CAS SECTION

ements and Binders Advisory Service provided by Intermediate Technology evelopment Group (ITDG), Myson House, Railway Terrace, Rugby CV21 3HT, UK

ASTE MATERIALS AND BINDERS

ere are a number of waste materials which are either zolanic, reacting with lime to form a binder, or have insic binding properties. Some, such as pulverised ash (pfa) from coal burning power stations, are now d widely, but others find little application – in spite of ensive research work – largely for economic or tech- l reasons. For example, it is not economical to ect waste if it is produced in small quantities at a large ber of widely dispersed sites. Particular technical iculties of waste utilization include contamination by anted materials, which is why materials such as sphogypsum from fertilizer production and lime n acetylene gas production or as a by-product of the ar industry have not found wider application. An- r factor is variation in properties of the material, h as of burnt clay pozzolana from pulverising waste erfired bricks and tiles. Refining such wastes to uce these problems introduces an additional stage in process and can lead to their utilization becoming conomic.

ditionally, a large number of waste materials could be d as aggregate in concrete mixes for a variety of lications. These materials include rice husks, mine ings, burnt coal or coke, broken glass, brick and tile stes and demolition wastes. However, waste materi- as aggregate are often inferior to sand, gravel and crushed rock and their use is only really justified where conventional aggregate is difficult to obtain or where extraction of conventional aggregate causes serious environmental damage.

Another application of largely organic wastes is in boards and sheets formed under heat and pressure with the addition of a small quantity of resin. Some organic wastes, for example, straw from wheat, barley and rice have intrinsic binding properties which are activated by heat and pressure. However the boards produced without addition of resin generally have low strength and their main use is for insulation.

In the following articles, an overview of the research work of the Central Building Research Institute (CBRI) in India on waste utilization in cements and binders is presented first. CBRI are one of the leading research organisations in this field worldwide. The second article describes a specific feasibility study and pilot project on introducing rice husk ash cement production in Kenya. Finally there is a short article on producing sodium silicate, a lesser known binder, from waste rice husks and utilizing it in low-cost building. These three articles give an indication of the range and diversity of possibilities of using waste materials in binders thus potentially saving the use of millions of tonnes of Portland cement, a scarce and expensive material in many areas.

EMENTITIOUS BINDERS FROM GRO-INDUSTRIAL BY-PRODUCTS

This article is based on a report made available to CAS by Dr. S.K. Malhotra, Scientist at :- Central Building Research Institute - CBRI, Roorkee - 247672, India.

TRODUCTION

Central Building Research Institute (CBRI) has at the forefront of research and development work utilization of agro-industrial by-products for entitious binders for several years and has developed ucts and processes which are now described. The wing table gives information on the availability of roducts in India with potential for use for cementitious rials.

By-Product	Annual Production (MillionTonnes)
Rice husk	17.0
Bagasse	5.3
Granulated blast Furnace slag	2.5
Gypsum	4.5
Fly-ash	30.0
Lime sludge	4.5

DEVELOPMENT OF CEMENTITIOUS BINDERS

Cementitious binders from rice husk and lime sludge.

A hydraulic binder has been developed from rice husk and by-product lime from sugar, acetylene, paper and other industries. The binder holds promise as a substitute to Portland cement in certain applications.

Method of preparation

The lime sludge and rice husk were mixed together in equal proportion by weight when dry along with 10-12% of plastic clay. After adding water the mixture was made into balls or cakes (fig.1). After drying in the sun, the balls/cakes were ignited in a trench or clamp or on a grating (figs. 2 and 3). The rice husk ash which is produced is rich in silica and can react with the lime. The maximum temperature recorded during firing was 900-950°C, producing a soft powder. As the reactivity of hydraulic binders increases with fineness the material is then ground in a ball mill.

