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ECONOMIC AND TECHNICAL CHARACTERISTICS OF CLAY BUILDING MATERIALS INDUSTRIES IN DEVELOPING COUNTRIES [1]

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Summary.

A convenient and efficient Industry in Developing Countries is charac- terized by: (1) Moderate use of foreign exchange in machinery and raw ma- terials. (2) Low total investment combined with good efficiency. (3) Good products at competitive prices. (4) Products fullfilling primary needs of the countries. (5) Correct balance between amount of workers and invest- ment. (6) Industrial establishments easy to be used. The Building Indu- stry and Building Materials Industries are believed to be convenient in- dustries in Developing Countries.

The general economic and technical aspects in relation to the estab- lishment of efficient Clay Building Materials Industries in Developing Countries are discussed. Much attencion is drawn on the selection of pla- ce, of mine or of clay deposit for the industry because it is, in plant life, a one time decision, which affect very much investment and produc- tion cost. Among the other important selections, natural drying combi- ned with the materials handling system are discussed extensively, and a new combination, which includes mechanical setting and drawing of kilns, is proposed for consideration. The possibility of the use of natural dry- ing in Developing Countries represents a real economic advantage, which drastically cuts investment and production cost.

Fast development of the Clay Building Materials Industries is believed to depend on certain kind of a standard brick plant, which could be easy multiplied to cover the needs of a whole country. An attempt to fix such a plant is done in form of a layout, which demonstrates brick plants with natural drying and annual production capacities of 6, 12, 18 and 24 mil- lions of normal bricks. Very much attention is given to the natural dri- er and to the materials handling system. For the big plant, an effici- ency of about 3 man-hour/ 1000 bricks is obtained with an investment of about US $ 550,000,00. Production cost in this plant is estimated to be US $ 8- 10/ 1000 bricks. These figures are very much appreciable, even in relation to those of modern plants in Developed Countries.

General Conditions for Establishment of Industry in Developing Countries.

The establishment of an industry with success in any part of the world depend on the rigth combination of the three principal factors for all industry:

1) Capital for investment and operation.

2) Raw materials (Cost and abundance)

3) Personnel (Salary and qualifications)

Concerning those three factors some considerations about the influence of the special conditions in a developing country should be taking before settling up an industry.

Capital: The capital market in a developing country is normally very limited. As this market also obeys the law about "Demand and Supply", a high interest is payed for the capital.

The exchange situation is normally very serious and the Government of a developing country must apply very drastic restrictions on all kinds of imported products included machinery and raw materials for industry.

The mentioned conditions signify that it is very expensive to establish industry in a developing country, if we want it done on the technological level of a developed country.

Raw materials: From every point of national interest, the limited capital should be invested in industries. which use local raw materials. Local raw materials for production of building materials are normally cheap and exist in abundance in most of the developing countries.

Personnel: Industry use professional as well as skilled and unskilled personnel. Since the labour market obeys the law about "Demand and Supply" the ratio between the wages of such personnel are: lo: 2: 1. Furthermore , if we compare the salary of a unskilled worker in a developing country with that one in a developed country, the ratio will be 1:5 to 1: lo.

Because of the little amount of industry existing in developing countries, personnel have normally little experience in running industrial installations.

As a result of the relatively low salary for personnel, the purchasing power is low. Anyway, the people of a developing country has the same buying power as that of a developed one, if we can offer to them those same products priced in accordance with their basic salary. This should be the task of a convenient industry. Furthermore, Industry shall give a high profit in relation to investment because of the higher industrial risk in developing countries.

If, from the standpoint of a developed country, we look at the conditions for industry in developing countries, we must conclude that machines should be replaced by men until a stage of industry with low investment is obtained. This replacement is done only because we desire the most efficient industry and the best business.

The Importance of Building Industry and Specification of Its Demand on Building Materials Industries.

Building Industry in a developing country has two very noble aspects: First, it produces dwellings for people making them to get a higher level of welfare and living conditions. Second, it occupies with a very low investment a great amount of skilled and unskilled personnel.

The importance of Building Industry is seen from the fact that about 30- 50 per cent of national income is used in Building Industry in most of the developing countries. The high absorbtion of personnel by the Industry is seen from the figure that approximately 40- 50 per cent of the above mentioned amount is payed as direct salary to the personnel. The rest is payed for land and building materials . If we consider Building Industry together with Building Materials Industries approximately 60- 75 per cent of the total amount is payed as salary to personnel.

Without any doubt, Building Industry together with Building Materials Industries should be on the top on every development plan for Developing Countries. Because of the magnitude of those industries, great economic result could be obtained by efficient planning and administration.

Anyway, there have been many attemps to do planning and administration on Building Industry, many of them got poor result, because it was not clearly recognized that Building Industry is an assembling industry depending loo per cent on its local semi products, the so called building materials.

It should be emphasized that standardization, planning and administration of Building Industry have no meaning if not extended also to the Building Materials Industries. The key to a fast and sound development of Building Industry is a simultaneous fast development of the Building Materials Industries.

The request of Building Industry on the Building Materials Industries consists in asking for low prices of products, great variety of them, fast delivery and a good quality. The price of the products is the most important demand and only in a few cases the other ones would be decisive on the choise of a building material.

