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PROMOTION OF BUILDING MATERIALS PRODUCTION

by

IAN KNIZEK

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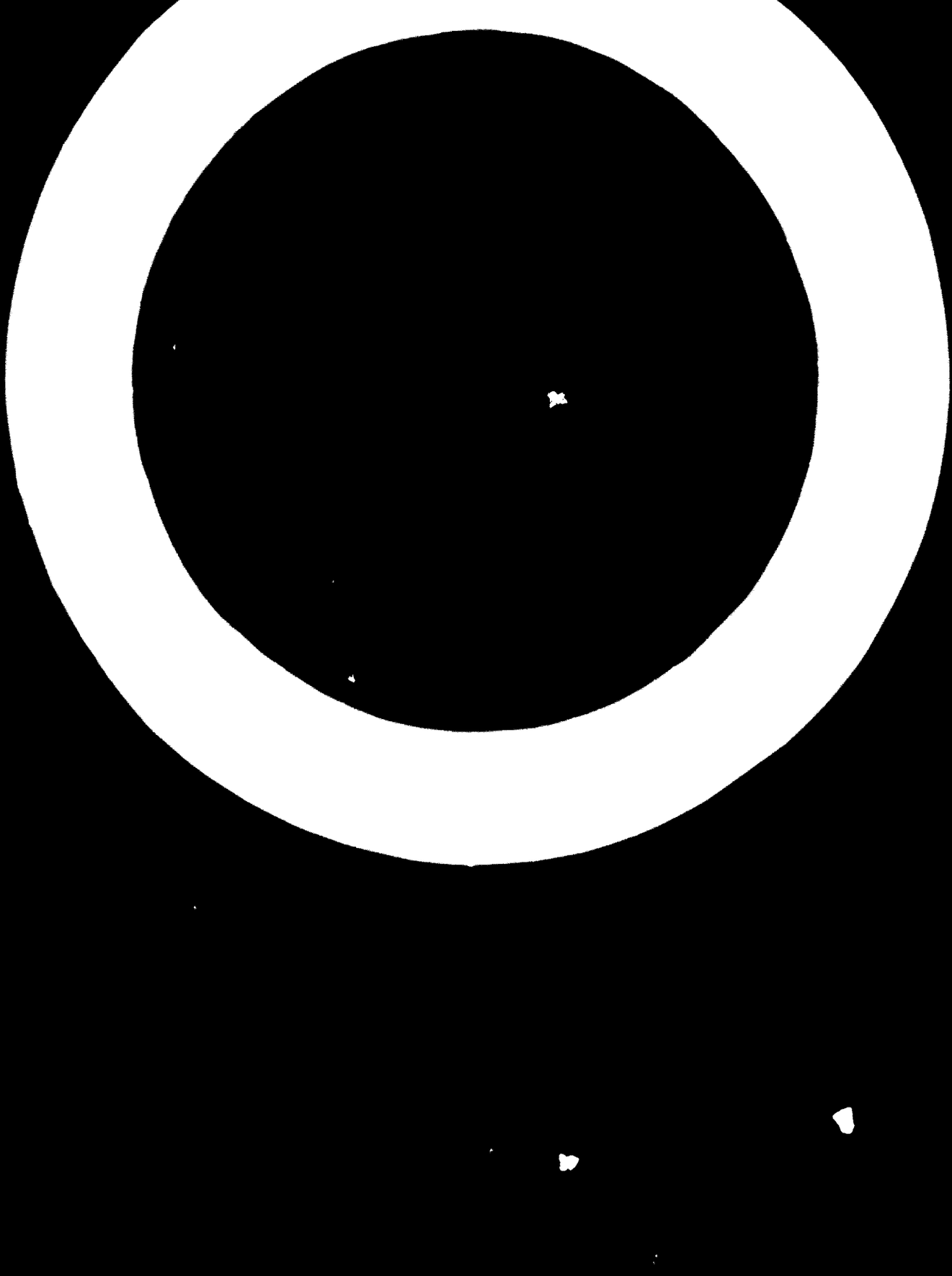
We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.



