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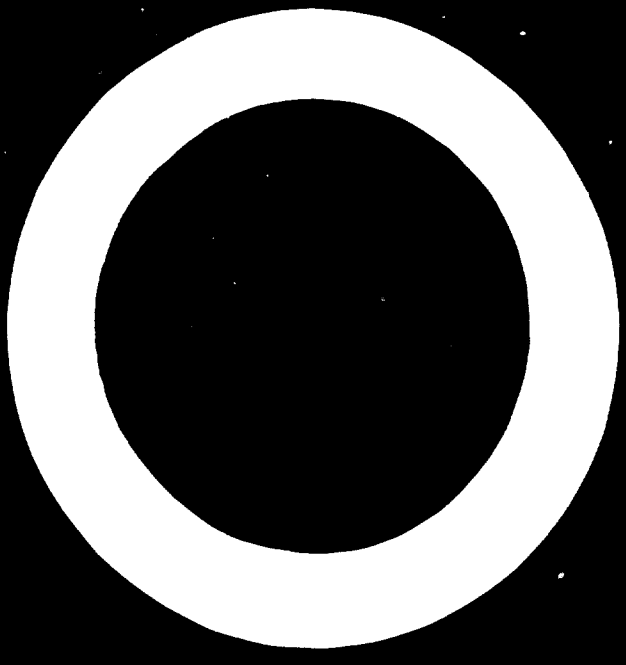
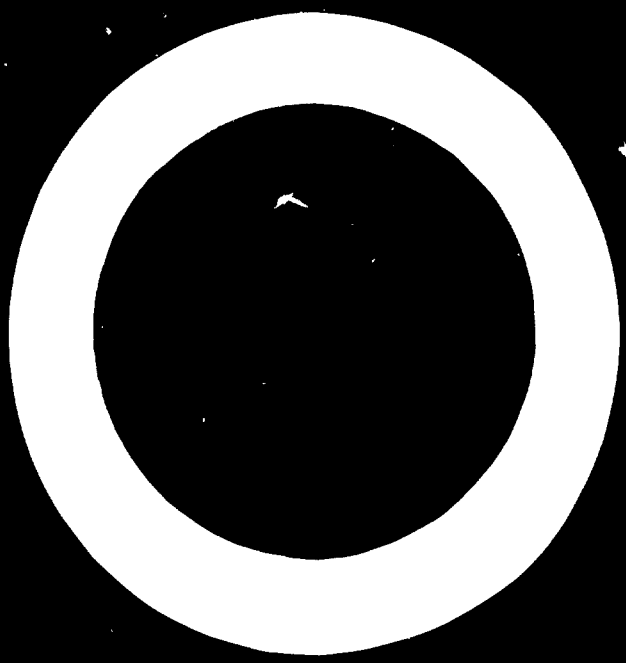
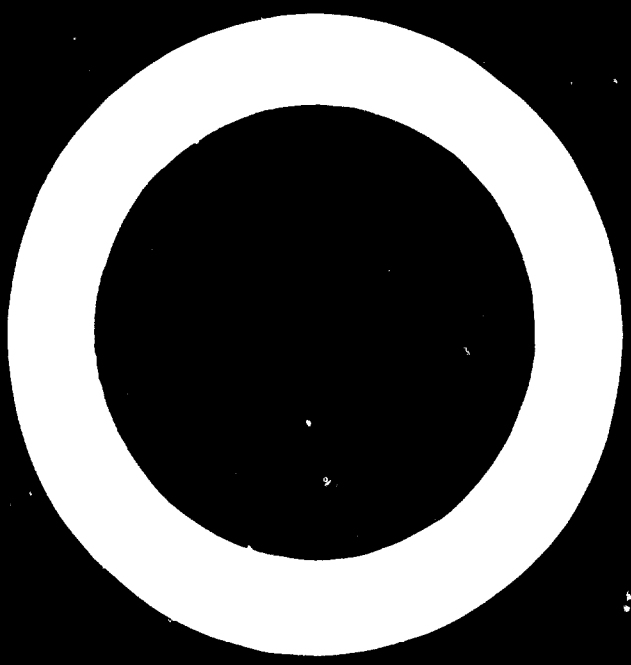
CLAY BUILDING

UNITED NATIONS





CLAY BUILDING MATERIALS INDUSTRIES IN AFRICA



UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
VIENNA

CLAY BUILDING MATERIALS INDUSTRIES IN AFRICA

Report of the Workshop
held in Tunis,
6–12 December 1970

Including a summary of lectures
presented to the Workshop

UNITED NATIONS
New York, 1971

ID/71
(ID/WG.81/27)

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EXPLANATORY NOTE

Ton refers to a metric ton (1,000 kg).

