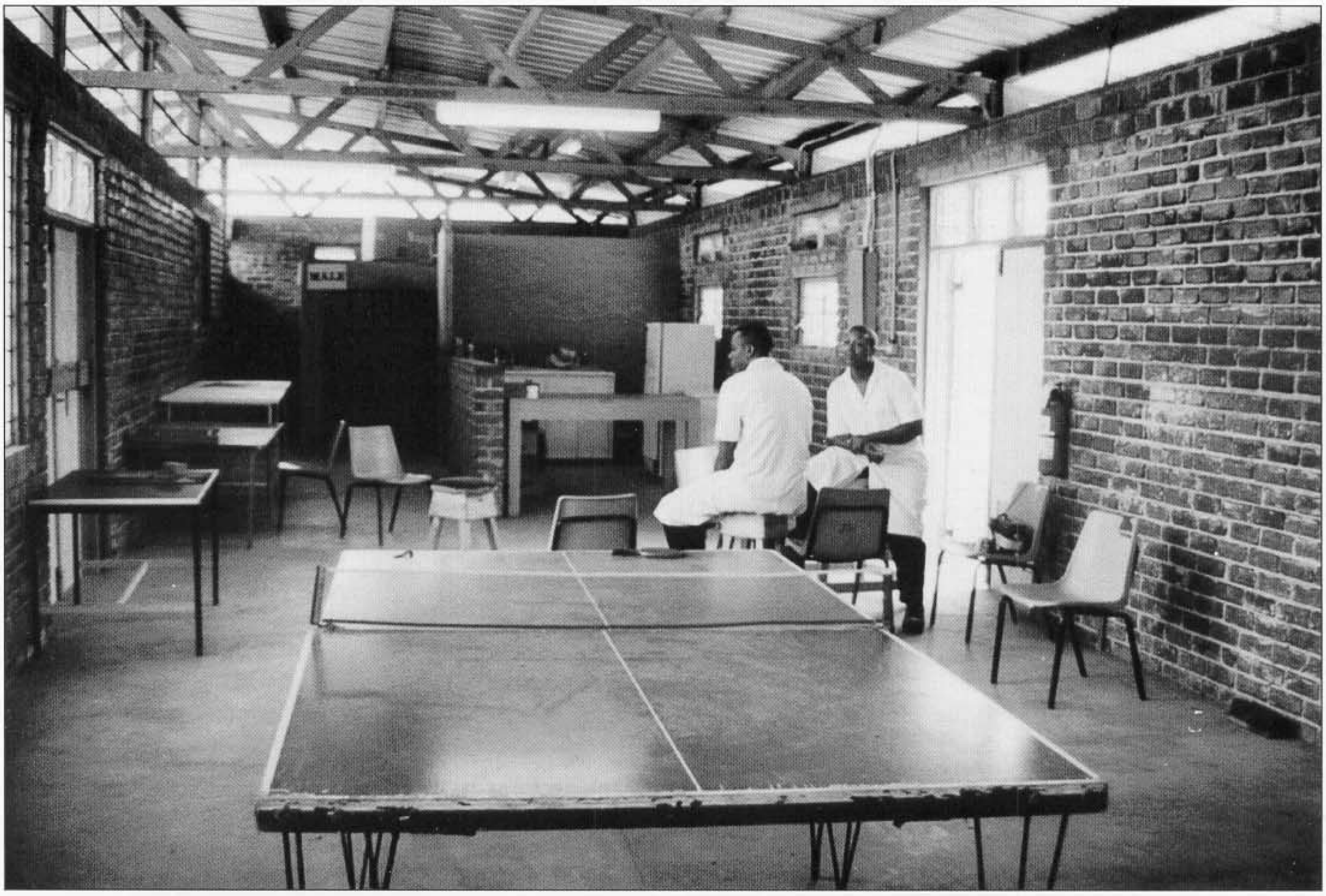

Fig. 3: Interior of JBI "Red Mud Demonstration Building" (Sports Pavilion)

Construction of the demonstration building of red mud cement bricks at the JBI

In 1992, when the JBI took the decision to construct the demonstration building for use as its sports pavilion, it was intended to use all the products of the project for its construction (Fig. 2). Unfortunately, only the silicate bonded red mud bricks were eventually used since routine tests conducted on bricks and blocks produced from the cement revealed a number of technical faults which were highlighted by (1) loss of strength with time and (2) mediocre weathering characteristics.