SUMMARY

In the first part of the paper the author presents short summaries of the Monographs submitted by the participating countries. In the second part the relevant facts, problems and situations, abstracted from the individual Monographs, are examined. Lack of knowledge of the available clay resources is one of the most commonly occurring situation. There are, however, significant exceptions. A rather disturbing aspect of the clay building materials manufacture in Africa is the steady decline of their popularity, which seems to take place in a significative number of countries. Where the loss of market is not due to a deteriorating quality (which seems to be the case in a few instances), it is almost always caused by poor marketing. The clay building materials industry in Africa has simply not responded creatively to the challenge offered by the spread of sand-cement products. The lack of skilled masons to erect attractive unrendered brick structures

seems to be a strong contributing cause. The fuel is becoming a problem as wood gets increasingly difficult to secure and more expensive at the same time. Proper firing control of Hoffman kilns still offers difficulties and experienced firemen are difficult to get. Brickmaking activities become complicated during the rainy season. The dilemma, however, whether to dry 100% of the output in artificial dryers (a solution favored at least by one country) or to depend on open-air drying under sheds, may only be uncovered after a painstaking analysis of all the factors involved, most of them of local character. Mechanization of brickmaking frequently causes the manufacturing costs to double when compared with handicraft or semi-mechanical operations. The convenience of labor-saving devices must also be carefully analyzed. In most African countries with an oversupply of inexpensive labor, their use will be confined to those operations which while fundamentally wasteful of labor - do not improve the quality of the product, if performed manually, such as transporting and setting.

Introduction

On behalf of the Centre for Housing, Building and Planning of the United Nations, the writer was commissioned by UNIDO to prepare a summary of the Monographs presented by the participants at the Workshop on Clay Building Materials

in Paris, December 6-12, 1970, concerning their experiences and the potential for the development and manufacture of clay building materials in their home countries.

Participants from eleven countries (excluding the host country) were present at the workshop, of which 9 contributed Monographs. Two of the countries presented two Monographs each. Two countries did not contribute Monographs but the writer was able to gather a fair amount of information by personal interviews with the participants during the workshop.

Characteristics and treatment of the material

It is an old axiom in many disciplines that the character and amount of information determine the form of the work based on them. As originally conceived, the data contributed by the participants were to be presented in a statistical form and discussed at the workshop. Individually the quality of the Monographs is very high, but the bulk of the information does not lend itself to statistical treatment. The situation of the clay building materials industry, as reflected in the Monographs, shows a wide variation of local conditions, shortages and needs. Furthermore, the presented information reveals a considerable degree of professional bias. This is only natural. An architect, a brickplant manager, a geologist or an economist - each regards the situation of the clay building materials industry from a viewpoint of his own.

All these viewpoints are equally valid but they do impart to the material a distinctive coloration. Thus the outlook presented to the observer is a kaleidoscopic rather than a synoptic one. Another of the characteristics of some of the contributions is that they deal with the situation of only a part of their country, most frequently the region around the capital city. How far their conclusions can be extrapolated to include the whole country is sometimes difficult to ascertai

Under these conditions every piece of information given in the monographs is an important and significant datum and must be thoroughly examined. Jairam, of course, the person best (as opposed to professional bias) is the obvious. Even though a given fact is mentioned in only one of the monographs, its absence from others might have been due to simple omission or to the possibility that the development of the clay building materials industry in these countries has not yet reached the stage to make its occurrence possible.

Consequently, the balance of the paper will consist of two parts. In the first the summaries of the individual monographs will be presented. In the second the relevant facts problems and situations abstracted from them will be examined and commented upon.

PART I

SUMMARIES

CONGO (B)

The Monograph starts by recognising that the use of clays (products) in building brings forth a considerable saving as compared with cement. Therefore, clays represents a natural resource of great importance. Clays are very common in Congo but the country lacks the means for their study. An inventory of the available resources should also be very useful. There are loams and pottery clays, plastic clays, kaolins and fire-clays. The latter are seldom pure. Kaolins outcrop in many creek beds but are mostly high in quartz. However, not all kaolins found in Congo are so high in quartz: good pottery is sometimes made from them; same is smooth, compact and has a good ring.

A large government-undertaking manufactures fired clay brick. Due to the dearness of mechanical equipment, primitive making methods are used in the villages. There does not seem to be a specific type of clay for use in brickmaking. Rather is varies from one region to another and even from one deposit to the next.

Nevertheless, the Monograph admits that Congolese clays are used in a quite disorderly manner. To improve the level of congolese clays used in the manufacture of brick, it

is necessary to supply the consumer in a consistent way with material of known characteristics which can be used with confidence. To be able to accomplish this, it is necessary to know them. To promote the consumption of clay bricks, it is necessary to know their possibilities and to communicate their standards of utilization to the consumer and to sell the brick at low prices.

In view of the importance of clay-based building materials for the economy of developing nations, it would correspond to UNIDO to assist Congo in improving their manufacture and in making them more competitive. Local authorities, on the other hand, may envisage the establishment of small undertakings for the manufacture of clay building materials. Under present conditions the ideal would be to decrease their high sales price.