INTRODUCTION

1. The Workshop on Clay Building Materials Industries in Africa was held in Tunis, Tunisia, from 6–12 December 1970. It was organized jointly by the United Nations Industrial Development Organization (UNIDO), the Economic Commission for Africa (ECA), the United Nations Centre for Housing, Building and Planning (UNCHBP) and the Government of Tunisia, with the co-operation of S.A. Batiment, Tunis.

2. The purpose of the Workshop was to review the status of the clay-based industries for building materials in African countries and to adopt conclusions and recommendations that could assist these countries in increasing the availability and quality of clay building products.

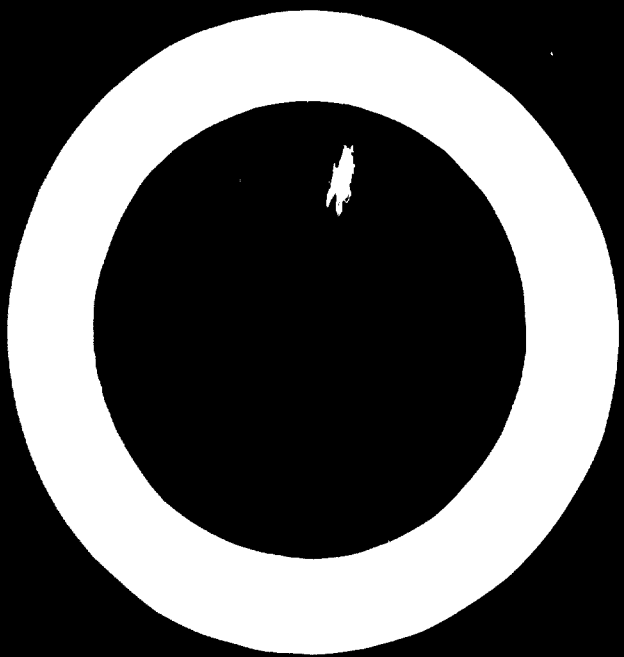
3. The Workshop was opened by Mr. Mohamed Masmoudi, Minister of Foreign Affairs. It was attended by participants and observers from eighteen developing and industrialized countries. Representatives were invited from United Nations Development Programme (UNDP) and United Nations Economic and Social Office in Beirut (UNESOB). A complete list of the participants, expert consultants and observers is given in annex 1.

4. Part I of the present publication is the report of the workshop. It includes a summary of the discussion, the conclusions of the group and recommendations they approved for action by the developing countries in Africa, by UNIDO and by the industrialized countries.

5. Part II contains summaries of the lectures presented. A list of the documents prepared for the Workshop is given in annex 2.

6. Mr. T. Abdelwahed, Batiment, and Mr. S. Boldyrev, Industrial Technology Division, UNIDO, were Co-Directors of the Workshop. Mr. J. O. Ahia-Lamptey (Ghana) and Mr. V. Ramangahalison (Madagascar) were elected Chairman and Vice-Chairman of the Workshop, respectively. The Technical Secretary was Mr. C. E. Rydeng, UNIDO, and the Rapporteur was Mr. Z. Engelthaler, UNIDO expert.

7. The participants visited Tunisian factories and observed different levels of mechanization in the brick and title industries. The factories are described in annex 3.



REPORT

Conclusions

8. The following conclusions are based on the information presented in the lectures and the subsequent discussion.

9. A regional institute for clay building and ceramic materials is necessary to carry out research on local problems as well as to provide advice and assistance with processing problems, to test clays and products and to train foremen, operatives in brickmaking and bricklayers.

10. In order to satisiy the growing construction needs in Africa, every effort should be made to improve local brick production in both quality and quantity. Industrial as well as hand-moulded production should be envisaged and encouraged. Stabilized soil bricks are of great interest to many African countries for low-cost housing.

11. The development of the building materials industries should be parallel to the demands of the building industry in Africa. In view of their significance, these important industries should be given high priority in the development plans of African countries.

12. The brickworks installed in North Africa have sufficient capacities to satisfy the present demand for clay building materials. However, a review of the clay building materials production in some countries located in this subregion indicates a low level of brick production.

13. In the other three subregions of Africa, the situation is different. The capacities of brickworks located in most countries of these subregions are insufficient to satisfy the need for clay building materials.

14. Statistical data are essential for the determination of future consumption. Data on local production and imports are not satisfactory at present.

15. The development of the production of clay building materials could provide a general solution to the enormous, current problem of insufficient building materials for housing in the majority of African countries.

16. Other clay products, such as low porosity products corresponding to stoneware ceramics, are of interest to African countries.

17. The importance of homogeneous raw materials was emphasized and methods of achieving homogeneity were discussed. However, there should be sufficient flexibility in a plant to handle some variation in raw materials.

18. The first consideration in establishing a new brickworks is to ensure that there is an adequate supply of good-quality raw materials. The reserves should be greater than the quantity required for the economic life of the works.

19. Interest was expressed in the semi-dry-pressed process. However, the process is relatively expensive in capital costs, and difficulties in maintenance and repair could arise.

