Reprinted from *Research and Industry*, 1977, Vol. 22 No. 4, pp. 237-239

Utilization of Lime Kiln Rejects

N. G. DAVE & S. P. MEHROTRA

Central Building Research Institute Roorkee

Recevied 22 *November* 1977; *acceptcd* 6 *December* 1977

Huge quantities of lime kiln rejects available at lime production centres are currently not put to any use. A process is reported for the production of a binder possessing cementitious properties from this waste material. The binder has been found suitable for the preparation of masonry mortars and plasters and for making bricks, blocks and flooring tiles. The economics of production of the binder and mortars based on it is given.

LIME production is an age-old industry in India scattered throughout its length and breadth, depending upon the availability of limestone at particular locations. Burning of limestone is carried out in kilns of different shapes and designs[1]. Most of the kilns are of mixed feed vertical shaft type, with a few exceptions.

Limestone is charged in these kilns usually as lumps of 5-20 cm size and lime is retrieved in lumps of almost the same size. Lime is always mixed with ashes from the fuels, clinkers formed through the interaction of these ashes with lime, overburnt and underburnt materials and lime powder. From the discharges, the lumps of lime are picked out and the rest of the material is discarded. Several thousand tonnes of such materials are being rejected every year[2]. In the vicinity of every important lime producing centre big dumps of such wastes are commonly seen.

Investigations were undertaken at this institute for finding out uses for this reject and a cementitious material suitable for use in masonry mortars and plasters and for making bricks, blocks and flooring tiles, etc. has been developed.

Manufacturing process

Samples of lime rejects from various lime producing centres in U. P., M. P., Rajasthan, Haryana and Chandigarh were examined. They were found to show wide variations in physical characteristics as well as chemical compositions. This is expected, as limestones with widely varying properties, different types of fuels, kilns and operating practices are used[3]. The ranges of variation of the contents of different constituents[4] in typical samples were as follows : Loss on ignition, 2.79-8.58; SiO_2, 40.29-60.58; R_2O_3, 21.95-32.80; CaO, 2.42-32.65; and MgO, 0.67-5.07%.

Ashes are known to possess pozzolanic characteristics[5]. However, when present in combination with other materials they may not necessarily exhibit these characteristics to the desired extent. Hence, to ensure purposeful utilization of these rejects, certain additives were added to them. The mixtures were then ground to stipulated finenesses (a fineness of at least 90% passing I. S. sieve No. 9) using a ball mill, which ensures thorough grinding and mixing.

Properties of the binder

Any binder that can be developed from lime kiln rejects must fall under the broad category of lime-pozzolana mixtures[6]. These were, therefore, tested accordingly and the results are given in Table 1.

Table 1— Ranges of physical characteristics of the binder from lime kiln rejects

(1) Setting time range	
Initial	34 min to 4 hr 45 min
Final	3.0 hr to 36 hr 50 min
(2) Compressive strength range (kg/cm²)	
(a) Binder : sand : : 1 : 0	
7 days	22 to 70
28 days	36 to 113
(b) Binder : sand : : 1 : 3	
7 days	4 to 10
28 days	15 to 29
(3) Water retention, %	65 to 78

Table 2— Economics of production of mortars using binder prepared from lime kiln rejects

Proportion (by vol.)				Cost per m³ of mortar having a flow of 110 ± 5	Saving in comparison to cement sand (1 : 6) mortar	Remarks
Cement	Lime	Sand	Surkhi			
1	0	6	0	112.80	—	Cement @ Rs 400/ tonne
1	1	6	0	130.40	—15.6	Hydrated lime @ Rs 225/ tonne
1	2	9	0	107.95	+ 4.3	Surkhi @ Rs 30/m³
0	1	0	2	97.50	+13.5	Sand @ Rs 20/m²
0	1	0	3	83.25	+26.2	Binder from lime-kiln reject @ Rs 200/ tonne
Binder from lime kiln reject						
Binder : sand : : 1 : 3				72.60	+35.6	
Binder : sand : : 1 : 4				64.80	+42.5	

It is evident from Table 1 that these binders have characteristics needed for their use in mortars and plasters. They have actually been used on field scale for this purpose and the constructions are behaving well for the past three years. The economics of production of mortars from lime kiln rejects is given in Table 2.

These binders have also been used for making blocks, both hollow and solid, which could be used for single and double storeyed buildings.

Commercial feasibility

Since lime kiln rejects are available in huge quantities in various parts of the country, a large number of units for the production of binders based on lime kiln rejects can be set up in the small and cottage scale sectors. The scheme could also cover the production of building blocks using this binder. Predesign cost estimates for the production of the binder are given in Table 3.

Table 3— Pre-design cost estimates

Product, hydraulic binder from lime kiln rejects.
Capacity of the plant, 2 tonnes per day (one shift)
Basis 300 × 2 = 600 tonnes/year

		Rs
(A)	Fixed capital on building, land, 150 sq m @ Rs 20/sq m	3,000.00
	Yard improvement	500.00
	Shed, 80 sq m @ Rs 180/sq m	14,400.00
	Building, 16 sq m @ Rs 225/sq m	3,600.00
		21,500.00
(B)	Fixed capital on plant	
	Ball mill (capacity 1/2 tonne) sieving equipment, weighing machine and bag stitching machine)	60,000.00
	Equipment erection	1.000.00
	Electrical installation	2,000.00
	Laboratory	2,000.00
		65,000.00
(C)	Working capital (10% of annual sales)	10,500.00
	Total capital investment (A+B+C)	97,000.00
	Cost of production (300 working days)	
	Raw materials	22,800.00
	Packing (Rs 30/tonne)	18,000.00
	Electricity (20 hp)	3,600.00
	Labour and supervision	
	3 labourers @ Rs 5 per day	4,500.00
	1 Supervisor @ Rs 300 per month	3,600.00
	Maintenance and repairs	
	Plant (6% of B)	3,900.00
	Building (2% of A)	430.00
	Taxes and insurance (2% on A+B)	1,730.00
	Depreciation	
	Plant (10% of B)	6,500,00
	Building (2.5% of A)	540.00
	Distribution and selling cost (5% on annual sales)	5,250.00
	Interest on total capital investment (@ 13%)	12,610.00
	Total cost of production	83,460.00
		say 83,500.00
	Annnal sales @ Rs 175/tonne	1,05,000.00
	Annual cost of production	83,500.00
	Return	21,500.00
	Return on investment	22.1%

As this binder will find market locally, it can also be sold without packing and thus its selling price will be reduced by Rs 30/tonne.

Acknowledgement

This communication is being published with the permission of Director, Central Building Research Institute.

References

1. DAVE, N. G. & MASOOD, I., *Studies on the existing lime kilns in India*, Proceedings, seminar on lime manufacture and uses, Lime Manufacturers' Association of India, CBRI & NBO, New Delhi, Nov. 1972, 98-116.
2. DAVE, N. G. MASOOD, I, MEHROTRA, S. P. & VERMA, M. L., *New lime and lime products for economy in construction*, Paper presented at Symposium on Economy in Construction, Thiagarajan College of Engineering, Madurai, 23 March 1974.
3. DAVE, N. G. *Indian chem. J.*, 7 (1971), 19.
4. VOGEL, A. I., *A textbook of quantitative inorganic analysis* (The English Language Book Society & Longmans, London), 1975, 628-67.
5. *Lime coal ash mortars, their suitability for masonry*, Civil Engineering Report No. 33, Railway Testing Research Centre, Lucknow.
6. *Specifications for lime pozzolana mixture*, IS : 4098-1967, Indian Standards Institution, New Delhi, 1967.