Dahomey

This country's contribution consists of two parts. There is in the first place a note about a brick and tile factory established in Jetenou before 1955, which closed down because of the "poor quality of its products". Tests reported indicate crushing strengths of 40 kg per sq.cm for solid brick 22 x 11 x 7 cm and between 10 and 20 kg per sq cm for hollow tiles 30 x 17 x 8.5 cm and 20 x 15 x 10 cm, respectively. The reasons for these results are not given. A new investigation of the possibilities

of the manufacture of clay based building materials is in progress but UNIDO's assistance is being requested.

The much larger Monograph, also contributed by this country, concerns the equipment and operation of a pilot plant for the manufacture of art pottery, utilitarian earthenware and finally also wall and vitrified floor tiles. After its installation in December 1969, commercial activities were started in August 1970. The equipment is the usual one for such an operation consisting of a Hammer Mill, a 1000 kg Batch Scale, a Blunger Mill, a 600 lt Ball Mill, a 1 m^2 Screen, Storage Tanks with Agitators, a Filter Press, a Vacuum Extruder, 2 Jiggers, one 60 Tons Tile Press, one Chamber Dryer with oil-fired heat exchanger, one Spraying Booth with Gun, Compressor and Exhaust Fan, three Electric Kilns.

The body is of the dolomitic type. The manufacture of jiggered ware appears to be well under control but difficulties are encountered with slip casting due to faulty deflocculation. The quality of the wall tiles appears to be satisfactory, except that the amount of reject is high due to underfiring. Vitrified floor tiles are also turned out but the degree of cracking is high. Terra-cotta wares are thrown on potter's wheels but difficulties are encountered with drying cracks.

The main problems faced by the pilot plant are the following: (1) the need for frequent and efficient maintenance. (2) Lack of spare parts, long delays in getting them from

Europe and the consequent necessity of keeping a large stock of supplies. (3) Lack or absence of machine shops in the country.

Ghana

There is only one brick and tile factory in Ghana situated in Accra. Installed in 1953, it closed down in 1956 and was rehabilitated in 1964. The original equipment was lately supplemented by two, originally mobile, brick plants which are now operating at the plant. The clay winning is by mechanical excavator, the manufacturing process being of the conventional continental type. Drying is natural. A Hoffmann annular barrel arch kiln of 32 chambers holding around 224.000 brick is used for firing. The fuel is wood, constituting one of the problems this factory is confronted with, as this fuel is getting both increasingly difficult to get and more expensive.

The other problem is of marketing nature. The marketing situation is best characterized by the fact that in 1964 another brick plant, operating in Accra besides the one under discussion, closed down because of lack of demand. This situation is attributed to the competition of sand-cement blocks which are said to be cheaper to use than brick. This problem seems to be aggravated by the shortage of skilled masons, capable of laying-up brick properly. The factory has intelligently responded to this challenge by maintaining a team of skilled bricklayers to assists its customers.

With larger sized clay products the price advantage of sand-cement blocks seems to be diminishing. It is planned to promote the use of brick in Low Cost Housing construction and even the establishment of another brick plant is under consideration.

LIBERIA

The country has a brickmaking tradition as a rural type of manufacture was started by the Firestone Corporation more than twenty years ago. The brick manufactured near Harbell are end-extruded and fired in permanent up-draft kilns by means of rubbertree wood from overaged trees. These bricks are highly regarded by the inhabitants of Monrovia but since the Firestone Co. needs the whole output of its brickwork for its own construction of worker's housing, very few of them are available for the general customer in Monrovia.

Liberia counts with extremely large clay deposits of very good quality. Most of them are situated in the immediate neighbourhood of Monrovia, in fact some of them have already been over-run by the growing city's population. The deposits have been explored by the Battelle Institute of Frankfurt and lately by an American Geological Survey Mission. A mechanised type of brickwork has been established some years ago in Monrovia. However, the demand for its products has been decreasing to the point that the brickworks operates today

only for a few months out of every year. The decline has been attributed to the poor quality of the product but is almost certainly due to the lack of skilled bricklayers in the country. Consequently, the cost of brick and clay tile constructions went up inspite of the fact that per unit of wall area the cost of the larger size clay products compares favourably with that of the ubiquitous sand-cement blocks.

A wall tile factory has been recently established in Monrovia. UNIDO's assistance is required to develop Liberia's immense clay resources.

LIBYA

The situation of clay based building materials in this country is favourable from the marketing standpoint. The demand is large and it is estimated that 70% of it is met by importation. So for instance in 1968 - 92.434 tons of brick and 2,007 tons of tiles were imported. One large mechanized factory (30.000 tons per year) is under construction near Tripoli and the setting-up of another in the Benghazi area (30.000 tons per year), is contemplated. They are expected to supply about 60% of the demand.