20. The choice between natural and artificial driers and the necessary drying time for small and medium-scale production in African countries were discussed. Natural drying is a more economical process in most of the countries.

21. The most desirable fuel for firing clay building materials is heavy fuel oil, even when it contains a considerable quantity of sulphur, because it can be easily transported and stored, has a high calorific value, and is relatively inexpensive. Scove kilns are best suited for small and medium-sized plants and Bull's ring and Hoffman kilns for large plants. The use of tunnel kilns should be considered only at an advanced stage of development and when there is a high level of consumption within a limited area.

22. Although mobile equipment has been installed in stationary works in one African country, the use of a truly mobile plant is an interesting possibility.

23. The importance of modular co-ordination was recognized. It should provide a link between design, planning, the manufacture of components or building materials, and their use at the building site.

24. At the ceramics factories, the driving belts must be equipped with adequate safeguards. There should be proper maintenance of all rotating parts. Workers should be trained in safe operating techniques.

Recommendations

25. The Workshop approved recommendations for action by the developing countries in Africa, by UNIDO and by industrialized countries. The recommendations may be summarized as follows:

A. *The developing countries in Africa should:*

(1) Consider establishing institutes for clay and ceramic products on a national or regional basis. In the latter case, after reaching agreement with at least two neighbouring countries, application should be made to UNIDO for promoting the regional institute;

(2) Ensure the maximum use of locally available raw materials, extend the scale of building materials manufactured from stabilized soil products, while emphasizing the manufacture of burnt bricks where resources are available;

(3) Use the appropriate channels in applying to UNIDO for technical assistance (national governments submit requests to UNDP, which could designate UNIDO as the executing agency);

(4) Promote brick consumption in Africa by increasing the quality of bricks, reducing production costs and training personnel in brickmaking and bricklaying;

(5) Use a proper materials-handling system to reduce the production costs;

(6) Institute and maintain quality control of raw materials and intermediate and finished products to improve the quality of fired clay building materials;

(7) Project new plants for clay building and ceramics industries from an initial, complete geological and technological evaluation of the raw-materials resources. Provide sufficient flexibility in the processing flow to allow changes in the blends. Use natural dryers which are normally economical for small-scale production. Use periodic kilns, such as scove kilns, for starting small-scale operations and Bull's ring or Hoffmann kilns for large capacities. Use tunnel kilns only for mass industrial production in areas with dense population and high consumption;

(8) Use the cheapest heavy fuel oils for firing clay building materials since they can be mixed with other organic, combustible waste materials;

(9) Extend the collection of statistical data concerning local production and imported clay building materials to enable national and international institutions and organizations to better assess the need for technical assistance and services and to help in the planning of these industries;

(10) Develop other low-porosity products in addition to bricks and tiles, such as wall tiles, engineering bricks and paving bricks;

(11) Provide extensive government measures for the further promotion and development of the clay building materials industries because of their importance to the economy.

B. *UNIDO should:*

(1) Initiate the establishment of a national or regional institute of ceramics industries in co-operation with UNDCHBP, ECA and other regional organizations at the request of an African country in which the industries are relatively well developed. The institute should provide technical services, including evaluation and testing of raw materials, preparation of feasibility studies, training of workers and foremen, and the collection and dissemination of technical information;

(2) Promote the development of clay building and ceramic materials by providing developing African countries with technical literature, such as monographs by experts, and clay and ceramic product data sheets;

(3) Prepare an abstract of specifications and uses of structural clay, earthenware and selected non-metallic mineral products as well as their raw-material requirements;

(4) Channel technical assistance and advice related to all stages of the establishment and operation of ceramics plants upon the request of a developing country;

(5) Convene a regional workshop for the countries of Africa covering a wide range of clay and ceramic products, such as structural and other types of ceramics; 1973 was suggested as the latest date for the workshop.

C. *The industrialized countries should*

(1) Extend assistance to the ceramics industries in developing countries by supporting the establishment of national institutes; offer fellowships, training opportunities and expert assistance through UNIDO and other international organizations;

(2) Establish temporary advisory centres; assist UNIDO in field work; and assist developing countries in establishing national or regional centres. All centres could host international experts in order to secure assistance at short notice;

(3) Continue to host and organize technical seminars and workshops, thereby facilitating a continuous transfer of know-how to developing countries;

(4) Continue their financial participation in the setting up of ceramics industries in developing countries.

Summary of the discussion

26. The role of the government in the construction industry is complex and varied in all countries regardless of their level of economic and social development. Generally, the primary role of the government is to ensure the welfare of the citizens. Construction is a sector of the economy that contributes to the national product and accounts for a large proportion of investments. The present volume and expected expansion of housing and other building activities indicate the necessity for an appropriate growth of the building-materials industries in African countries.

