Fig. 3: Wet mixing of raw materials just before pressing

- Cinva-Ram Press
- Bre-Pak Press
- Platbrood Semi-Automatic Press.

All three were eventually used to produce red mud bricks. The Cinva-Ram press is perhaps the oldest known manually operated press associated with the stabilized soil brick technology and was first used in Jamaica as far back as the 1950's, long before any co-ordinated building materials development programme was started in the country. This press was used to produce red mud bricks as 10cm x 15cm x 30cm (4" x 6" x 12") units at a fixed forming pressure (Fig. 1).

The Bre-Pak press produces bricks in the dimensions of 29cm x 14cm x 8cm (11 1/2" x 5 1/2" x 3 1/2") and has the advantage of facilitating an increase of forming pressure by the use of an attached hydraulic jack, after the initial pressure is applied. As a result, it was used to fabricate red mud bricks at pressures of around 40 MPa (Megapascals); these largely yielded compressive strengths that exceeded 5 MPa. The problem with this machine, however, is that like the Cinva-Ram machine, the absence of any form of automation ensures that it is unsuitable for operation in a productive environment.

The Platbrood semi-automatic press is produced in Belgium. It is capable of producing over 100 bricks per hour if handled by two operators who, in addition to pressing, would measure and mix the material before pressing. This machine was demonstrated in the project to be capable of producing 720 bricks per 8-hour day, when operated by two untrained and inexperienced operators. At each pressing, two bricks in the dimensions of 20cm x 10cm x 10cm (8" x 4" x 4") are produced. It is estimated that the pressing pressure is about 27 MPa. The machine is essentially a compact diesel engine with a simple clutching system, which facilitate pressing and release of pressed bricks (Fig. 2). The machine was used in both the BRI and JBI projects and as a consequence produced several thousand bricks to facilitate the construction of two separate demonstration buildings. In spite of the dusty nature of the dry mud coupled with the relatively high alkalinity of the red mud brick formulations, the machine required very little maintenance. In general, it performed excellently in both of the red mud R & D projects pursued to date in Jamaica, and is highly recommended to people in other countries who may want to undertake commercial stabilized red mud brick making projects in the future.

Mixing and fabrication

In the manufacturing of red mud bricks as with many other building materials, it is necessary to effect primary preparation to the separate components of the final mixture followed by stockpiling of each before the brick production process is started. Red mud requires drying and crushing, river sand requires screening, but the other component, cement, requires no special preparation since it has to be purchased as a refined product.

It was discovered during the course of the project that it was advantageous for the two operators to mix the material in 60 kg batches (dry basis) before pressing. In the mixing process used, the red mud, sand and cement were mixed dry at first by a shovel, after which water was added intermittently between more mixing until a total of about 18% w/w water was eventually added to yield a consistent mixture (Fig. 3). Special care had to be taken to avoid lumping which militates against smooth incident free pressing.

After weighting and mixing the first few batches of raw materials and water, the operators became familiar with the quantities and subsequently apportioned the separate components on a volume basis, based on their own judgements. In addition, they were able to develop a certain appreciation of the correct texture of the mixed material for pressing and made necessary adjustments to water quantity needs from time to time which was necessitated by changing climatic conditions throughout any given day.

A 60 kg batch would normally yield 28-30 bricks and significantly, almost all bricks fabricated with the fixed material formulation which consist of 50% red mud, 43% sand and 7% cement, were demoulded as smooth unscathed units, and

very little recycling was necessary. This was not the case with stabilized soil bricks where even the very best soils resulted in about 15% of all bricks pressed, collapsing on handling and having to be recycled.

After drying, the bricks become brighter red in colour and resembles terra-cotta clay bricks to the extent that untrained eyes would be unable to make a distinction between the two types of bricks. Although relatively moist just after being demoulded, they are generally compact enough to enable stockpiling to two brick levels, and in 12 hours many more can be stacked thereupon. In making stockpiles, however, it is essential to ensure that as many surfaces as possible are exposed to air or direct sunlight to avoid abnormally slow drying/curing, which under ideal conditions can be completed in three weeks.

Completion of curing in three weeks is contingent on regular spraying with water over at least the first ten days after demoulding, but ideally every day for the period. A garden hose with an appropriate sprinkling head is best for this purpose but even if the water pressure is not particularly high it is recommended that sacking or fabric material or even newspaper might be used to cover the bricks before applying the water jet. This is to prevent pitting or other surface abrasions that may result from direct contact of water jets.

