8.7	355	Yellow
Indalco	7.5	*11.6*	*19.1*	*1950*	*10.8*	330	Yellow
Alcorpon	*12.6*	Hair cracks and deshaping					

*Passing 1 mm

The water absorption and bulk density of briquettes made from red mud compositions are more or less similar to clay briquettes.

Normal size bricks were moulded with 50 per cent red mud because, in general, it gave best results in case of briquettes. A 50 per cent addition also assures a major utilization of the waste material for brick manufacture. Table VI gives the results of bricks fired at 980° and 1020°C. All the bricks obtained are of class 1 quality.

Colour of Bricks

The colour of fired bricks changes from brick red to brownish-yellow or light yellow through light chocolate, light brown and dark yellow as the quantity of red mud mixed with clay is increased from nil to 100 per cent. Separate experiments conducted showed that the intermediate light brown or dark yellow colour obtained in 50 : 50 composition is due to combined effect of white titanates and red oxide or silicates of ferric iron. Addition of 5-6 per cent of TiO_2 in brick clays produced similar colour upon firing.

Drying Time

Drying time of red mud-clay bricks was determined as a function of weight loss (per cent dry basis) and was compared with bricks made only either with clay or red mud. The bricks were moulded at optimum water of plasticity and dried in an oven at 40±1°C. Results given in Fig. 3 show that drying time of 50:50 bricks is about 10-20 hours less than those made either with red muds or moderately plastic clays. It is also seen that use of less plastic Indalco clay with red mud considerably reduces the drying time of the bricks. The results show that use of red mud, in general, reduces the water of plasticity requirement for moulding the bricks. This is due to well known effect of sodium ion (present in red mud) on kaolinite and illite clay minerals[8,9]. The bricks, consequently, take less time during drying.

Extrusion

Extrusion of Hindalco 50 : 50 composition was carried out satisfactorily in a laboratory extruder. It was noticed that the composition could be extruded at less water content than is required for extruding moderately plastic clays. Addition of red mud increases the pH and workability of the clay[6]. Briquettes extruded at a moisture content of 17 per cent gave a compressive strength value of 460 kg/cm² when fired at 980°C. The total shrinkage and water absorption values were 20.5 and 12.5 per cent respectively.

Flooring Tiles

Pleasant looking yellow coloured flooring tiles could be prepared from semi-dry red mud-clay compositions moulded in a tile press. The tiles (22 x 22 x 3 cm) made from 50 : 50 Hindalco composition were fired at 1000-1020°C. These satisfy the minimum requirement of breaking load and maximum water absorption values of 6 kg/cm and 10 per cent respectively (Table VII).

Dimensional Stability

The dimension stability of red mud-clay bricks was compared with normal clay bricks under drastic conditions of temperature and moisture. The linear expansion of fired clay bars after immersion in boiling water for one hour varied between 0.016-0.048 per cent. In case of fired red mud-clay compositions (30-70 per cent red mud) this value was found to be 0.013-0.065 per cent. No deterioration was observed after immersion. A wall of size 2 x 3 meters constructed with these bricks with portland cement mortar did not show any sign of failure though a period of 18 months has passed.

pH of Red Mud-Clay Compositions

The pH vlues of redmud-clay compositions were determined both before and after firing For this 100 gms of powdered material (passing 0.5mm) was kept in contact with 500 ml of distilled water with occasional stirring for 24 hours. This was then tested for pH. Fired compositions containing red mud upto 70 per cent gave pH values between 7.0-7.5 (Table VIII). The pH for 50 : 50 compositions was found to be between 7.0-7.2 which being similar to that obtained in case of fired normal clay should not be considered detrimental in any way.

No efflorescence or scum formation was noticed in 50:50 bricks.

The soluble salt contents determined as per standard procedure in 50:50 Hindalco and Indalco fired compositions were found to be 0.059 and 0.114 per cent respectively. In case of normal clay bricks made from Roorkee clay, which showed neither efflorescence nor scum formation, the value was determined as 0.109 per cent.

The pH of 50:50 red mud clay compositions before firing lie between 9.1 and 9.7 If red mud slurry is washed once before mixing with clay, the values are brought down to about 7.7-79.