27. Some materials, such as cement and clay building materials, are key materials in African developing countries because they are essential in most construction and account for the majority of the materials used in many buildings.

28. Clay building materials made from local raw materials are the traditional building materials in African countries because of their low value/weight ratio. In order to completely satisfy the present and immediate future demand, to extend the viability of constructions made from substitute building materials (such as "chica" and semi-dried bricks), to use good quality sedimented clays that exist in practically all African countries, it was stressed that the industrial development of clay building industries with due regard to local market conditions had become a matter of urgency, and several suggestions were presented.

29. Since bricks and roofing tiles represent only part of a wide range of ceramic products that are used in construction, the developing countries of Africa have begun to use local raw materials and develop other ceramics industries for structural and domestic products. However, several examples have shown that if the government is not properly assisted, important losses may occur and large difficulties may arise. An increase in international assistance will shorten the development period of the related non-metallic mineral industries as well as promote the commercial use of local resources.

30. The low quality and efficiency of clay building materials and other ceramic products are common features in the majority of the African developing countries. In order to promote the technological evaluation of raw materials and manufacturing processes, to increase the assortment of manufactured products and to increase rationalization, it was expected that UNIDO would continue to expand its activities by establishing contacts with experts, providing assistance during the initial stages of manufacturing, promoting the necessary infrastructure, collecting statistics and distributing data of interest to the industry.[1] The participants expressed their strong interest in the establishment of an institute for clay and ceramic products, which was regarded as urgently needed for the further development of non-metallic mineral industries in Africa as well as for other activities relevant to the infrastructure, such as standardization, statistical evaluation, market potentiality determination and specification.[2]

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[1] *The Development of Clay Building Materials Industries in Developing Countries*, Report of the Interregional Seminar on Clay Building Materials Industries, 1968, United Nations Sales No. E.69.II.B.16.

[2] *The Establishment of the Brick and Tile Industry in Developing Countries* United Nations Sales No. E.69.II.B.19.

Annex 1

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Annex 2

LIST OF DOCUMENTS PREPARED FOR THE WORKSHOP[1]

ID/WG.81/1	Provisional agenda
ID/WG.81/2	Problems and potentials for the brick industry in Africa *by ECA*
ID/WG.81/3 and Summary	Progress, acceleration and standardization *by H. W. H. West*
ID/WG.81/4	Production technology – winning, preparation and shaping of clay *by H. W. H. West*
ID/WG.81/5	Proposal concerning setting up brickworks in Libya *by ECA*
ID/WG.81/6	Proposal concerning the setting up of a plant for ceramics production *by ECA*
ID/WG.81/7	Proposal for the construction of a ceramics factory in the Ivory Coast *by ECA*
ID/WG.81/8	The drying and firing of baked clay products *by R. G. Burkhardt*
ID/WG.81/9 and Summary and Corr. 1 and Add. 1	Resources for anticipated development *by I.O. Knizek*
ID/WG.81/10	Economic and technical characteristics of the clay building materials industries in developing countries *by S. B. Johansen*
ID/WG.81/11 and Summary	Technology of clay building materials manufacturing *by N. Z. Shinkarouk*
ID/WG.81/12 and Summary	Environmental characteristics of the clay building materials industries in Africa *by Z. Berhane*
ID/WG.81/13	Provisional list of participants
ID/WG.81/14	Provisional list of documents
ID/WG.81/15 and Add. 1	Contribution du Niger *by K. A. Labo*
ID/WG.81/16	Le développement des industries des matériaux de construction à base d'argile en Tunisie *by T. Abdelwahed*

[1] A limited number of copies are available upon request.

ID/WG.81/17 A monograph on the clay building materials industry in Ghana
by J. O. Ahia Lamptey

ID/WG.81/18 L'industrie de la terre cuite dans la région de Tananarive. Technique actuelle et perspective immédiate
by V. Ramangahalison

ID/WG.81/19 Clay building industry in UAR
by K. Zeitoun

ID/WG.81/20 Notes on investigations of clay resources of Libya
by A. A. S. Breni

ID/WG.81/21 Contribution Marocaine
by A. Affia

ID/WG.81/22 Usine de céramique au Dahomey
by T. F. Mito-Baba

ID/WG.81/23 Utilisation des argiles Congolaises dans la construction
by D. M. Cickasso

ID/WG.81/24 La terre cuite au Togo
by P. Dansou

ID/WG.81/26 Promotion of building materials
by I. O. Knizek

Annex 3

DESCRIPTIONS OF THE PLANTS VISITED

Manoubia Brick and Tile Factory, Tunis

The first Hoffmann kiln was constructed in 1898 with gradual additions until 1962 when a tunnel kiln was constructed. For the annual production of 60,000 tons of extrusion-pressed red bricks, blocks and tiles, 243 labourers, 18 office personnel and 2 engineers are employed.