Relatively large clay deposits have been discovered in various parts of the country and while not all of them have been sufficiently explored and investigated, the overall situation appears to be well understood.

MADAGASCAR

In this country the programme of urbanization of large cities is reported to be hampered by the shortage of building materials and their insufficient quality. While the daily demand may be calculated at more than 80 tons, the production scarcely reaches 40 or 50 tons.

There are three brickworks in the region around Tananarive of which one appears to be a handicraft operation. The second may be described a partially mechanized one, because the preparation of the clay is manual, the extrusion mechanical and the wire-cutting again manual. Its yearly output is reported to be 4000 tons. The firing is done in a wood-fired rectangular kiln. The quality of the product is variable and the firing inconsistent. The third factory appears to be the best advanced even though its equipment has been installed as early as 1955. The materials from several sources are mixed and their proportion is varied to suit the product being manufactured. As clay mining is done during the rainy season, that is from April to November, so that sufficient clay must be kept available to continue the plant's operation during this period.

The technological process in the aforementioned one is used with minor variation in purpose. Around 70% of the factory's output is dried through artificial dryers, the rest in open-air ones (10-15 days). The production is fired in a rectangular kiln. The bottle-neck is reported to be the drying operations as the kiln is capable of firing from 20 to 25 tons per day whereas the dryers yield only 10 to 15 tons.

The quality of the product is satisfactory; it permits the erection of unrendered brick structures several stories high. On the other hand the quality of handicraft brick is much lower as their crushing strength is only 10 to 20 kg/cm^2.

A new factory has been proposed in which the whole output of about 65 tons will be dried in artificial dryers of the conventional type. Two thirds of the required heat will be produced in generators fed by heavy fuel oil. The kiln will also dispense with the obligatory wood and will burn heavy fuel oil from the Tamarive refinery. This new plant design is expected to permit a considerable improvement of the ratio of labour to output from the present 500 kg per worker to the anticipated 2000 kg per labourer. The kiln will be set by lift trucks.

[redacted]

Almost all mechanised brickworks in this country use greenish blue clays occurring all over Morocco generally derived from miocene strata. Brickmaking activities appear to be considerable. The whole industrialised ceramic sector (which however includes pottery) produced in 1969 a total of 191.000 tons. Nevertheless, the industry is reported as weakl mechanised. The handicraft production in this sector is estimated at 45.000 tons per year. The range of products offered by the country's mechanised brickworks appears to be

ample. The prices at the building sites, as may be judged from an example from Rabat, vary between US $ 15.00 and US $ 25.00 per ton according to the sophistication of the product.

Apparently, a great deal of interest is shown in the development and use of stabilized earth concrete. Impressive results (discussed in considerable detail in the Monograph) have been obtained.

NIGER

The Monograph presents excellent stratigraphic information about clay and kaolin deposits in the country. Their properties and suitability for the manufacture of diverse ceramic products have already been determined. Alluvial silts are used in the manufacture of both "banco" and fired clay brick. Handicraft, semi-handicraft and industrial brickmaking are all being practiced in Niger. There is, furthermore, a considerable burned brick tradition in the country since the 16th century.

The first semi-handicraft brickmaking operation was started in Niamey in 1925, operating during 5-6 months per year. A new mechanized brickworks was started in 1966 on an investment of US $ 352.000 and a nominal production capacity of about 10.000 tons per year. In 1969 the yearly output came to 6000 tons. The price per ton of product is US $ 18.00. The manufacturing equipment is of the traditional European type. The

clay comes from a sedimentary deposits near Niamey. The products are dried in three buildings equipped with metallic frames, covering 1500 m^2 and capable of holding 300 tons of products.

For firing there is a Hoffmann kiln 100 m long by 5.7 m^2 cross-section. Wheelbarrows and lift-trucks are used for transportation. The fuel is ground-nut husks, the consumption being around 500 calories per kilo of product.

Burned handicraft brick (size not given) sell at about US $ 20.00 per thousand. The prices for industrially made products range from US $ 76.00 per thousand for the size 23 x 20 x 4 cm to US $ 172.00 per thousand for the 32 x 20 x 15 cm size. These are FOB factory prices, for quantities of 1000. There are discounts of about 8% for purchases over 10.000. The price of cement is given as US $ 56.00 per ton.

