Cheaper Cement from Furnace Slag and Fly Ash

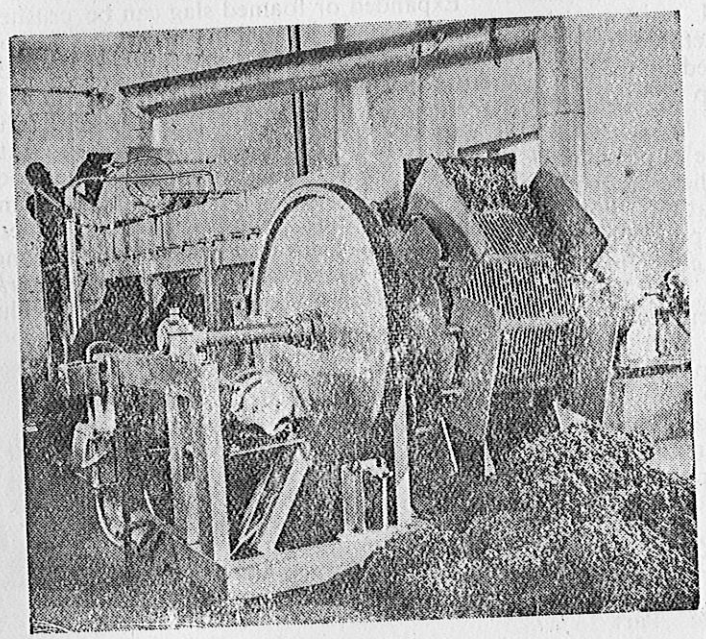
During the Third Plan period 900,000 houses are to be built under different schemes for which a provision of Rs 202 crore has been made. Besides, an investment of Rs 1,125 crore is expected to be made in the private sector during the period.

Though building activity in the country has increased considerably there is a shortage of building materials. Prices are also high. More and cheaper varieties of building materials are required to meet the increasing demand. The Central Building Research Institute (C.B.R.I.), Roorkee, has evolved some new building materials from industrial wastes and its recommendations have been published in various journals from time to time.

The following article sent by the Institute gives a brief account of some materials that can be manufactured from industrial wastes and used in building houses.

Fuller Use of Our Resources 4

A pilot plant producing sintered light weight aggregate from fly ash.



ONE possible way of meeting the shortage of traditional building materials is to make greater use of the large quantities of industrial wastes that accumulate in the vicinity of steel plants.

Of the principal industrial wastes which can be utilised in the building industry blast furnace slag and boiler furnace residue are most important.

About 2 million tons of blast furnace slag are available per year in the country for disposal. Every ton of iron produced in the steel plants yields ½ to ¾ tons of slag as by-product. The slag is either air-cooled, granulated or expanded, depending on the condition under which the molten slag is cooled. Air-cooled slag, or the molten slag allowed to cool gradually in the air, can be used as an aggregate in concrete or concrete products, or as a metal for roads. Molten slag when cooled more quickly produces granulated slag. This is suitable for the manufacture of slag cement or pressed bricks. Expanded or foamed slag is formed when the slag is cooled with a limited quantity of water. This can be used as a light-weight aggregate.

Furnace residue may be either cinder or fly ash. When lumps of coal are used for raising steam in boilers, the furnace residue, available in lumps of various sizes, is called cinder or clinker. The Railways and thermal power stations using lump coal produce about 3½ million tons of cinder which can be used as an aggregate in precast blocks or as pressed bricks or in mortars or plasters. Fly ash is the finely divided residue caused by the combustion of pulverised coal in the boiler. It is produced at thermal power stations. About 1½ million tons of fly ash are produced per year and the quantity is expected to rise to 3½ million tons by the end of the Third Plan. It can also be used for manufacturing pozzolanic* cement, as a light-weight aggregate for use in concrete, concrete blocks or slabs, in masonry mortars, in making fly ash cinder bricks and aerated concrete.

Industrial wastes in raw or processed form can be used in the manufacture of pozzolanic cement, slag cement or masonry cement. The first two have the useful properties of lower heat of hydration, increased resistance to attack by sulphates or acidic waters, improved workability and reduced segregation, making them particularly suitable for special construction jobs.

The Institute's work on the use of Indian granulated slag in the manufacture of Portland blast furnace slag cement showed that it can be prepared by separate or

*A volcanic dust first found at Pozzuoli near Naples, which forms with mortar a cement that sets in air or water.

combined grinding of 65 parts of the Portland cement clinker with 35 parts of the slag from the Tata Iron and Steel Works at Jamshedpur. The Chaibasa Works of the Associated Cement Company have started using Tata's slag for the production of this cement. Slag from Bhilai and Durgapur steel plants are also proposed to be used for producing this cement. The grinding of slags in the wet state can be exploited for mass concreting. The slag is ground finer and is more active and can replace as much as 65 per cent of Portland cement in mortars and concretes.

