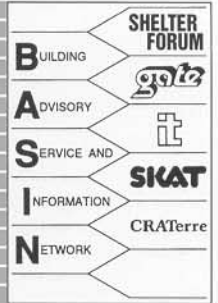




# Wall Building

## Case Study



## Small and medium scale brick and tile production in Ghana – 2 Technology alternatives

### Introduction

Based on a study undertaken at the end of 1996, the first paper on small and medium scale brick and tile production in Ghana gives an overview of the current situation in this industry. This paper deals with the various levels of technology applied.

The building materials industry is one of the few industries where many levels of technology exist. Some of these technologies are highly sophisticated and automated and some are manually operated at all stages of operation. In between these extremes are many technologies which have different combinations of labour and capital. This group of technology is generally termed semi-mechanized.

### Technology for brickmaking

#### *Labour-intensive technology*

The main characteristics of labour-intensive, small scale brick and tile factories are:

- They require very little capital investment.
- They mainly require unskilled labour, which is always abundant.
- Most operations are done manually.
- Operation costs are relatively low.
- They are suitable for the rural areas with small markets, where demand is below 3 million bricks per year.
- Firing is done in intermittent kilns or clamps, which are cheap and straightforward, using a vast variety of agro-waste material as fuel.
- Production rates are low and energy consumption is high, through radiation and convection losses during firing.
- Product qualities are low, but sufficient for low-rise housing construction.

The most common manual operations are: digging the clay with picks and shovels, removing stones, roots and other undesir-

able objects by hand, breaking down the big lumps of clay and sieving with simple implements. The same applies to the correction of the particle size distribution, by adding sand to clayey soil, or adding clay if it is too sandy. About 40% of the labour-intensive factories use pugmills for mixing, the remaining 60% mix manually, by treading the wet clay with feet. The clay is covered to prevent it from drying out and allowed to mature for a few days before it is moulded.

The bricks are formed in wooden moulds on a moulding table. The inner surfaces of the moulds are brushed with sawdust to facilitate demoulding. The clay is thrown with force into the mould to give it a dynamic compaction, the excess is removed

with a wire-cutter, and the formed bricks are demoulded onto a wooden pallet. The pallets with the wet bricks are placed on racks in a drying shed. Air drying takes about 3 weeks, but may take longer during the rainy season. During the harmattan (dry) season the drying is faster with accompanying shrinkage cracks.

The green bricks are usually burnt in intermittent kilns, with capacities ranging from 5,000 to 20,000 per day. A few of the labour-intensive factories carry out clamp firing, with clamp capacities ranging from 15,000 to 25,000 bricks, using firewood. Some factories use a combination of firewood and palm kernel shells, others a combination of firewood and sawdust briquette, but none of them use solely palm kernel shells or sawdust briquette. The setting up of the green bricks, the removal of the burnt bricks from the kiln, their sorting and stacking are all done manually.

There is no control over the firing once it has started. A large proportion of the products may be over or under-burnt. Using intermittent kilns, higher production quality can be achieved. To improve the efficiency of bricks clamps, adequate insulation needs to be provided to reduce heat loss, and firing should be slow during the first few hours of the process.

The equipment and tools required are simple and relatively inexpensive. These include pickaxes, shovels and cutlasses for winning the clay; headpans and/or wheelbarrows for transporting the clay to the factory; drums for storing water, or if there is a pipe borne water source at the factory then a long water hose may be required. Saws or machetes are required for obtaining firewood; Wellington boots to be worn by the mixers if they have to tread with their feet; moulding benches and wire cutters; wooden moulds or metallic ones. Sometimes locally manufactured pugmills are found in these factories.



Figure 1 Hand-moulding of clay bricks

Figure 2 Placing the pallets with the wet bricks on racks for air drying



### *Semi-mechanized technology*

The main characteristics of semi-mechanized, medium scale factories are:

- They allow for various degrees of mechanization or combination of labour and capital.
- They require both skilled and unskilled labour.
- Some of the operations are carried out mechanically and some manually.
- Operation costs are higher than in small scale factories.
- They are not suitable for the rural areas unless they are close to big commercial towns with sizeable markets, where demand is 3 - 5 million bricks per year.
- Firing is usually done in continuous kilns, using residual oil or gas as fuel.
- Product qualities are good, providing a variety of products for a wide range of construction purposes.

There are many levels of semi-mechanization. Generally, the winning, preparation, mixing and moulding processes are mechanized. These are extensive operations to ensure greater homogeneity and easier passage of the clay through the die.