The need for fired clay brick among the large rural class is pressing. Unfortunately, it lacks the means necessary for the construction of durable housing. Eighty-four percent of the population is reported to have an annual income of abou US $ 80.00 and a thousand handicraft bricks cost US $ 20.00. (Probably in Niamey). The creation with UNIDO's help of a Building Institute, that would devote itself to finding solutio to the housing problem, which is said to be acute, is suggested.

SOMALIA

Fired clay bricks were introduced into Somalia by the Italians during the second world war. These bricks were handmolded by prisoners of war. After the war, brickmaking activities ceased altogether and the manufacture of sand-cement block was introduced. This is today the sole building material produced with imported cement costing US $ 90.00 per ton.

Several years ago a mechanized brick plant was built near Mogadiscio. For reasons unknown it has never produced a single brick. Clay based building materials are highly regarded in the country and badly needed. Somalia is reported to possess good clays and abundance of wood (charcoal is being exported) even though the Government recently decreed a prohibition of the use of this fuel.

Seventy percent of the materials used in housing construction are imported. Fourty percent of the cost of construction goes for materials and 60% for labor.

ZAIRE

This country has also known an important brickmaking tradition. In fact most of Leni's older buildings were erected with bricks manufactured more than fifty years ago. The brick quality started to deteriorate as soon as the clay deposits in the immediate neighbourhood of the Capital City began to be exploited. The clays found there are very sandy and consco-

mostly open-burning. The molding technique is generally sloppy.

The product measuring something like 20 x 10 x 5 or 22 x 11 x 6 cm is burned in up-draft coco kilns. Coconut husks are used as fuel almost exclusively, the average heat input being approximately 200 cal. per kg. of brick.

Despite of two United Nations missions which showed the way towards improvements, the clay brick situation continued to decline. To complicate matters, most of the clay pits around the capital city are already in the process of being built-over by the expanding population.

A modern mechanized brickworks has been established near Lomé and is expected to start production in the very near future. The production will consists mostly of hollow tiles because the cost of solid or even perforated brick (which this factory might eventually produce) is expected to be about three times as high as that of the handicraft brick which presently sells at around US $ 7.00 per thousand.

As regards the interior of the country, brickmaking was practiced at several points but later abandoned.

A new period in the development was initiated with the creation by the Togolese Government and the United Nations Special Fund of a Housing and Construction Center near Lomé, in collaboration with the Center for Housing, Building and Planning. Since one of its primary objectives was the development of local building materials, considerable attention was

given from the beginning - two years ago - to structural clay products. Facilities are being provided for testing of raw materials and building products, as well as for their development. A survey of brick clays over the whole country was undertaken in the early stages of the project and several good deposits located. Since the manufacture of handicraft brick around the Capital City can not be revived, the envisaged solution is to develop cement and/or lime-stabilized clay bricks for low cost housing in Lomé and its surroundings. For this, the clays around the Capital City appear to be suitable. As regards the interior of the country, the manufacture of either stabilized earth or burned clay bricks will be introduced, strictly according to the suitability of the clays, availability of fuel and local idiosyncracies. Improved handicraft brickmaking methods are now being demonstrated at the Housing and Construction Center. One of the important developments which took place there was the use of the Cinva-Ram for moulding clay bricks by what may be termed a semi-plastic method. For use in the interior of the country an improved type of handicraft field brick plant was evolved at the said Centre.

It is planned to install brickmaking "shops" of this type at such places in the country where the previous survey has already demonstrated the presence of suitable clays!

U.A.R.

The United Arab Republic produced in 1969 over 700 million bricks. This is considerably less than in 1964 when 1185 millions were produced. However, 1500 million will be required annually during the quinquennium 1970-75.

Present production comprises Common Brick, Building Brick and Engineering Brick the compressive strengths being 25, 150 and 450 kg per sq. cm. and water absorption of the order of 27, 15 and 5%, respectively. The size is normally 25 x 12 x 6, 6.5 or 7 cm, but there appear to be variations especially in the last category, normally hand-made. A relatively small proportion of the total brick production is machine made by the usual process of extrusion and wire-cutting but the manufacturing equipment is unvariably rather old (over 40 years). A small part of the production (probably engineering brick) is extruded, wire-cut and repressed. By far the largest part of the output is hand made. With insignificant exceptions, the raw materials are clastic sediments recovered from the Nile by an ingenious system of sedimentation. Hoffmann or up-draft field kilns are used for firing the bulk of the production. The fuel is heavy oil in most cases.

The brick making and supply situation was radically changed by the erection of the Aswan High Dam which causes the retention of the major part of the sediments behind the dam, thus depriving the brickmakers of their valuable raw-

material. Some of them resorted to strip-mining nearby agricultural lands, an undesirable expedient.