The other two types of cement which can be manufactured by utilising slag are lime-slag cement and super-sulphate cement. Experiments made indicate that super-sulphate cement with good strength and resistance to sulphates and acidic waters can be manufactured from the Tata slag. The granulated slag is activated by means of $CaSO_4$ in presence of a small quantity (up to 5 per cent) of Portland cement clinker.

Fly ash can be used for the manufacture of pozzolanic cement either at the cement works or at the construction site, where it can be added to the cement at the time of mixing. Though used for general purpose Portland fly ash cement is more suitable for mass concrete work. It is cheaper and also economical. Fly ash from Bokaro, Durgapur, Kanpur and Madras have been tested. They also fulfil the specified requirements and are suitable for use as pozzolana for producing Portland pozzolana cement. Up to 20 per cent of the Kanpur and Madras varieties and 25 per cent of those of Bokaro and Durgapur can be used for manufacturing Portland pozzolana cement.

Durgapur fly ash can also replace up to 20 per cent of sand in 1:8, 1:10 and 1:12 cement, sand, and Madras fly ash up to 15 per cent of sand in 1:3:6 cement, sand, gravel concrete. Part of sand replaced by fly ash increases workability, reduces bleeding and segregation and also saves cement.

A number of power stations are concentrated in the West Bengal-Bihar areas. In view of the nearness of the cement-producing centres and higher level of industrialisation in and around this area, manufacture of Portland fly ash cement at the factory site or use of fly ash at the site of construction of minor and major projects can be started.

A New Aggregate

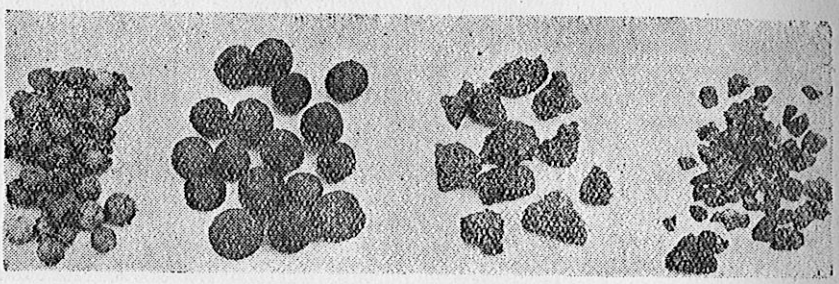
Blast furnace slag from the Tata Iron and Steel Company has been found to possess suitable physical and mechanical properties for use as an aggregate. The resulting concrete has properties similar to those of ordinary dense concretes. Standard tests on air cooled slag of Bhilai steel plant has also given satisfactory results for its use as an aggregate.

Light-weight aggregates can be made from any of the following four materials: clinker, sintered fly ash, expanded or foamed slag and bloated clay. Clinkers contain a comparatively high content of unburnt fuel. Concretes prepared with them possess greater moisture movements and drying shrinkage. Steam curing for 10 hours at atmospheric pressure reduces the drying shrinkage and increases stability. A 1:6 cement cinder mixture (by volume) is suitable both for strength and stability. The cost of cinder concrete block construction is cheaper than that of brick masonry work at places where bricks are available at Rs 50 or more per thousand. Blocks made with the sintered fly ash aggregate are lighter and more stable.

The Institute has produced a sintered light-weight aggregate on a pilot sinter strand with the Bokaro and Durgapur fly ash. The cost of production is estimated to be about Rs 35 per 100 cubic feet. The unit weight of crushed sintered aggregate is 55 lb. per cubic foot. The aggregate is suitable for making concrete blocks and for on-the-spot concrete construction.

Expanded or foamed slag can be crushed to suitable sizes and used in making light-weight concrete. Slags from the Mysore Iron and Steel Plant at Bhadravati and from the Durgapur steel plant have been found suitable for making foamed or expanded slag light-weight concrete. It is lighter, free from deleterious material and suitable for use with reinforcement. The production of this aggregate does not require complicated machinery and capital investment is low. Cinder and sintered fly ash and expanded slag can be used for making concrete blocks.

Coal ash can also be used in place of *surkhi* in making lime mortars. The proportions (by volume) are 1:2, 1:3 lime coal ash or 1:1:1, 1:1:2 lime, coal ash, sand. The mortar is prepared in the same way as that of lime *surkhi* mortar. Lime coal-ash mortar is cheaper than cement mortar and is suitable for building two-storey houses.



Light-weight aggregate : (Left to right) fly ash, bloated clay, expanded slag and clinker.

Cheaper Bricks

Among other materials evolved at the Institute are pressed bricks and another variety called clinker mix bricks. Pressed bricks have been manufactured by using a suitable mixture of lime, cement and granulated slag. The Indian Iron and Steel Company, Burnpur, has produced this variety and used it in its constructions. As regards clinker mix bricks, it has been found that they can be manufactured by using 10 per cent cement by weight of fly ash. They are suitable for manufacture near the thermal stations where production of clay bricks proves expensive.

The Central Building Research Institute has done valuable work on the manufacture of building materials from industrial wastes. Some offer immediate prospects, though others require setting up of new machinery.