All the semi-mechanized factories hire draglines and multi-bucket excavators for winning their clays, and tipper trucks or dumpers to transport the clay to the factory. The mixing is undertaken mechanically by a clay crusher, feed conveyor and a pugmill, and forming takes place in a pugmill-cum-extruder with constant flow. The machine delivers a continuous "column" of clay which is cut up into formed bricks of required size by a wire cutter. All these machines are hand operated. The green bricks are transferred onto pallets and placed on racks under a drying shed, where the drying is natural. In the case of artificial drying, the green bricks are placed in drying chambers, which make use of the heat recovered from the cooling zone of the kiln.

Continuous kilns or different versions of Hoffmann kilns (with accessories equipment, ie thermocouple and pick-up, oil and water storage tanks) are used for firing with residual oil or gas. Some factories use only coal, or wood and agro-waste for firing. The setting up of green bricks, and removal, sorting and stacking of the burnt bricks are done manually.

The manpower requirements are principally a manager, a fitter, an electrician, a mason, a carpenter and unskilled labour.

### *Fully mechanized technology*

The main characteristics of fully mechanized, large scale factories are:

- They are capital-intensive and very sophisticated.
- They require highly skilled personnel.
- All operations are fully mechanized and, in most cases, the machines are automated.
- Operation costs are extremely high.
- The production capacity must be in the range of 15 - 20 million bricks per year to be viable.
- Firing is done in continuous kilns, Hoffmann type kilns or even tunnel kilns, using residual oil or gas as fuel.
- Product qualities are excellent, providing a variety of products for high standard constructions.

The machinery used is the same or even more sophisticated than that described under semi-mechanized technology. In some cases, where the clay deposit is fairly close to the factory, a conveyor system is installed in the pit to carry the clay to the factory. The fully mechanized technology requires that the clay is very well prepared to meet a precisely defined particle-size distribution and moisture content. The motorized presses and extruders are fully automated and the green bricks are dried in artificial drying chambers.

The bricks are burnt in continuous or Hoffmann type kilns, or in the more sophisticated and capital-intensive tunnel kilns, in which the bricks are passed through an area where the fire is stationary. This type of technology was used by the Prampram factory before it collapsed.

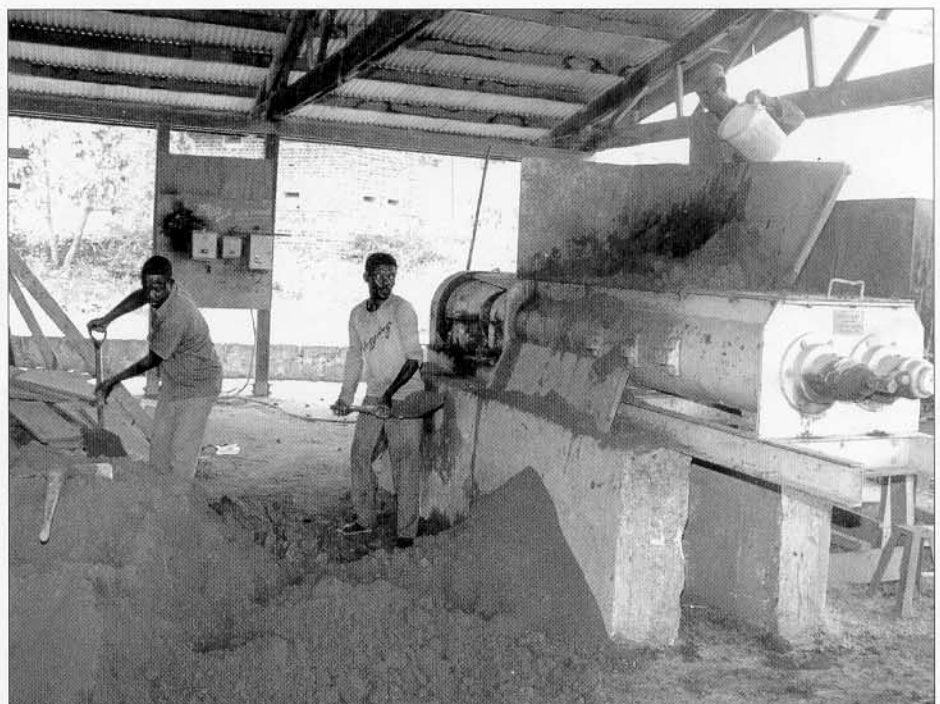
The type of highly skilled personnel needed for this technology are: experienced management and administrative staff; mechanical, electrical and electronic engineers; fitters and other skilled labourers; specialists for servicing and repairing of equipment, and a workshop with a good stock of spare parts to enable quick repairs.