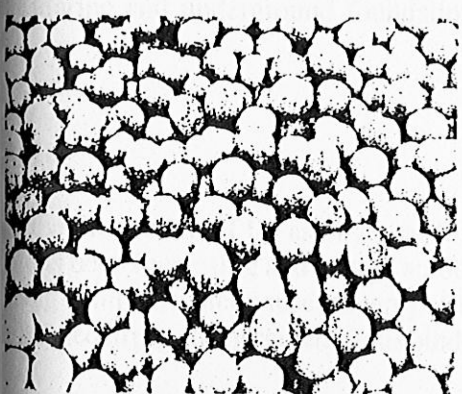

Fig.1

Fig.2

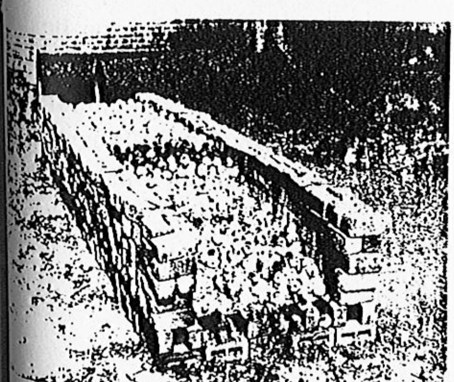

Fig.3

Properties of the binder

The strength development of the binder is based on the lime-pozzolana reaction. Physical properties of the binder were determined according to methods described in the Indian standards.

The binder was found to conform to the compressive strength requirements of the standard on quick-setting lime-pozzolana mixtures and to have acceptable time limits for setting as a hydraulic cement. It also exhibits improved water retention, workability, water tightness and other properties, compared with lime-based compositions.

Applications

The binder has been found suitable in applications such as masonry mortars, plasters, foundation concrete and concrete for sub-flooring and terracing.

Advantages

Since the binder is prepared entirely from industrial and agricultural wastes and its manufacture does not involve special skill and machinery it can be used as a partial substitute for cement, and would be particularly suitable for rural and low-cost housing programmes.

GRANULATED BLAST FURNACE SLAG

In India about 10 million tonnes of blast furnace slag is produced every year, of which about 2.5 million tonnes is being granulated. Granulated blast furnace slag is a glassy material and possesses good hydraulic properties. Its main uses are in the production of sulphate-resisting cements, that is slag cement and super-sulphated cement.

Slag cement

Slag cement can be produced by controlled blending of granulated blast furnace slag, Portland cement clinker and a small amount of gypsum to regulate the setting time. The hardening of slag cement is due to two processes – hydration of Portland cement, which releases lime, and then the slower process of slag activation with lime. The properties of the slag cement[ref.2] prepared from Indian slags conform to the *Specifications for Portland slag cement* IS 455-1989.

Supersulphated Cement

Supersulphated cement is an intimate blend of granulated slag (70-80%), gypsum anhydrite (20-25%) and a ll amount of Portland cement (5-10%), which acts as ctivator. CBRI has developed a supersulphated ent[ref.3] using Indian slags. These slags have relatively lime and high alumina contents and their sulphate vation has been studied to optimize the manufacture supersulphated cements. The optimum amount of vator (gypsum anhydrite) was found to be 20-25 per as against the commonly recommended value of 10- er cent. The cement thus prepared conforms to the *ifications of supersulphated cement* IS: 6909-1990. manufacturing technology is available indigenously there is good demand for this type of cement. The al strength of this cement is obtained by the forma- of ettringite but the final strength is achieved by ation of hydrated calcium silicates as with Portland ent.

antages

antages of slag cement include cheapness and saving ergy, increased resistance to sulphates and lower of hydration compared to Portland cement. The retes made from slag cements can be used success- in marine and underground foundations and in s.

ASH

dia the production of fly ash by coal-fired power ns has been increasing and a large amount of this s being dumped, which causes severe pollution. Fly an be used in preparing cementitious binders in two s.

and-pozzolana cement

sh being a pozzolanic material can be used for the ction of Portland-pozzolana cement which can be red by inter-grinding it with Portland cement clin- nvestigations have shown that the fly ash onent can be as high as 25 per cent for the nt to still conform to the *Specification for nd-pozzolana cement* IS: 1484:1976[ref.4].

Portland-pozzolana cement can be used in ituations, where ordinary Portland cement d and reduces the heat of hydration, water ability and alkali-aggregate reaction while ving resistance to attack by contaminated s.

Activated lime fly ash mixture[ref.5]

Extensive study of lime-pozzolana binders with fly ash as the pozzolana has been carried out by CBRI. It was observed that most Indian fly ash possesses poor reactivity with lime with long setting and hardening times.

