basin BUILDING PARTNERSHIPS

Wall Building
Case Study
building advisory service and information network

Production of red mud building materials in Jamaica:

Case Study 1: Production of cement stabilized red mud bricks

Introduction

Before the end of the decade of the 1980's red mud became a major concern in world environmental discussions, and international attention focused on Jamaica alongside Australia and Guinea which by then were the world's three largest producers of bauxite and alumina.

A number of studies designed to mitigate the negative effects of red mud have been undertaken by the bauxite companies that operate in Jamaica over the years; but because these were always private, very little of the results have been published or shared in any significant way with the international scientific community, or even with the relevant departments of the Government of Jamaica.

In 1986, the Building Research Institute (BRI) in Jamaica designed a Research and Development project to seek to identify at least one commercial use for red mud that would conceivably reduce the accumulation of this waste material in designated storage areas. This particular project involved the use of the processes involved in the stabilized soil technology, to produce red mud building bricks. Subsequent to that, the Jamaica Bauxite Institute (JBI) successfully secured funds from the IDRC (International Development Research Council) in Canada to undertake another project also directed at the development of building components from red mud.

The latter project was pursued between 1987 and 1995, and in addition to the JBI, involved the University of Toronto and The University of the West Indies. By the time the project was concluded in 1995, several modifications were applied to its original format and scope, and the new final phase was actually sponsored by Alcan Jamaica LTD, one of the largest processors of bauxite in Jamaica.

This is the first of two case studies that are intended to showcase Jamaica's efforts to develop useful avenues for red mud, which is by far the most voluminous waste that arises from commercial and industrial activities in the country. This particular study focuses on the BRI cement stabilized red mud project whilst the other will highlight the JBI/IDRC project.

The bauxite and alumina industry in Jamaica

Bauxite is the ore from which the mineral Alumina is extracted by a particular industrial process, and subsequently converted to the notably lightweight metal, Aluminium, in another industrial process.

For more than thirty years bauxite and alumina together have been Jamaica's largest commodity export products, amounting to more than 60% of such exports in 1997.

It is typical throughout the Jamaican bauxite/alumina industry which uses the Bayer refining process exclusively, that for every tonne of alumina produced from bauxite, an almost equivalent quantity (1 tonne) of waste product (bauxite tailing) called red mud is produced. This material is pumped from each plant as a bright red coloured slurry and has been disposed of traditionally by dumping in natural depressions, and more recently by dry stacking on gentle slopes.

Over the past forty years, millions of tons of red mud have accumulated in red mud lakes and dry stacking areas associated with four processing plants operated by three private companies throughout central Jamaica. These were virtually ignored by environmentalists in the earliest years but in more recent times, evidence has been supplied to vindicate long held suspicions that hazardous chemicals which includes caustic soda, that are contained in red mud, have been seeping into water aquifers and are possibly contaminating ground water supplies.

Oxide	Gibbsitic Mud (wt %)	Boehmitic Mud (wt %)
Al_2O_3	16.52	16.35
SiO_2	3.05	7.99
CaO	5.68	9.06
P_2O_5	1.32	0.91
Fe_2O_3	49.53	42.33
TiO_2	6.80	5.99
Na_2O	1.40	4.60
L.O.I	13.40	10.20

Table 1: Chemical composition of Jamaican red muds

With the intervention of some of the more active international environmental activist organizations, this problem has become a universal one but particularly so in countries such as Jamaica, with relatively large bauxite/alumina industries. The resulting controversy has spawned global efforts to find meaningful uses for red mud. These efforts have included the production of a variety of building materials; and in Jamaica, projects have been pursued with the main objective of producing building bricks and blocks from red mud in combination with other materials.

Jamaican red mud

Of the four plants that produce red mud as a by-product, three of them process gibbsite-rich bauxite and consequently the resulting red muds are gibbsite-rich, whereas the other for obvious reasons, produces boehmite-rich red mud. The chemical composition of gibbsite-rich and boehmite-rich muds are listed in Table1.