Raw materials are conveniently located; clay is excavated in the neighbourhood of the plant and the sand is obtained from a nearby quarry. Fired rejects are pre-crushed, ground and screened for use as a grog in blends for other products.

Clay from the deposit is transported to a station where the first crushing takes place. The clay is loaded into small funicular railway cars by means of a belt and transported into the plant. Before the second step of clay preparation, the clay is mixed with sand and grog.

The extruding plant has a vacuum extruding press that is equipped with a fully automatic Frey cutter. The bricks are transported on a rope conveyor to an artificial chamber drier and to open-air driers. Maintenance of the equipment is the responsibility of a shop that is part of the factory.

One modern tunnel kiln and two Hoffmann kilns are used for firing the following products at 950°C:

Small bricks	(3 hole)	4.5 X 10.5 X 21.5 cm,
	(6 hole)	6.5 X 10.5 X 21.5 cm;
Large bricks	(8 hole)	10 X 20 X 30 cm,
	(12 hole)	15 X 20 X 30 cm;
Hollow blocks (Roger type)		13 X 20 X 33 cm,
		16 X 20 X 33 cm,
		19 X 20 X 33 cm;

Flat ridge (Marseille) tiles;
Extruded solid bricks;
Pressed solid bricks.

Jendouba Brick Factory, Jendouba

The modern factory was built in 1966 and began production in 1967. For the annual production of 15,000 tons of extruded red bricks and blocks, 75 labourers, 2 office personnel and 1 engineer are employed.

The raw materials are transported to the plant from a quarry of limey clay with horizontal extraction that is located next to the factory and from a quarry of excellent non-calcareous clay

that is 25 km from the factory. The limey clay deposit is not a homogeneous one, and fluctuation of impurities in the clay is one of the factors which requires attention in proper production control.

The modern manufacturing process uses the following equipment: jaw crusher, crushing rolls, tempering mixer, vacuum extruder and automatic cutter. The bricks are transported on racks from the extruder to the drying chamber by fork-lift trucks. An Italian type chamber drier is equipped with fans and fed warm air by a hot-air generator.

The modern tunnel kiln, 63 metres long, is fed by burners using heavy fuel oil No. 2. The firing temperature is 800°C. Maintenance of the equipment is the responsibility of a shop that is part of the factory.

Tabarka Tile Factory, Tabarka

The modern wall-tiles plant was built in 1966 and began production in 1967. The production is on a high technological level. This plant operates 50 per cent above the projected capacity and thus gives high economic returns.

In addition to the annual production of 3,150 tons of white, coloured and decorated wall tiles (dimensions of 150 X 150 mm and 75X 150 mm), frits are melted in the factory for internal use as well as for local kitchenware manufacturers and small ceramics shops. The personnel includes 105 labourers, 5 office personnel and 1 engineer.

The raw materials of white kaolin, dolomite, sand and grog used in the processing of wall tiles are stored in a roofed area in front of the main production hall. Any necessary drying is done in the open air.

The technology is based on crushing the raw materials, dry grinding of the batch, granulating the mass in a granulator by adding water and regulating the moisture content. This is followed by semi-dry grinding in dry-processing, edge-runner mills, and screening before storing the mass in two bins. Tiles of both formats are pressed by three friction presses, two automatic and one semi-automatic. The mechanical strength of the green body is excellent. Pressed tile edges are cleaned after pressing. The pressed tiles are loaded on biscuit-kiln cars and dried in a double-tunnel drier for 63 hours to decrease the pressing moisture. The tunnel kiln, 50 metres long, for biscuit-firing of wall tiles is equipped with 16 side-firing burners using heavy fuel oil No. 2. The biscuit-firing temperature required by the dolomite-siliceous body composition is 1,050°C.

Owing to relatively low shrinkage during the biscuit-firing process, no special calibration is needed. However, the edges of biscuit tiles are "cleaned" by whetting them on a transport belt before glazing. Two double waterfall glazing machines are installed in the plant. About 30 g of a raw white glaze are applied on a 150 X 150 mm biscuit tile. One piece of glazing equipment is used for the manufacture of decorated tiles. After being glazed, a biscuit tile proceeds gradually to three automatic screen-printing machines, each of which prints one colour of a design. The glazed and decorated tiles are then inserted by hand from the belt directly into saggars on muffle-kiln cars.

Frits for the glaze preparation are melted from their components in a stationary rotary kiln at 1,400°C temperature. After the melting process is completed the frits are cooled in water. The glazes are ground wet in ball mills from frits and additives, such as kaolin. Only opaque glazes are used in the manufacture of wall tiles. A commercial opacifier of zirconium silicate is melted in the frits.

The glazed tiles are loaded on wagons and then fired at 980°C in the muffle kiln. Heavy fuel oil No. 2 is used in the burners. Fired wall tiles are manually unloaded from the saggars and sorted into first and second qualities and rejects. The tiles are then boxed for transport.