Attempts were made to manufacture brick from clays mined in some of the many available sedimentary deposits. Economic studies showed, however, that their cost would be twice as high as that of the Nile-mud brick. Further attempts are now being made to devise simplified manufacturing methods, dispensing with most of the usual mechanical equipment. A pilot plant to produce 60 million brick per year is now being planned along these lines. Due to the availability of both sand and limestone, it is planned that ultimately one half of the total brick demand will be supplied by the sand-lime product. One plant to produce 200 million brick is already under construction.

PART II

FACTS, PROBLEMS AND SITUATIONS

It may be said that with a few significant exceptions the lack of knowledge of the available clay resources is still the most commonly encountered situation. The preparation of a clay deposits inventory certainly is one of the most pressing tasks for most African Countries. It must be stressed in this context, that a clay resources investigation is not exactly like any other mineral resources survey, in the sense that it should be preferably conducted by clay and ceramics orientated geologists. In other words the accent should be on technology rather on geology.

Let concern us next with the most disturbing aspect of the clay brick manufacture characterized by the following set of situations: (a) A brick works is unable to sell its output or may even be forced out of the market. (b) Once highly regarded clay brick, either of the handicraft or of the industrial type, steadily lose their market. This situation occurs in a surprising number of countries (3 out of 11) therefore requiring a most careful treatment.

From the available evidence it would appear that excepting cases of poor quality, the problem seems to be one of marketing. The industry has in many cases failed to produce the type of material capable of competing with the, by now ubiquitous, sand-cement block. Furthermore, the outstanding

features of clay brick have not been properly promoted.

We have to admit the fact that at least in the African Countries under discussion, the days of the usual fired clay brick (meaning something measuring from 20 x 10 x 5 cm to approximately 25 x 12 x 7.5 cm) are just about over. That is as far as industrial production is concerned. All the evidence suggests that a "small" brick can not compete with the sand-cement block. Evidence from the same source suggests that when it comes to larger sizes, the clay product not only holds its ground but may actually undersell the sand-cement block.

What the African clay building materials industry should do would be something akin to the way in which the Swiss brick industry reacted in the fifties to the challenge offered by the spread of substitute building materials: by creating a "large brick" called B 25, measuring 25 x 30 x 13.5 cm. (The author does not want to suggest here that exactly this size be adopted. After all, the 25 cm thickness was selected in this particular case because it provided just the right degree of insulation for the most severe exposure. Under the climatic conditions of most African Countries such a thickness would be excessive).

A "large brick", developed for the manufacture and use in African Countries, should be precisely that: a <u>brick</u> and not a <u>tile</u> with its two or three large-sized cavities, which is not always sufficiently resistant to impact. The

bricks insulating properties must be obtained rather through multiple perforations with a proportion of voids of approximately 33% giving a bulk density of 1 kg per cu.dm.

What was meant by the statement that not enough was done - promotion-wise - out of some outstanding characteristics of clay building materials, was the fact that burned clay products may and should be used unrendered, thus making plastering superfluous and reducing or even eliminating future maintenance.

This, of course, brings up another problem also mentioned by some of the participants: skilled bricklayers are required to erect attractive and lasting unrendered brick structures and there appears to be a shortage of such personnel; a well devised training programme imposes itself. This is a situation which will sooner or later present itself in most African Countries.

The review of the Monographs also indicates, however, that brickmaking may be forced out of existence due to the deteriorating quality of the product being turned out. And this may occur with either the handicraft or mechanised brickmaking. We have at least one case on record where the decline of handicraft brickmaking was due to both an unsuitable raw material and sloppy manufacturing methods. However, a case of a mechanised brickplant going out of business because of poor quality of its product is fortunately not too common. Unsuitable raw material is the most frequent cause of such

failures. In connection with this particular problem we must stress the necessity of full-fledged production trials to which all clays intended for brickmaking must be subjected before they can be declared fit for that purpose. It happens only too frequently that a costly investment in equipment is made on the basis of flimsy evidence obtained from indirect or small-scale laboratory trials.

A brick plant erected years ago that has never produced a single brick, must certainly be considered a rather unique situation. Unfortunately, we possess too little information about the causes of such an occurrence. Once more, however, the need for a thorough survey of the clay resources and for full scale production trials must be stressed.