(C) Field Trials

Two small field trials of manufactring building bricks from 50:50 Hindalco red mud-clay composition were carried out at a local Bull's trench kiln during May-June 1973. Red mud and clay were mixed and ground in a pan mill grinder. In the first trial the composition for 1000 bricks was entirely left at the disposal of the moulder who added in it the usual amount of water (about 30 percent) required for moulding normal clay bricks. This was, however, found in excess and created difficulty during moulding of bricks. The moulders were then demonstrated that the composition developed required workability at a much lower water content In the second trial, 1000 bricks were, therefore, moulded after mixing 24 per cent water. As shown earlier, the plasticity index value of red mud-clay composition is 2-3 per cent lower than that of normal brick clays. One has to be, therefore, careful while adding water in such compositions.

The first trial gave bricks of bulk density, water absorption and compressive strength values of 1500 kg/m², 21.7 per cent and 134 kg/cm² respectively. The bricks made during the second trial showed these values as 1750 kg/m³, 15.3 per cent and 185 kg/cm² respectively. The firing temperature in both cases was around 950°C.

(D) Process & Economics

Any plant or kiln for the manufacture of building bricks from red mud has to be established near an aluminium factory where red mud and clay are easily available. The production can be carried out in two ways. In the first case water mixed red mud slurry from the storage tank can directly flow by means of drains or pipes to the pits where it is mixed with clay manually (ghol method). (This will avoid grinding of red mud which becomes sufficiently hard lumps after drying). In the second case where kiln is situated away from the red mud tank (preferably within 1 km), dry red mud lumps are to be transported to the kiln site where these are mixed with clay in a mechanical pan mill grinder. In both cases, the mix can be used for making hand moulded bricks. Where a grinder is installed, the mix can also be used for making bricks by extrusion process. The bricks can be dried and fired in the usual way in any type of prevalent brick kiln. If the composition causes slight irritation during hand moulding on account of alkaline conditions, either plastic hand gloves can be used or red mud slurry can be further washed, before it reaches clay pits, to bring down the pH. Appendix 1 gives

TABLE VII

Properties of Flooring Tiles

Firing temperature °C	Total shrinkage Per cent	Bulk density kg/m³	Water absorption Per cent	Breaking load kg/cm	Flexural strength kg/cm²
980	21.3	1858	12.6	12.0	38.0
1000	23.7	1928	9.9	16.9	51.4
1020	24.6	2010	7.5	19.0	60.0

TABLE VIII

pH of Red Mud-Clay Compositions before and after Firing (1000°C)

Composition per cent by volume		Hindalco		Indalco		Alcorpon	
Red Mud	Clay	Before firing	After firing	Before firing	After firing	Before firing	After firing
—	100	6.9	7.2	6.4	7.3	6.4	7.0
30	70	8.5	7.3	8.8	7.2	9.4	7.0
50	50	9.1	7.2	9.4	7.2	9.7	7.0
70	30	9.6	7.1	9.7	7.5	9.8	7.5
100	—	10.6	7.7	11.0	8.8	10.6	9.2

in short the total capital investment and manufacturing cost for these bricks. This may slightly differ from place to place according to local conditions and type of process adopted.

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The present study forms part of normal research programme of the Institute and the paper is published with the permission of the Director.

APPENDIX I

Cost of production of building bricks from alumina red mud

Basis: (i) 30,000 bricks per day or 72,00000 produced in a season of 8 months.

(ii) 50 per cent red mud is mixed with clay by volume.

(iii) Red mud is available free of cost at disposal tank.

(iv) 16 tonnes of coal (taken as Rs. 100/ton) is consumed for firing one lakh bricks.

	Manual mixing (Ghol method) Rs.	Mechanical mixing (Pan Mill Grinder) Rs.
A. Capital Investment (kiln, *10* years land for clay pits, pan mill, tube well etc.	*1,27,500*	*1,67,500*
B. Raw Materials & Utilities clay, water, coal, wood, electric power etc.)	*1,46,400*	*1,61,550*
C. Labour and Transport	*1,24,600*	*1,55,000*
D. Over Heads and Depreciation	23,775	28,375
E. Annual cost of Manufacture	2,94,775	3,44,925
F. Working Capital	58,955	68,985
G. Total capital investment	*1,86,455*	2,36,485
H. *10%*Return on G	*18,646*	23,649
I. Selling Price (E+H)	3,*13,421*	3,68,574
J. Selling Price per *1000* bricks	43.53	*51.19*

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Bauxite-based medium industries

Bauxite is found in abundance in the earth's crust and we are fortunate to have large deposits of this mineral scattered throughout our country.

Aluminium, known as the common man's metal because of its use in making vessels, is obtained from bauxite which is basically trioxide of aluminium element. The metal is light but strong and a good conductor of heat and electricity and is used in aeroplanes, power cables and paint.

