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A New Hydraulic Binder from Waste Lime and Rice Husk : Part I—Basic Properties

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A new hydraulic binder based on waste lime sludge and rice husk, two important agro-industrial wastes, has been developed. The binder is composed essentially of lime and silica and is hydraulically active. Its setting and hardening behaviours are similar to those of hydraulic cements, by virtue of which it can be used in such applications as masonry mortars, plasters, foundation concrete, soil stabilization, etc. in the same way as portland cement. The binder has been prepared by firing together lime sludge and rice husk. Apart from acting as an integral fuel for burning the calcium carbonate of the lime sludge, rice husk also provides silica *in situ* to the lime formed in the process. This process controls the lime-silica ratio as well as the temperature of firing of the binder as a result of which the variations in the quality of the product are narrowed down considerably. Since the temperature of firing of the binder is in the same range in which lime is generally produced (900–950°C), there is little danger of the product getting overburnt or becoming unsound even if magnesian lime is used.

MORE than three million tonnes of waste lime in the form of lime sludge are thrown out in India every year by the sugar, paper, acetylene, tanning and other industries. Since the purification of this lime and its reuse are uneconomical, the impure lime is not being put to any worthwhile use. India produces about 60 million tonnes of paddy annually, and paddy husk constituting about one-third of this quantity does not find any

major use, except that a small portion of it is burnt as fuel by the rice mills in their boilers. Both the wastes present serious problems of disposal.

Some efforts have already been made to utilize these wastes for the development of materials of construction[1-3]. A new hydraulic binder has been developed at this institute, which possesses hydraulic or cementitious properties similar to those of portland cement. The binder made from lime sludge and rice husk holds promise as a replacement for cement in certain construction applications. This note outlines the preparation, some important properties and suggested uses of this binder.

Preparation of the binder

Materials — The chemical composition of the lime sludge used (Mahalakshmi Sugar Mills Iqbalpur, Roorkee) is given in Table 1. Rice husk which on burning gave a total silica residue of up to 17.6% was used in crushed form.

Method of preparation — Both the materials, i.e. lime sludge and rice husk, were dry mixed in equal proportions (by weight) to give a self-burning mix. The mix was put to fire in the open and allowed to burn completely. The ash obtained after burning was collected and ground in a ball mill for about 1 hr to a fine powder of greyish white colour. The maximum temperature achieved during firing was 950°C.

Testing methods — The chemical and physical properties of the binder were tested as per standard methods recommended by the Indian Standard Institution (Table 2).

Results

The results of chemical analysis of the binder and the lime sludge from which it has been prepared are given in Table 1. The main characteristics of these materials are given in Table 2. Curves in Figs. 1–4 show the relationship of the compressive strength of the binder with its fineness, curing period, water content and sand content at room temperature.

Discussion

The chemical analysis of the binder shows that it is composed predominantly of calcium oxide and silica. This is imperative, since the major constituents of the substances from which it has been made are calcium carbonate and silica. Measurement of the loss on ignition of the binder showed that it contains 3.77% residual calcium carbonate, which has not decomposed during firing. The content of unburnt carbon is 1.13%.

From the values of the compressive strength of the binder obtained under different conditions it is clear that it possesses hydraulic properties comparable to those of superior types of hydraulic limes (class A limes of IS 712–1973) and natural cement of the type of ASTM Designation 10–54 (1961). Without further modification, the hydraulic setting characteristics of the product are within convenient time limits to which the hydraulic cements are brought by the use of retarders, such as gypsum. Fig. 2 shows that at normal room temperature, its 3 day and 7 day compressive strength is about 40 and 56% respectively of its 28 day strength. The

Table 1 — Chemical analysis of the binder and lime sludge

	Binder	Lime sludge
Loss on ignition, %	4.90	41.29
Silica, %	37.77	6.07
Aluminium oxide, %	5.80	5.12
Iron oxide, %	1.32	1.18
Calcium oxide, %	42.92	39.71
Magnesium oxide, %	5.28	4.81
Phosphorous pentoxide, %	1.70	1.20

Table 2 — Physical characteristics of the binder

Characteristic	Result	ISS method
Fineness		
Residue retained on 150μ IS sieve, %	1.0	6932 (Part IV) 1973
Residue retained on 74 μ IS sieve, %	21.7	-do-
Air-permeability apparatus sp. surface area, cm^2/g	9840	4031 : 1968
Bulk density, kg/m^3	764	
Setting time (by Vicat's apparatus)		4031 : 1968
Initial, min	75	
Final, min	500	
Soundness		
Expansion in Le-Chatelier's moulds, mm	2.5	6932 (Part IX) 1973
Compressive strength, kg/cm^2		
3 days	20.5	6932 (Part VII) 1973
7 days	27.8	
28 days	50.00	
Heat of hydration, cal/g		
7 days	48.46	269 : 1966
28 days	64.90	