Testing of bricks

The Jamaica Bureau of Standards (JBS) has been for many years developing Jamaican standards for all categories of building materials used in Jamaica. One of those recently completed is a product standard for clay bricks, which is essentially patterned from the ASTM standards. Although some of the parameters are easily achieved by cement stabilized red mud bricks, a major problem exist as far as compressive strength is concerned, and at present, interested parties are advocating for the relevant authorities to do the necessary research, and proceed to establish Jamaican standards that would cover not only red mud bricks but also stabilized soil bricks. It is believed that the results obtained from tests conducted on existing demonstration buildings made from these materials, will in the medium and long term, significantly assist in achieving this objective.

In many countries in which stabilized soil technology is contemplated, the considered acceptable compressive strength usually lies in the range 4-5.5 MPa. Cement stabilized red mud bricks produced in this project have consistently yielded compressive strengths that largely exceed 4.5 MPa. Many leaders in the country's building industry consider this satisfactory but there is need to get the relevant government authorities to join these leaders in arriving at a consensus.

In testing the bricks several parameters were explored but the most important ones were water absorption, compressive strength, durability (wetting and drying) and squareness.

Some of the notable properties of Jamaican cement stabilized red mud bricks are as follows:

- Bulk Density: 1380 kg/m^3
- Weight of Brick 4 kg
- Water Absorption 18% - 20%
- Abraison Loss 0.78%
- Compressive Strength 4.7 MPa (690 psi)
- Dimensions of Brick 20cm x 10cm x 10cm.

Construction of demonstration building

Over 6,000 cement stabilized red mud bricks were made with the semi-automatic brickmaking machine, and cured over a period of one month before construction of the demonstration building was started. The building as it now stands, is about 37 sq m (400 sq ft) in size and consists of two rooms of unequal dimensions (Fig. 4). The larger room has three metal louvre windows which if opened allows significant solar illumination at daytime and also affords tremendous air change, while the other only has two small concrete louvre windows and requires artificial lighting even in daytime hours. These contrasting features in the design of the rooms were deliberately executed to facilitate the various tests that were planned for subsequent years.

In addition, it was designed to accommodate other relatively new building materials, particularly stone masonry blocks and concrete funicular shells, both of which are building materials technologies that were only shortly before transferred from India.

In the construction of the building, the strip footing foundation was immediately overlaid by 15cm x 15cm x 30cm concrete stone masonry blocks and brought up to a level of 1/2 metre above surface; this was done to ensure that the yet unproven red mud bricks would not be exposed to waterlogging that would result from possible sustained flooding.

All walls were constructed with stabilized red mud bricks while openings, lintels, the belt course and the roof were done with concrete; this includes the exclusive use of funicular shells as roofing material. The use of the English bond method of brick wall construction necessitated that steel reinforcement was not included in

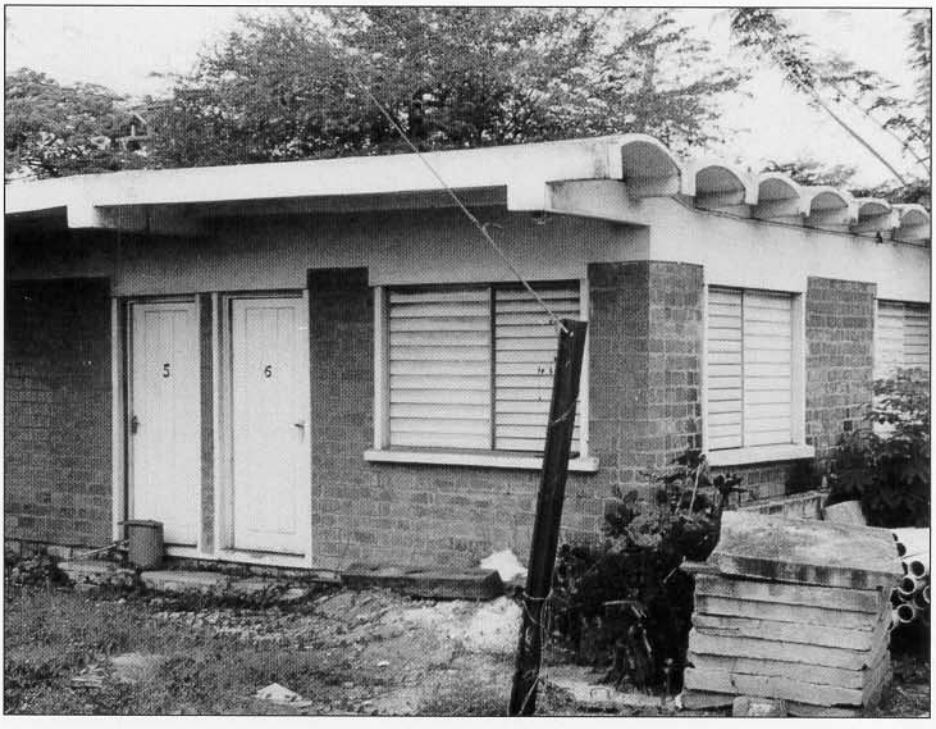

Fig. 4: The BRI red mud demonstration building (1998)

the construction of the walls, however, normal amounts were included in all other areas that did not include bricks.