Bauxite mineral is whitish pink, pisolitic and is found at Loharadaga in Bihar, Belgaum in Karnataka, Katni in Madhya Pradesh, Shervoy hills in Tamil Nadu, Jammu in J and K, Saurashtra in Gujarat and Kolhapur in Maharashtra. Reports have recently appeared in the press that huge deposits have been located in the Rayalaseema region of Andhra Pradesh.

In richness of deposits, Maharashtra ranks first with an estimated 80 million tonnes. The proposed Ratnagiri project will be fed with this source for its raw material needs.

Bauxite, bringing to one's mind aluminium, makes the people of the region where it is found clamour for an aluminium project. This leads to the planning of gigantic schemes which are highly capital intensive in nature and with long gestation periods. These are intensely sought after by the public who later become disappointed when such schemes fail to take fruit for want of funds and technical handicaps, uneconomic returns, and so on. Ratnagiri provides a live example of such a project which has caused a lot of discontent among the people.

It is possible to have small industries for certain end-products but then the utilisation of resources would be very low. Further, there is the spectacle of small industries getting benefits and incentives disproportionate to investment and returns thereon, finally making them sick units, as they are not commercially viable.

A via-media must be thought of to combine advantages of both types of industries to suit bauxite mineral processing and faster exploitation of mines to achieve the economic uplift of the area concerned. In this it is essential that a project should be economically feasible, easier on capital finance and employment-oriented. More such medium-scale or middle-sized industries spread over a number of regions wherever bauxite is located would help in satisfying the regional clamour for industrialisation.

This is very important in view of the fact that, at present, for an economic aluminium project an outlay of Rs. 80 crores or so is considered essential whereas to produce intermediate products, prior to actual metal extraction, approximately Rs. 80 to Rs. 100 lakhs would be enough.

All these days it was not thought feasible to set up bauxite-based middle-sized units on the scale proposed here but the new concept in designing and process alteration developed by a team of technocrats, notably C.N Satyanarayan Rao a chemical engineer, and Chandrakant J. Aundhkar, a mechanical engineer of Ambarnath, Thana district, Maharashtra, would help to have more such industries.

Aluminium metal projects are necessarily capital-intensive and power-consuming due to smelting operations involved in the extraction process. The total cost of an aluminium project influenced by the economic production capacity of the metal as such. These aluminium extraction units, as they can be described, are presently suppliers of intermediate products like activated bauxite, alumina hydrate and its calcined form both for local markets and export.

The middle-sized industry stops short of metal production, avoiding smelting and, in turn, heavy power and huge finance. Hence with only one per cent capital outlay, an industrial unit can supply intermediate products to numerous consumers, and later even to smelting units which need not have or need not expand bauxite processing capacity but restrict themselves to metal production.

Bauxite mineral can be processed into calcined form and emery which find use in refractories and abrasives. A fairly large share of bauxite converted to these forms are utilised by the concerned industries. It is known that emery grain and calcination units can be set up, depending on capacity, within a few lakhs of rupees or up to Rs. 50-60 lakhs.

The third form to which bauxite is converted is alumina hydro, either plain or calcined. In India, glass and ceramics, alum, toothpaste, ink, vitreous enamels, inorganic chemicals are industries which use alumina hydrate which further finds use as catalyst, adsorbent and reinforcing agent in rubber. With rapid industrialisation, scope for its use will increase further.

Recently BALCO (Korba), a government of India undertaking, contracted to sell 40,000 tonnes of alumina hydrate to the USSR. Iran had indicated its willingness to enter into a long-term contract for purchasing this material and was ready to finance the setting up of an industry for this purpose at Kandla. This shows how much scope exists for its export.

All along, giant units like Korba in M. P., already in production, or the one proposed at Ratnagiri have a capacity of 1,000 to 1,500 tonnes of alumina hydrate per day, no doubt correlated to the final metal product. However it is now possible to set up units with only 40 to 100 tonnes per day capacity on the basis of the design and process developed by Rao and Aundhkar.

It would be desirable to set up many such units throughout the country to cater to the needs of local industries and also to effect exports, if the units are near ports. The cost of production in these smaller units compares very favourably with the cost in larger giant units. But the other advantages of utilising bauxite at various places, reducing transportation, providing local employment, developing regional industrialisation, decide the choice favour of medium-scale industries.

For an ideal alumina hydrate project which is economically feasible, the various costs work out as under :