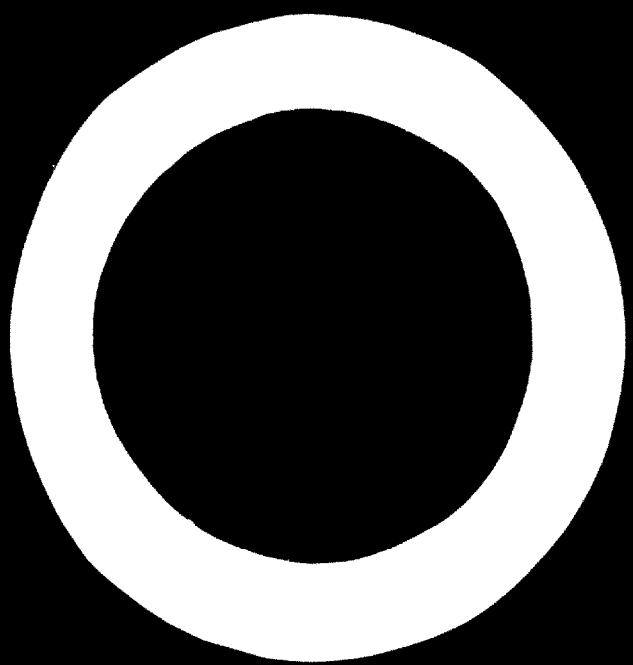
The plant laboratory performs production control, tests and research. A photographic laboratory produces screens with different designs for screen printing machines. Maintenance of the equipment is the responsibility of a shop that is part of the plant.

Nabeul Brick and Pottery Factories, Nabeul

Traditional processing of bricks and pottery is practised in the factories. One of the artistic ceramics shops is a governmental pilot plant.

The traditional brick processing is based on simple clay preparation in cylinder mills. Bricks are shaped in an extruder. The hollow bricks are dried in the open air and then fired in periodical kilns that are heated by wood and agricultural wastes. Owing to the high content of limestone in the clay, the firing temperature is only 850°C. Two of the brickworks form part of a company with 220 workers, which annually produces 20,000 tons of bricks and hollow bricks as well as twice-fired, sanitary pipes and fittings.

The artistic ceramics shops are on a good technological level. In spite of simple body preparation, different attractive product shapes are cast from plaster moulds and shaped on pottery wheels. The products are decorated by engraving green bodies, by using underglaze decorations with transparent glazes or by handpainting engobes and opaque glazes. In addition to the open-fire and wood-burning muffle kilns, small, periodical electric kilns are used to fire products. The biscuit-firing temperature is about 950°C and the glost-firing temperature about 900°C. Finished products are aesthetically pleasing, the glazes do not crase and the colours applied are pure. The use of traditional Tunisian designs on the artistic ceramics promotes a large tourist interest in them.



SUMMARIES OF LECTURES PRESENTED

Problems and potentials for the brick industry in Africa

prepared by Economic Commission for Africa (ECA)
United Nations Secretariat

Bricks and cement products are the most important building materials in Africa. The following kinds of traditional bricks are used: sun-dried bricks which are sometimes strengthened by straw, hand-made fired bricks and industrially manufactured bricks. The latter are marketed as full bricks, hollow bricks, hollow blocks and tiles. In the handicraft brickworks wood and agricultural wastes are used, however the industrial plants prefer fuel oil and coal.

The quality of the bricks produced in Africa is generally very low. The estimated lifetime is only ten years owing to their low mechanical properties. About 30 to 40 per cent of the total artisan production is well burnt, the balance is either under- or over-fired.

The further development of brick production in North West and Central Africa has been studied by ECA. From the estimated growth of the national economies concerned ECA concluded that brick consumption will increase fivefold within the next fifteen years. Since the prices of red-clay products are competitive with the prices of concrete blocks, there is no limitation for their use in modern construction if good quality is consistently maintained.

Winning, preparation and shaping of clay

by H. W. H. West

The origin and composition of clays for brick and tile manufacture are treated in a general way. Common impurities are identified, and ways to remove them and to treat their effects are described. Specific raw materials are not discussed as there is a wide range of these available on the African continent. The way in which different types of raw materials affect the process, and the appropriate plant for each type are described. Consideration is given to production-control procedures for raw materials and the necessary quality-control tests.