Basic Philosophy of Project

The Jamaica Building Research Institute, as part of its pre-project activities and with limited resources, conducted a number of logistical and site studies at different storage areas (ponds and dry stacking areas) and as a result, only the mud from Alcan's (Ewarton) dry stacking area was used in the actual project.

In the selection of possible Research and Development projects that could be pursued towards the development of one or more types of building materials from Jamaican red mud alone, or in combination with additives that would be relatively inexpensive, a number of preliminary studies were done which involved investigations of:

- Qualitative physical and chemical properties of the muds from all four factories to identify fundamental similarities and differences;
- The utility of red mud as it relates to its potential to replace aggregates or extenders in industrial or commercial processes that do not require chemical combination of these types of materials;
- Natural bonding properties of red mud;
- Drying dynamics of red mud.

Although some definitive results were obtained from these exercises it was difficult to adduce conclusive trends primarily because a lack of essential equipment and other resources curtailed their effectiveness. After a process that involved the elimination of many technologies for a variety of reasons, it was decided that the most practical way of using red mud as a building material at the time was to use it as one would use a proven soil to produce building bricks with the stabilized soil technology.

It is significant that Jamaican clays in general, and in particular, red coloured terra-cotta type clays almost always have relatively fine particle sizes and high plasticities which are the chief physical characteristics normally used to explain why they are notably poor soils for the application of stabilized soil technology. Red muds, on the other hand, have very fine particle sizes, which are similar to clays, but unlike clays, they have very low plasticities.

The unique combination of a fine particle size and low plasticity was seen as a good reason to apply the technology to red mud. In addition, the mineralogy of the mud which is typified by high iron and the presence of residual aluminium oxides, made it easy to choose Portland cement or lime as the stabilizer given that either of these stabilizers tend to form agglomerations of hydrated cement or lime phases with available fine particles of the participating materials. In this particular case, cement was the obvious choice since it is less costly than lime in Jamaica.

Materials and equipment

Red mud

Red mud for the purpose of R & D work is usually collected from the driest part of the mud lake or dry stack because nobody wants to transport unwanted water for several miles to an R & D facility. The mud accumulated at the Alcan (Ewarton)

Fig. 1: Bricks produced with a CINVA ram and stacked on the ground for drying

dry stack contains about 4% moisture at any given time. About the same level of moisture would be associated with mud from the driest section of any of the traditional mud lakes; but generally, the dry stack is more accessible and hence all mud for this project derived from the Alcan (red mud) dry stack. A front-end loader or a backhoe can easily remove mud from the dry stack and load a lorry. Similarly, where small quantities are needed for experimental work, it is normally removed from the dry stack with a shovel and used to fill plastic bags.

Untreated mud from the dry stack has particle size distribution ranging from 5cm (2") down to sub-micron size, with a high concentration of particles larger than 0.6cm (1/4") in size. This is due to agglomeration of the naturally fine particles during the process of solar drying in the dry stack.

In order to use the mud from the dry stack to manufacture bricks or other building materials using this technology, it has to be ground mechanically to give a desirable blend of coarse and fine particles. The BRI project involved the use of a simple hammer mill fitted with a 0.6cm screen, to reduce the natural dry mud (in lumps) to a particle size spread ranging in size from 0.6 cm (1/4") to dust. In handling dry red mud it is necessary for handlers to wear polypropylene gloves, and for crushing, it is essential for handlers to wear respirators. Furthermore, it is preferable to undertake all activities inclusive of drying, crushing, mixing and fabrication of bricks in open air, possibly within the confines of an open shed.

Portland cement

A single factory in Jamaica, which accounts for all the markets for this commodity since there is no notable importation, produces Portland cement. Because of this monopoly situation no effort was made to establish standards for the stabilizing cement. However, it is noteworthy that Jamaican cement is marketed as a very fine-grained material.

River sand

Although there are a few areas in the country in which wind blown sand is mined from natural dunes for construction purposes, river sand is almost ubiquitous in the building and construction industry. This sand which is used for mortar and concrete preparation is mined from the lower reaches of rivers and subsequently screened before use. Typical construction sand has a size range of 0.5-1.00mm.