By the time the final report of the project was written in the latter months of 1995, all the external walls of the building were completed, in addition to the roof and other aspects. At present, the building is still unfinished due to shortage of funds but tests on the building envelope are ongoing.

The silicate bonded bricks used in the construction were fabricated as 20cm x 10m x 6cm (8" x 4" x 2 1/2") units, which means that the thickness was reduced from the usual 10cm for which the mould was designed and also departs from the size of the bricks made in the BRI project. This size, however, represents the standard size for bricks produced in Jamaica and many other countries, principally by the extrusion of clay. This size was achieved by inserting a spacer (timber) of desired thickness into the mould just before it is filled with material for pressing (Fig. 3).

The building, which was only recently completed, is very attractive and the particular hue assumed by the silicate bonded bricks is a large contributor (Fig. 4). Close inspection of the walls that have been in place for the past five years, reveal a number of minor faults due to weathering. These include the formation of white coloured carbonate material at some of the brick/mortar interfaces. Generally, however, the faults are considered minor and should be surmounted by simply fine-tuning the material formulation and the production process.

As far as the red mud cement is concerned, a relatively short-term project to address the problems identified has been designed, and now awaits funding for its execution. Despite the problems, however, the cement is thought to be of immense potential, particularly since:

- It is versatile, being adaptable to the production of either bricks or blocks;
- It is composed of four different industrial by-products namely, red mud from bauxite processing; gypsum fines (tailings) from the gypsum mines; carbide lime, a by-product from the production of industrial gases; and bagasse-ash, a by-product from the sugar processing industry;
- It hardens readily and acts like other known pozzolanic cements for a long time, before it loses strength. This particular problem was also identified with Japanese red mud cement and the Japanese researchers are also optimistic that it can be corrected without significantly affecting the cost of producing the cement.

Study of the compatibility of reinforcing steel bars with red mud cement

The possibility of using red mud pozzolanic cement to fabricate standard size hollow building blocks to compete with concrete blocks necessitated that this investigation was done. This is primarily because considerable amounts of reinforcing steel is used in normal building construction as required by the authorities since the country lies in a relatively active seismic belt.

It was done on the basis that corrosion of reinforcement steel is normally influenced by:

- Initial pH of the material while it sets;
- The porosity of the cement once it sets;
- External attacks of chlorides and sulphur ions through the pores;
- Intrusions of water of low pH.

The necessary experiments, which involved the measurement of several parameters, were designed and carried out. Subsequently, the results were compared with known results for Portland cement.

It was eventually concluded that when a steel bar is embedded in red mud cement, its surface corrodes at a very slow rate due to the high pH of the fresh cement. Early reaction results in the formation of a corrosion layer of Iron Oxide (Fe_2O_3). This layer becomes permanent and very little corrosion continues after the cement sets (three to four weeks) at which time the pH is significantly reduced to a near neutral position. The basic inference is that generally the corrosion of reinforcing steel in red mud is considered similar to that in Portland cement, which means that it is fairly benign.

Radiological properties of Jamaican red mud building materials

The study of radioactivity in red mud buildings in Jamaica, has been carried out largely by Dr. Willard Pinnock, a lecturer at the University of the West Indies (UWI). Like this writer, Dr. Pinnock has been involved with all of the red mud projects pursued by academic and public sector agencies in Jamaica over the past fifteen years.

The study, which started as an independent exercise was incorporated into the JBI/IDRC project at what was considered an appropriate time. It undertook to estimate the levels of radiation (as doses) that an occupier of a room made of red mud building materials would be exposed to over specific periods of time.