The problem of fuel for brickburning is fast becoming an acute one in many developing countries. Larger brickworks operating in the neighbourhood of capital cities find the traditional wood harder to get and increasingly expensive. In countries with large forest resources, wood would appear to be the most logical fuel. However, even in such countries indiscriminate felling of trees may ultimately lead to a disaster because a control of the lumbering activities is difficult to enforce. It is hard to escape the conclusion that large brickworks operating Hoffmann or large up-draft kilns should use residual heavy fuel oil in preference to wood. As far as the handicraft brickmaking is concerned, which will

be probably practised in rural areas, it will have to depend on wood or on the use of agricultural wastes, if available. It would be well, however, if, while promoting handicraft brick-making, the idea and necessity of forest conservation be promoted at the same time.

The proper control and firing of zeffman kilns is an art that is not easy to master. Again a training programme for firemen appears to be highly desirable.

There appears to be no way around the fact that brick-making activities during the rainy season become complicated. And that holds true for both the industrial and handicraft operations. The rainy season affects the operation of a mechanised brickworks chiefly in two ways: In most cases clay winning from water-logged pits is next to impossible. And even if it were practicable, the so mined clay would be too moist for proper working. Consequently, there is seldom any other possibility but to stockpile the clay needed for a five to six months operation. Fortunately, clay may be piled high up so that the area occupied is seldom excessive.

A much more serious problem is that of drying the brick required for the kiln's operation. Few mechanised brick-works in Africa appear to be equipped with artificial dryers that could use the waste heat from annular kilns. And even if they were thus equipped, only about one third of the output

could be dried in them. So open-air drying is almost the rule. During the dry season, drying may take two or three weeks. In the rainy season drying time becomes unrealistically long and in most cases the output is seriously impaired. Furthermore, to maintain the production going even at a slower pace, huge drying areas are often occupied. And, of course, the drying bricks must also be sheltered against rain. Effective sheds are not cheap and sometimes the land itself may be of considerable value. However, cases of brickworks keeping in drying shed several millions of brick are not uncommon.

The question whether it is preferable to build and use artificial dryers even with the added necessity of generating heat for the whole output of the brickwork, or dispense with such admittedly expensive installations and depend exclusively on open-air drying, can not be resolved a priori. At least not on the African Continent. A decision can only be reached on the basis of a strictly economic analysis. Against open-air drying we have: (1) Cost of large tracts of land kept relatively idle for drying purposes. (2) Cost of sheds protecting the drying bricks. (3) Cost of labour required to transport the brick to and from the dryers sometimes over large distances. (4) Loss of revenue due to lower output during the rainy season. On the other hand, the following points must be considered against artificial drying: (1) The usually high cost of artificial dryers ads considerably to the total investment. (2) The fuel needed for generating the head

required for artificial drying may cost as much or more than that expended for firing. While admitting that sooner or later the decision will turn out in favor of artificial drying in most African countries, it must be kept in mind that, at least for the time being, the solution arrived at in one country is not necessarilly valid for another. Capital availability, its dearth, climatological conditions and many other factors must be carefully weighed.

A situation created by a sudden loss of 95% of its traditional raw materials is certainly a rather unique one in the whole history of brickmaking. Not so unique, however, is the concomitant fact that brick manufactured from alternate raw material using more sophisticated manufacturing methods, cost twice as much as the original ones. A partial answer to this problem and a temporary one at that, consists in utilizing only the most indispensible equipment such as pug-mills and extruders of the most rudimentary sort.

The convenience of labor and labor-saving devices has been raised by a rather small proportion of the participants. And, of course there is a good reason for it as in general terms the labor force in African Countries may be considered as underemployed. Most experts in the field would probably agree that the employment-enhancing effect of brickmaking activities must not be disregarded. The question of labor-saving devices must, nevertheless, be faced, especially when

the design of a new brickworks is under consideration. In such a case one would probably shy away from extreme mechanization, not to speak of automation of the type practiced in some developed countries and particularly in the U. S., on account of the high initial investment involved, which the abundance of relatively inexpensive labor would not justify.

What also has to be taken into consideration is the fact that inexperienced labor, while cheap and easy to get, also requires more supervision who may be more expensive and rather difficult to train and keep.