This technology is suitable where sufficient financial resources are available, where labour is scarce and costly, where high production rates are needed and there is a high demand over a long period. It is also suitable for projects that specify high quality bricks and where there is sufficient energy supply at the factory and its environs, as well as facilities for repairs and maintenance. Clearly, all of these conditions are lacking in Ghana and in many developing African countries. The experience of total collapse of the Prampram factory suggests that Ghana is not yet ready for this type of technology.

### **Products of each technology**

The products of labour-intensive methods have low compressive strengths ranging from 4 - 8 N/mm<sup>2</sup> with fairly high water absorption of 12 - 20 %. The dimensions of the products tend to be irregular, but their rustic texture is preferred by many architects; they are economical, and are produced with little investment capital. The strength properties are adequate for a one or two-storey low-cost house, and for all non-load bearing building components.

Bricks from a fully mechanized factory possess high quality with optimum dimen-



*Figure 3* Mixing clay in a locally manufactured pugmill



sional uniformity and stable edges. The compressive strengths range from 17 - 42 N/mm<sup>2</sup>, with water absorption of 2 - 6 %, and are thus suitable for engineering projects. Clearly, products of this technology have strengths far more than will be required for low cost housing. They tend to be relatively expensive, as the process requires heavy investment and a sustained demand, two important factors that affect the pricing of these products.

The semi-mechanized products appear to be the most suitable, since they combine the merits of the labour-intensive and those of the fully mechanized ones. The strengths range from 7 - 18 N/mm<sup>2</sup>, and water absorption from 5 - 15 %. The dimensional uniformity of the products is fair to good. For a low cost housing project, the products of the labour-intensive and the semi-mechanized processes are the most suitable.

## Technology transfer to the urban and rural areas and communities

### Training of personnel

The basic requirement for the brick and tile industry to be successful is a comprehensive training of both the producers and users of burnt clay products.

- Brick and tile producers

The management staff should have some background in engineering or the physical sciences, or at least a first degree in chemical technology, metallurgical engineering or material science. The specialized training in the technology and methods of producing bricks and other structural clay prod-



Figure 4 Medium scale factory using mechanized methods of mixing and moulding bricks

ucts may be a concentrated six month programme and should include, but not necessarily be limited to, clay technology; drying and firing clayware; kilns, their design and operation; layout and economics of brick plants; quality control and plant management. At the end of the formal training, all trainees should have a four to six weeks tour of several factories covering a range of manufacturing methods and finished products. A similar programme should be organized for technicians and operators, but in these cases the emphasis will be on on-the-job training.

- Brick and tile users

Sandcrete and concrete blocks have been the main construction materials in Ghana

for such a long time that there are mainly blocklayers and relatively few bricklayers in the construction industry, so it is necessary to retrain the blocklayers to lay bricks as an additional skill. But also the client, the consultant or designer, and the contractor or builder should receive special training in the use of bricks and tiles for housing:

*The Client:* Since he provides the jobs for the industry, it is vital that he is fully aware of the possibilities and advantages of using burnt clay products, as compared to other building materials. The client is difficult to train, because the brick and tile industry in Ghana has not yet succeeded in producing sufficient, good quality bricks at reasonable costs. His training, therefore, demands the concerted efforts of all concerned with the production and use of bricks and tiles.

*The Consultant:* In the building construction industry, architects, structural engineers, material engineers, building technologists and quantity surveyors are the main professions which come together to form consultancies. Their ability to design with bricks as efficiently and economically as they have been doing with concrete and sandcrete blocks is crucial for ensuring the sustainability of the brick and tile industry. Should they lack the knowledge and experience, special training is essential. The architect and structural engineer must know the special design requirements and codes of practice for brick constructions. While the materials engineer and building technologist must have a thorough knowledge