Equipment

The stabilized soil building materials programme was started at the BRI a number of years before the red mud brick project was conceived and as a result of the years of experience with this technology, as much as three different types of fabrication equipment for brick-making were acquired. These are:

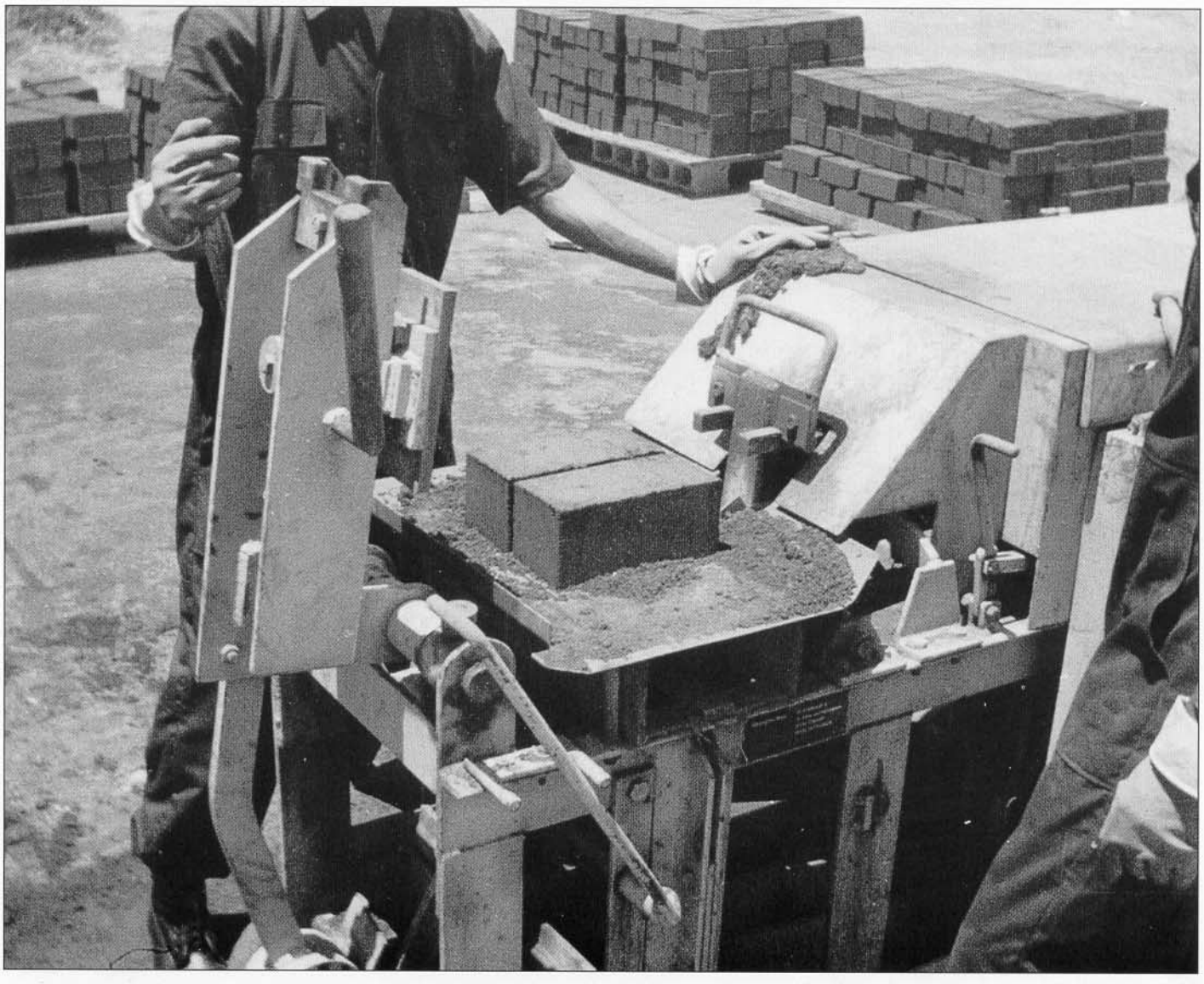

Fig. 2: Demoulding of bricks