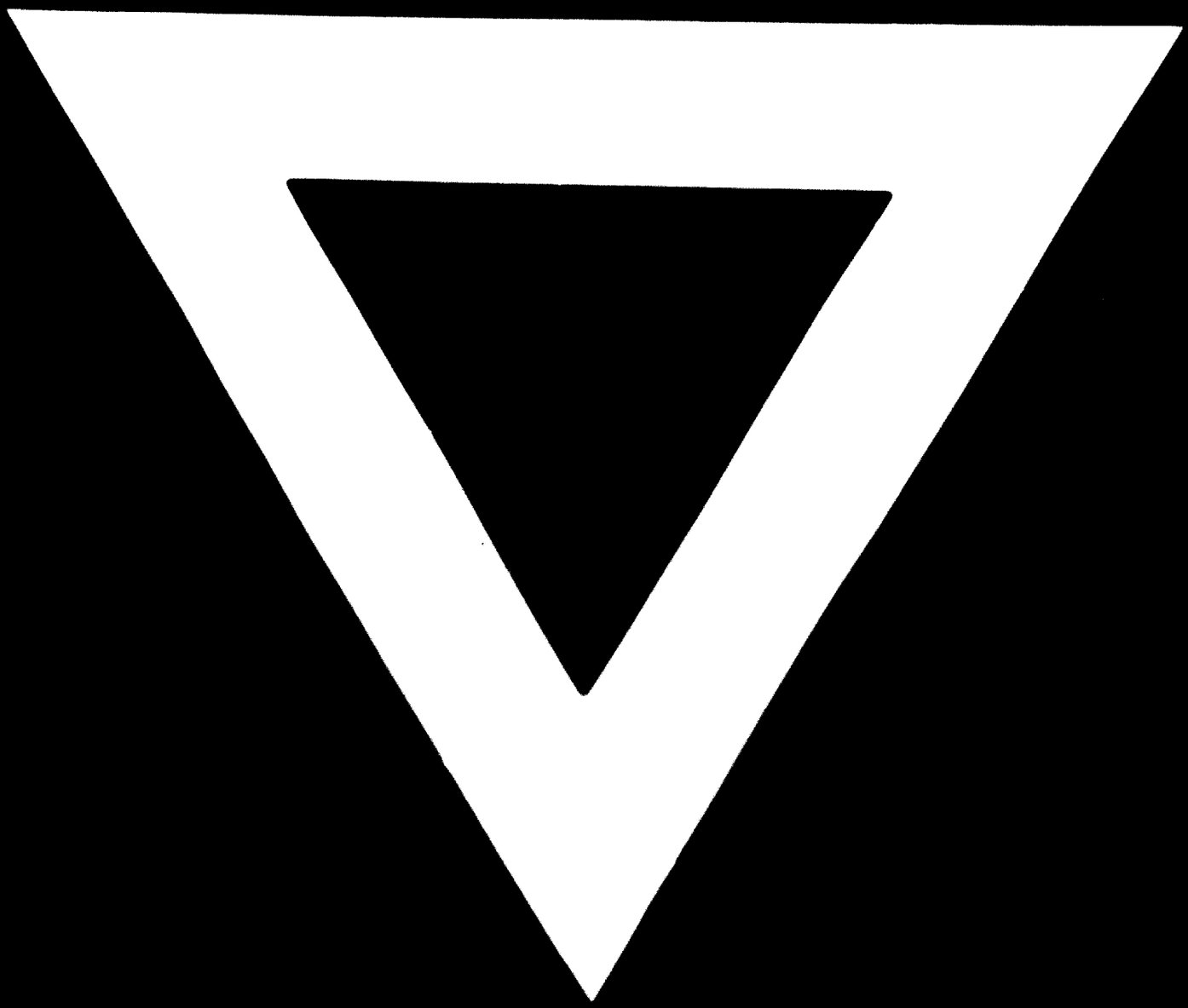
When the total labor engaged in brickmaking in a more or less mechanized brickworks is classified according to the specific activities, one usually discovers that the largest proportion of it is expended in either winning and hauling the clay, or in transporting the brick to the dryers and kiln and in setting them. The dilemma between hand-winning and hauling as opposed to mechanical excavating and transporting may be resolved on the basis of an economic analysis, always taking into consideration the local need to create employment and to maintain it at a reasonable level.

There is, however, one group of brickmaking activities where labor saving should be introduced regardless of the local employment situation. New kilns - in developing countries generally of the annular type - should be designed or chosen in such a way as to permit setting by means of lift-trucks.

In other words, the old type of annular kiln with its small doors for every chamber should be supplanted by any of the numerous types now available, in which the galleries are open at both ends to permit the passage of the lift-truck that does both the setting and the unloading. That up-draft kilns may be set by lift-trucks is naturally nothing new, as they lend themselves even better for this type of setting.

The packs for lift-truck setting may be formed either immediately with fresh brick from the extruder or with the already dryed product; that depends entirely on the manufacturing methods adopted.

The chief reason why lift-truck transportation and setting should be introduced without regard for its adverse effect on the employment situation is that hand-transporting and manual setting and unloading far from improving the quality of the products, may actually damage it requiring in the process costly supervision.



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