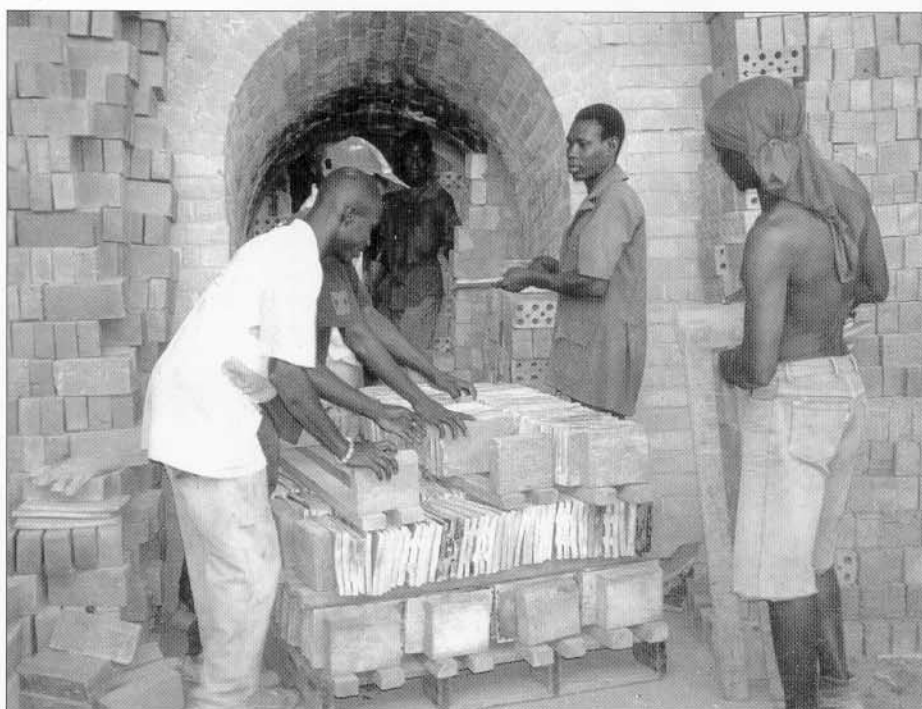


Figure 5 Manual removal of bricks from a kiln in a medium scale factory

of the types of bricks, their strength and durability properties, the quantity surveyor only needs an appreciation of the specifications of bricks and their unit costs.

*The Contractor:* This group consists of engineers, building technologists, financiers, technicians and craftsmen. Particularly the engineers and the building technologists should be more knowledgeable than their counterparts in consultancy, in order to call attention of the designer to incorrect detailing, because it is well known that failures of brickwork, very often lie in poor design and detailing. The blocklayer undergoing a retraining course should know the influence of water absorption of brick on mortar, how to prepare different mixes of mortar and the right thickness of mortar to use; different kinds of bonding; and many other things. The retraining of blocklayers to lay bricks is a rather delicate affair, as bricklaying is more of a craft and all craftsmen need a considerable number of years of practical experience to acquire the feel of the job. Therefore, an inexperienced bricklayer with a City and Guild certificate should not be made a foreman over a seasoned craftsman with many years of practical experience, but without a City and Guild certificate. The retraining programme should involve the Ministry of Education, Ministry of Works and Housing, the Building and Road Research Institute, the University of Science and Technology, Kumasi, and help from international bodies, like ODA, GTZ, ILO, and the bricks and tiles manufacturers.

#### *Technology transfer through low-cost housing programmes*

To enhance the transfer of the brick and tile technology to the urban and rural areas it is important to link the transfer with low-cost housing projects and organize both the rural and urban communities to participate in low-cost housing programmes as partners. Here participation is meant to include conceiving, planning, elaborating, managing and financing the project at village, district, provincial and regional levels, as well as national levels.

Experiences from other parts of the world, notably Latin America and Southeast Asia, show that for such programmes to be successful there should be full participation of the local community, where the people are able to improve their level of living with as much reliance as possible on their own initiative, by self help and mutual help. This is the underlying principle of the programmes. Initially, technical help will be required to provide the necessary training

of the people with the aim of transferring the technology to the community. In Ghana, the Building and Road Research Institute in Kumasi organizes a brickmaking course for any interested groups of people. The course is a practical training of all stages of brickmaking, from the identification and selection of suitable clays, techniques for preparation, mixing, and moulding of bricks to the firing of the green bricks. After the training, the trainees go back to train more people. A parallel training programme in bricklaying is also organized by the same institute. This way, construction of low-cost houses in bricks is promoted.

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## What is BASIN?

Building materials and construction technologies that are appropriate for developing countries, particularly in the low-income sector, are being developed, applied and documented in many parts of the world. This is an important prerequisite for providing safe, decent and affordable buildings for an ever-growing population.

But such new developments can do little to improve the building situation, as long as the information does not reach potential builders. The types and sources of information on standard and innovative building technologies are numerous and very diverse, making access to them difficult.

Thus, in order to remedy this drawback, Shelter Forum, GATE, ITDG, SKAT and CRATerre are co-operating in the Building Advisory Service and Information Network, which covers five principal subject areas and co-ordinates the documentation, evaluation and dissemination of information.

All five groups have a co-ordinated database from which information is available on Documents, Technologies, Equipment, Institutions, Consultants as well as on Projects and Programmes. In addition, printed material or individual advice on certain special subjects is provided on request. Research projects, training programmes and other field work can be implemented in co-operation with local organizations, if a distinct need can be identified and the circumstances permit.

BASIN is a service available to all institutions and individuals concerned with housing, building and planning in developing countries, but can only function efficiently if there is a regular feedback. Therefore, any publications, information, personal experiences, etc. that can be made available to BASIN are always welcome and will help BASIN to help others.



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