A process for improving the properties of lime and fly ash mixtures has been developed by CBRI, thus enhancing the rate of reaction between lime and fly ash so promoting faster setting and rapid development of strength of mortars and plasters. The exact composition of such a lime-pozzolana mixture depends upon the type of lime used and the reactivity of the fly ash. The complete process is shown schematically in fig.4. This uses chemical additives and grinding and compounding of constituents. Tests indicate that such mixtures can comply with the specification for *Quick setting lime-pozzolana mixture* IS 10772-1983.

BY-PRODUCT GYPSUM

Huge quantities of gypsum ($CaSO_4.2H_2O$) are produced by phosphoric acid, super phosphate and hydrofluoric acid industries. Also gypsum anhydrite ($CaSO_4$) is obtained during the manufacture of hydrofluoric acid by the treatment of fluorspar (CaF_2) with sulphuric acid. These by-products contain impurities of free acid, fluorides and phosphates which may affect their properties as binders. However, the amount of impurities can be reduced simply by washing with water.

Cementitious binders from fluorogypsum anhydrite

(a) Plastering material

A cementitious binder[ref.6] from gypsum anhydrite has been developed which is suitable for plasters. Gypsum anhydrite itself does not react with water. It needs an accelerator, generally a sulphate. Results of trials of a

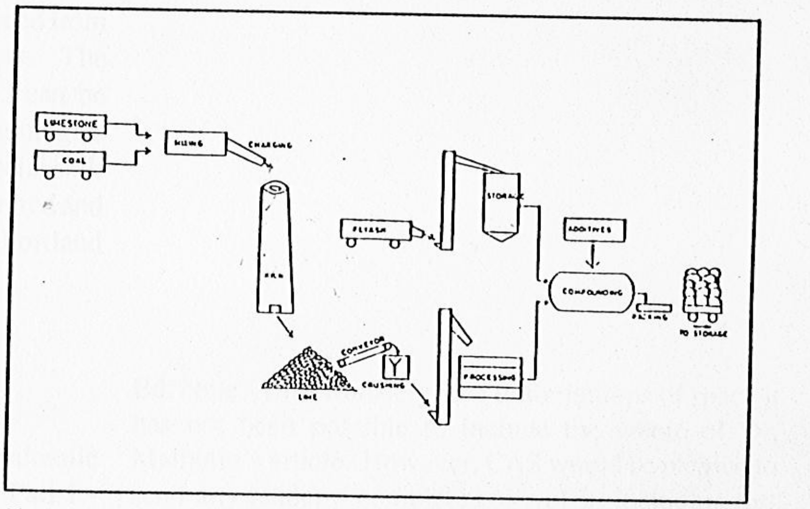

Fig. 4

mbe;;of different accelerators show that 2% K_2SO_4 or aHSO$_4$ gives the required setting time. The effect of ee acid in the anhydrite can be neutralized by the ldition of a small amount of lime (2.5%) at the time of ending.

) Supersulphated Cement[ref.8]

ue to the scarcity of high grade gypsum anhydrite for e manufacture of supersulphated cement, efforts have en made to utilize by-product gypsum anhydrite. udies have shown that supersulphated cement made ith the by-product conforms to the standard *Specifica-ns of supersulphated cement* IS: 6069-1990.

ementitious binder from phosphogypsum[ref.9]

vestigations have been made to produce a durable psum binder based on calcined phosphogypsum, fly h, Portland cement and a retarder and the properties of ch a binder have been tested.

AGASSE ASH BASED CEMENTITIOUS INDER[ref.10]

vestigations indicate that bagasse ash has good pozzo-nic activity. It was found to consist of about two-thirds ica, most of which is in an amorphous state.

n attempt has been made to produce a quick-setting ne and bagasse ash mixture by intergrinding a hydrated ne, bagasse ash, 10% Portland cement and 4 per cent psum in a ball mill to a fineness of 90% passing ough a 200 mesh (75μ) sieve.

ch a mixture would have potential application as a ortar or plaster, particularly in rural areas.

NCLUSIONS

ariety of cementitious binders can be produced from ferent types of agro-industrial by-products. The ders developed are of varying grades and can be ized depending upon the situation. The technologies olved in their production do not require special skill machinery. Therefore they can be manufactured and d as a partial substitute for high energy Portland ent on a small scale.

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Ed. Note - Unfortunately, due to limitations of space it has not been possible to include the whole of Dr. Malhotra's article. However, CAS would be pleased to send any reader a complete copy of it, including test result data, on request.