It was designed with the understanding that bauxite is known to have small amounts of the following radionuclides:

^{238}U, ^{232}Th, ^{40}K.

Significantly also, it has been well known that red mud contains about twice the amount of these sources of ionic radiation as it was before in the form of bauxite.

The red mud demonstration building associated with the earlier BRI project became the subject of most of the experiments carried out, and since the bricks used to construct this building consisted of only 50% red mud, plus sand and cement, the results obtained were extrapolated to reflect the expectations for a building with walls of nearly 100% red mud, such as the JBI building.

After it was agreed that the level of ^{40}K radiation associated with red mud was proven in many previous studies to be similar to that of river sand and gravel and therefore generally acceptable, the study became concerned primarily with:

- Direct gamma radiation through the body and
- Inhalation of the decay products of the inert gas, radon, which would be present in the air within such a house.

Doses due to gamma radiation were measured by thermo-luminescent detectors while radon levels were measured using strips of CR39 plastics as track etch detectors that register counts produced by radon and its daughters. In order to use a reliable model to predict the radon related dose levels, it was necessary to measure other parameters on which radon dose levels depend. These include:

- ^{238}U and ^{232}Th activity concentrations in the walls;
- Air turnover rates and
- Radon levels outdoor.

All tests were carried out in worst case situations in which a person could con-

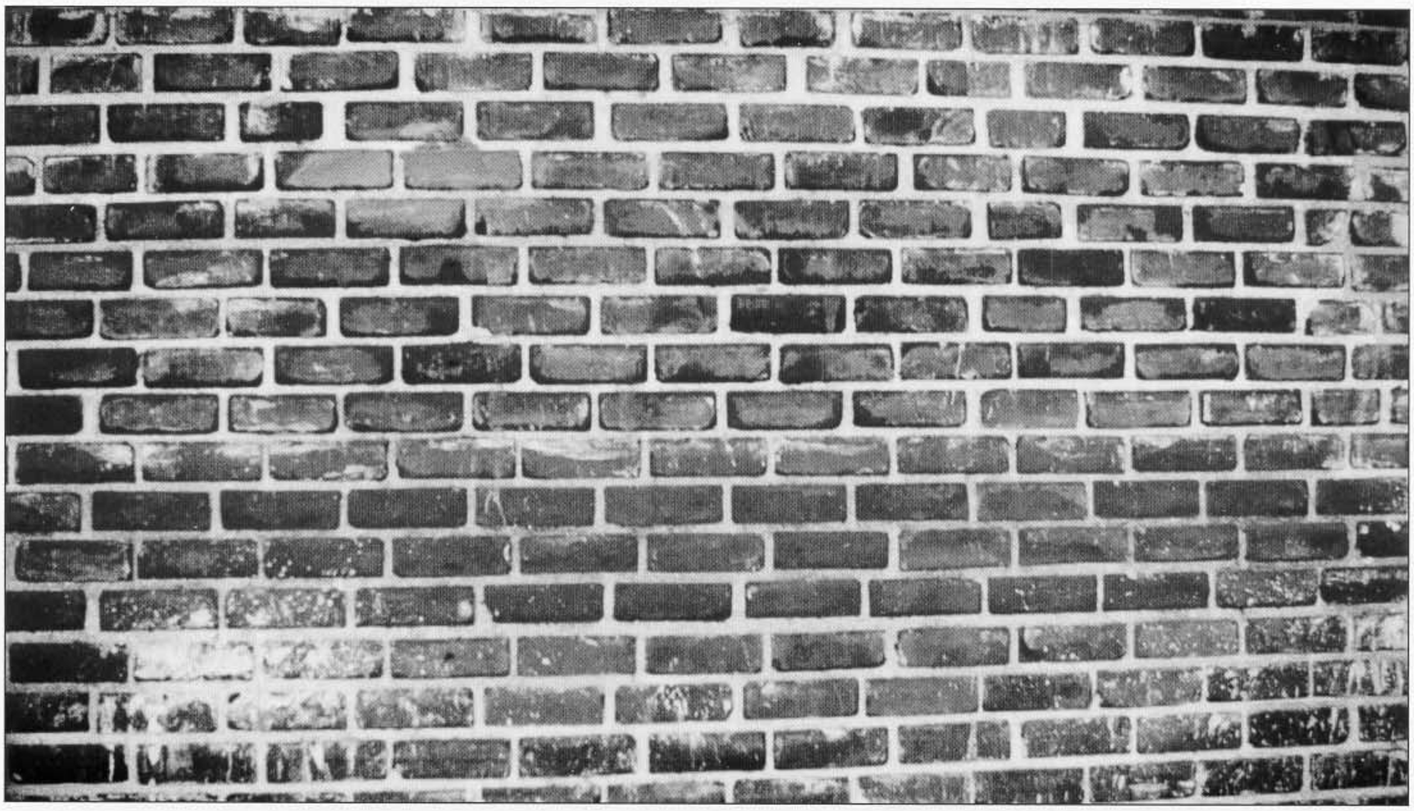

Fig. 4: Close-up of brick masonry of JBI Sports Pavilion

Type of House	Gamma Component	Radon Component	Total
BRI Red Mud Building	0.80	0.64	1.44
Hypothetical Building with walls of: 100% Red Mud	1.25	0.82	2.07
Typical Concrete Building	0.51	0.35	0.86

Table 3: Dose equivalents for houses made of different materials (msv/y)

ceivably live in a house. This included, for example, the closure of doors and windows of the red mud building save for the top segment of the metal louvre windows, which were only partly opened, for several weeks.

Table 3 indicates the estimated dose equivalents, based on the experiments carried out, of houses made of two different types of red mud based materials, and the other from concrete.

From Table 3, the total value of 0.86 msv/y (millisievert per year) estimated for a house of concrete is taken as background dose level since concrete is the most acceptable building material internationally, and in addition, it is the most used building material in Jamaica. From the other results, the BRI house made of bricks of 50% red mud, has an estimated dose level of 1.44msv/y which is 0.58 msv/y above background, and the JBI house has an estimated dose level of 1.21 above background, in worst case scenarios.