The factors affecting the method of winning are outlined and the methods available equipment and their characteristics are discussed The important factors in choosing a method of haulage are listed and various methods are indicated

Primary and secondary preparation of clay by dry and plastic methods is discussed The importance of storage including bulk storage weathering and blending of raw materials and intermediate storage and souring of prepared clay is considered in detail Attention is focused on the problem of blending clays and additives

The five basic processes for shaping are discussed In the order of decreasing moisture content they are hand-made soft mud extrusion stiff plastic and semi-dry pressed In addition the manufacture of roofing tiles is described

Monetary cost data are not suitable for comparisons between different countries but the basic unit of a man-hour (m/h) is used to compare processes Labour figures are given for various operations of winning and haulage and for simple and more complex clay preparation and shaping methods Suggestions are given for the first stages in the mechanization of the processes of winning, haulage, clay preparation and shaping, which may be suitable for application in developing countries

The labour requirements for various steps of the process are given Modern plants have total productive labour requirements of less than 2 m/h per 1,000 units, other plants require less than 1 m/h per 1,000 units Such plants have high capital requirements as well as high running and maintenance costs The degree of mechanization has to be weighed carefully in each particular case, taking into account the investment costs, the running costs including maintenance, and the availability of skilled labour

The drying and firing of burnt clay products

by R Burkhardt

The importance of determining the mineralogical type of the clay to be used and studying the geological reserves of clay before setting up high-capacity plants is stressed The influence of different clay types on the processes of drying and firing is analysed Before selecting driers and kilns for brick manufacture it is necessary to evaluate the available type of fuel with special reference to the costs and qualities of fuel oil, as well as the dangers of deforestation

The availability of skilled workers and technical personnel plays an important role in the manufacture of good-quality bricks and tiles As the level of skilled labour in most African countries is still low, the author suggests the establishment of three training centres for ceramics workers and bricklayers in Africa

Taking into consideration the climatic conditions with regard to the alteration of bed rocks and clays (lateritization), the author suggests the most suitable driers and kilns for new projects being considered in African countries

Promotion of building materials production

by I Knizek

Summaries of the monographs submitted by the participating countries are given. Problems and situations from the monographs are examined. The lack of knowledge of the available clay resources is one of the most commonly occurring situations. There are however significant exceptions. A rather disturbing aspect of the manufacture of clay building materials in Africa is the steady decline of their popularity which seems to be taking place in a significant number of countries. The loss of market is due to the deteriorating quality of the product in a few instances, otherwise it is almost always caused by poor marketing practices. The clay building materials industries in Africa have not responded creatively to the challenge posed by the increasing use of sand and cement products. A strong factor is the lack of skilled masons to erect attractive, unrendered brick structures.

Fuel requirements are beginning to be a problem as wood becomes increasingly difficult to secure and its price increases. The difficulty of properly controlling Hoffmann kilns is aggravated by the scarcity of experienced firemen. Brickmaking activities become complicated during the rainy season. The dilemma, however, whether to dry 100 per cent of the output in artificial driers (a solution favoured at least in one country) or to depend on open-air drying under sheds, may only be solved after a painstaking analysis of all the local factors involved. Mechanization of brickmaking frequently causes the manufacturing costs to double as compared with the costs of handicraft or semi-mechanized operations. The conveniences of labour-saving devices must be carefully analysed. In most African countries with an oversupply of inexpensive labour, their use will be confined to those operations which while fundamentally wasteful of labour do not improve the quality of the product if performed manually, such as transporting and setting.

Economic and technical characteristics of the clay building materials industries in developing countries

by S B Johansen

The development of the building industry and the building materials industries are synchronized to a great extent. Therefore, if planning, administration and standardization are necessary for one of these industries, they will be necessary for the other industry, if the economic effect shall be maximum in developing countries. Because of their great influence on the national economy, those important industries must be given priority in every industrial development programme for developing countries.

The clay building materials industries might provide a universal solution for the enormous problem of lack of building materials in developing countries. However, the industries must demonstrate their convenience and efficiency. For this purpose, the establishment of brick plants must be in close accordance with

prevailing economic and technical conditions in the developing countries, which have been shown to be quite different from those in developed countries.

Layouts are proposed for brick plants of different sizes according to the needs of the various developing zones of a country. The basic principle used in these layouts is natural drying which, in the author's opinion, represents an overlooked or not fully exploited gift to the developing countries. The conditions of natural drying and the construction of natural driers are discussed. In order to maximise the advantage of natural drying, the author selects stiff extrusion for the brickmaking process and proposes internal transport by fork-lift trucks and pallets. Large brick plants could then benefit from natural drying. The Hoffmann kiln is the standard kiln element for large brick plants, although zigzag and periodical kilns should be taken into consideration for small productions and by brick plants with a varied production programme. The characteristics of the proposed brick plants are *(a)* relatively low investment, *(b)* good labour efficiency, *(c)* economic and simple plant operation, and *(d)* security of production, even in the case of heavy machine repairs. The brick plants are expected to deliver good-quality products in accordance with the general salary and price levels in developing countries.

It is recommended that each African country establish a national committee for the development of the clay building materials industries. The Committee would act as a link between building industries and the clay building materials industries and should channel economic and technical assistance from governments and international organizations to the clay building materials industries.

Environmental characteristics of the clay building materials industries in Africa

by I. Barbaev

The properties and uses of clay building materials that are presently produced in the North, West, Central and East African regions are briefly discussed. The past and present demand and supply of clay building materials in Africa are considered as well as the influence of other recently developed building materials, such as concrete blocks and gas concrete, on the clay building materials industry.