Sand-cement mortar was used in the brick wall construction, which was pointed for added aesthetics (Fig. 5). The only two doors used were of Timber, and internally, fixtures were installed to match the overall intended functions of the building. The larger side of the building was intended for use as a display area for the BRI's technologies while the other section was to be used as a canteen facility for workers at the Laboratory/Workshop facility.

Unfortunately, although the building was completed, it was never put to the intended uses and even to date it has never been used. This is a consequence of the closure of the Institute shortly thereafter, and the Government of Jamaica not subsequently finding use for it although it is located on one of Kingston's better properties. The aggregate of these circumstances is the fact that whatever results are obtained on the performance of the building envelope now, or in the immediate future, save for radiation studies, will be confined to the exterior of the building.

The results of the radiation studies carried out in this building are reported in the second case study which focuses on the production of silicate bonded red mud bricks and pozzolanic red mud cement in a subsequent project undertaken by the Jamaica Bauxite Institute. Although the results are preliminary and need to be embellished by other investigations, they are encouraging, to the extent that it is now believed that radiation might not be a factor as far as safety is concerned, in the rational use of red mud building materials to construct houses and other buildings in Jamaica.

Conclusions

After eleven years of existence, between 1987 and 1998, the demonstration building constructed primarily of cement stabilized red mud bricks in Kingston, Jamaica is characterized by the following:

- Good weathering of red mud bricks with no brick having signs of fatigue or peeling due to water saturation;
- Good bond of bricks and cement mortar;
- High resistance to the growth of fungus or other types of micro-organisms;
- No fading of the incipient red colour;
- No cracking that would suggest a need for steel reinforcement in brick masonry.

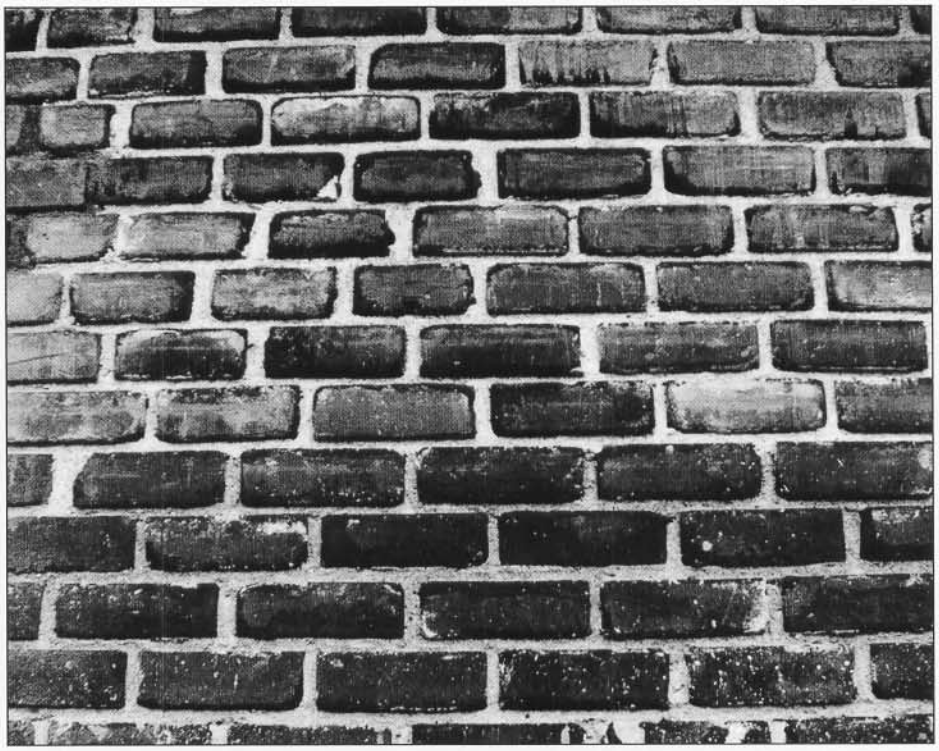

Fig. 5: Close-up of brick masonry of BRI red mud demonstration building

These results were obtained in spite of the fact that in the period 1990 -1993, a number of medium intensity earth tremors with considerable after-shocks were experienced in Jamaica.

In addition, although bauxite and red mud are noted internationally to have higher than normal levels of radiation, investigations carried out in the building over a period of time, have given early assurance that there is no inordinate risk of radiation exposure if such a building is used as a permanent dwelling.

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