On the basis of these results, it is believed that building construction with either material would be acceptable in Jamaica. However, a direct recommendation would not be made immediately to the Jamaican authorities, not the least of which is the Bureau of Standards, since there is every justification for additional investigation to be done in the two available red mud buildings, and also for the other situations/conditions to be simulated and evaluated.

Conclusions

Silicate bonded red mud bricks

The development of a process to produce silicate bonded red mud bricks was successful. It was demonstrated that carefully selected sodium silicate solution significantly increased the compressive strengths and afforded good overall appearance and stability to bricks made of 100% Jamaican red mud. The cost of the silicate solution became a problem in Jamaica because it is not produced in the country and its importation in an economic environment in which a high percentage of imports are restricted by punitive tariffs, makes it uncompetitive with conventionally used concrete products. It is, however, possible that if the desired silicate is produced in Jamaica, given the abundance of one of the two main ingredients, silica sand, that the cost of silicate per brick can be significantly reduced, which would make it competitive.

Outside of Jamaica, this technology could provide a good opportunity for countries that are able to either produce or import the silicate cheaply, to effectively use their stockpiles of red mud.

Red mud pozzolanic cement

This pozzolanic cement is more versatile than other red mud building material formulations, being able to produce both bricks and hollow blocks. It is notable that most new construction projects involve the use of hollow blocks primarily because it enables easy inclusion of reinforcing steel.

The problem of reduced strength with time is believed to be only superficial and consequently a short-term project has been designed to correct it. This new dimension will only be implemented when the requisite funds are identified.

Rational Research and Development work in red mud building materials internationally, may very well concentrate on fine-tuning this technology. The type of cement produced may vary from country to country since it will be dependent on the nature and quantity of residual alumina contained in the respective muds.

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