The relationship between the consumption of clay building materials and of Portland cement products in various African regions is analysed. The results indicate a future trend of high demand for clay building materials and an inadequate supply unless proper planning implemented. Measures are suggested to alleviate the acute problem of the shortage of clay building materials in Africa.

Resources for anticipated development

by I. Knarek

The three available resources are as follows: the clay itself, the knowledge of the clay, the human intelligence to learn about it and the consequent ability to use it

property, and the availability of mechanical equipment suitable for the transformation of the basic raw materials into a marketable product.

The author discusses first the difference between handicraft and industrial manufacture and then the specific raw materials. After a brief description of the constitution and basic characteristics of common clays, the importance of clay testing is stressed. A technological approach is necessary to determine the suitability of a clay for brickmaking. Preparation and manufacturing methods are discussed in detail, especially in relation to recent innovations in these processes. Attention is focused on drying and drying behaviour, and the importance and convenience of open-air drying are stressed. Handicraft brick manufacture is illustrated by means of slides showing the techniques used in various developing countries. The use of well-designed scove kilns is discussed. The advantages of a Bull's ring kiln and the desirability of its introduction in Africa are outlined. The design and operation of zigzag kilns are discussed as well as the latest developments in the construction and operation of tunnel kilns.

The choice of fuel for firing bricks in different types of kilns is very important. The use of cheaper, high-viscosity grades of fuel oils in developing countries is central to the industrialization of firing processes. Excessive use of wood may lead to gradual deforestation.

The necessity for the promotion of brick consumption and the impact of standardization are stressed. Brick consumption may be increased simply by improving the quality of the product. It should be stressed that well-made structures of fired clay products need no rendering and furthermore have low maintenance requirements. The best way to promote brick consumption would be to increase the availability of skilled brickmakers. Considerable care must be exercised in setting up quality standards.

Progress, acceleration and standardization

by H. W. H. West

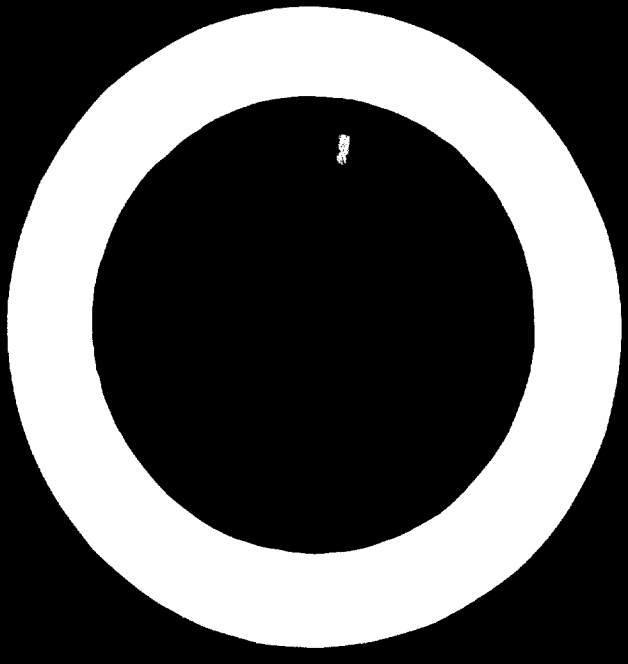
The economic situation of developing countries in Africa is considered. The present output of bricks and postulated outputs for 1980 are compared with data from Great Britain, which has a fully developed brick and tile industry. During the industrial development of a country there will be considerable potential demand for bricks and tiles. Suggestions are given of ways to increase the production and thus satisfy this demand.

Productivity is examined in relation to the situation in the United Kingdom where labour-intensive processes were used. Manpower requirements for various types of production are given. Simple improvements are described and their manpower requirements listed. Modern, highly mechanized plants can have productive labour costs of less than 1 man-hour per 1,000 bricks. The capital costs of new works are discussed. The increase in these costs and the decrease in labour costs are demonstrated for the period 1955 to 1968. The production of the total operating costs that can be debited to each part of the process is given and compared with costs derived from data suggested by BCA.

Research and development facilities for a central research establishment and for laboratories in the works are considered together with the distribution of responsibility, a projected research programme and the development of new products. Quality-control tests and charts are described. Reference is made to the apparatus and methods for various testing procedures.

National standards are important to the development of the industry, and the requirements for a standards organization are discussed. The principles of modular co-ordination are outlined. The initiation of a system of standards provides an opportunity to ensure that they are all related on a modularly co-ordinated basis.

In the early years of the development of a brick and tile industry, emphasis must be placed on production technology. As the products improve and the buildings become more sophisticated, it is necessary to study their performance during use and to establish advisory facilities for the consumer.



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