Therefore, a new industry on the field of building materials should omly be established if its products is competitive at least to existing building materials industries within the same market.

Economic and Technical Considerations about Establishment of Clay Building Materials Industries.

The outstanding advantage of a clay building materiale industry is its capacity of producing a great amount of different building materials. With exemption of the foundations, the doors and the windows practically all other necessary building elements for house construction could be produced at only ome good industrial establishment. No other building materials industry have this particular feature.

The radio of action of a building materials industry depends on product prices and on the weigth/volume ratio, because of fast transportation cost will be a considerable per cent of product price. Clay building materials , as perforated products, could be delivered with a lower weigth/ volume ratio than other normal building materials.

In a developing country there exist various developing zones. The capital and its surrounding areas represent the most developed zone. Here exists at least some kind of competion between different building materials industries and the market is to some extend covered. If we want to settle a clay building materials industry in this zone it must be a specialized efficient one producing only few different products for the sake of competition. It should be noted that in this case we cannot exploit the particular feature of many different products. Plant size should be 12- 24 millions of normal bricks and its production programme based on standard building elements.

The other big towns of 100- 500,000 habitants represent, within the country, medium developed zones which on account of bad infrastructure could be isolated areas. In such areas there could be a complete lack of some building materials because the market is to small to justify settlement of various factories. Here a clay building materials factory could be a good solution if for example 1/3 of its capacity is used to produce many different products and 2/3 of its capacity for the great bulk of standard elements. The industrial risk of such a factory is small because the production programme always could be changed to the profitable products, which also means the really needed products. Plant size could be equal to 12- 18 millions of normal bricks, but with a varied production programme.

Towns of 50- 100,000 habitants represent very isolated areas where two stock houses normally would be the most sophisticated construction. Here the Clay Building Materials Industry would be the most convenient solution for supply of building materials, if not the only. Plant size could be equal to 5- 12 millions of normal bricks.

In areas with less habitants hand-made bricks and roof-tiles would perhaps be the only source of building materials. Because of the very primitive stage of industry very little could be done to help this kind of industry. Technical assistance should be limited to standard plans for kiln and natural drier.

It should be noted , that the proposed sizes of brick plant are all of approximately same order. A reason for this is that equipment for brick plants is produced in such a size. Because of the high transportation cost of building materials it is better to have the building materials industries spread around the principal market serving at the same time some secondary markets, which by same reason should be exclusive for only one plant.

This distribution of industry lowers the industrial risk for each plant and it gives a better geografical covering of the area in question. Therefore, if the market permits settlement of more than one brick plant the other ones should be settled around the principal market and in opposite geografical positions to each other and to the existing building materials industries. Disponible clay deposit could change this concept, but it should not be considered before it is investigated.

A disadvantage of a Clay Building Materials Industry is that it uses fuel as raw material besides the local raw materials. If we are dealing with a developing country which does not have fuel as natural source, it must be impotted affecting then the exchange balance. Anyway, if we compare the Clay Building Materials Industry with the competitive building materials industries, which use cement, chalk and gipsum as binder besides local raw materials, it will be clear that there is no principal difference between all these industries, since the production of cement, chalk and gipsum also involve a burning process.

For a given area we have to transport fuel to the site of the Clay Building Materials factory. For the other building materials industries first we have to transport fuel to the factory of cement, chalk or gipsum. Then we must transport the burned product to the local building materials industries. Calculating the real difference is out of the limit of this paper, but it is important to have the argument clear if discussion arises against the Clay Building Materials Industries.

In the planning stage of a Clay Building Materials Industry we make a series of decisions, which affect the economic result of our factory for the rest of its existence. If our task is to establish a cheap efficient industry then we must number the important decisions. The subscriber will propose the following order:

1) Selection of place , of mine or of clay deposit.

2) Determination of production programme.

3) Selection of the materials handling system.

4) Selection of kilns and burning system.

5) Determination of drying process and system.

6) Selection of machinery for moulding.

<u>Economic and Technical Aspects in Selection of Place, Mine or Clay Deposit for Clay Building Materials Industries.</u>

The only real reason for settlement of a clay building materials industry in a certain area is a lack of building materials. Therefore, some kind of a market study should always be the first step. This market study should be at least approximately a guide to select plant size. Then it should permit determination of a proposal to production programme. Finally, the market study should fix centers of primary and secondary markets within the area in question. If the market study is favorable for settlement of a brick plant, then we have to look for the raw materials.

Here, it should be emphasized, that we are not only seeking a usefull clay in sufficient amount, but more important we are seeking the combination between a usefull clay and local conditions near a mine, which will give the best economic result to brick plant the rest of its existence. Let me give an exampel:

<u>We want:</u> A brick plant with natural drying, annual production about 12 millions of normal bricks, plant life estimated to be 25 years.

<u>We seek:</u>

1) A clay pit or mine with a useful clay and of a capacity of about 1,2 millions ton of clay. Cheap draining of pit is desirable.

2) A flat or almost plane area of about 20- 30,000 m^2 near to clay mine destined for building of brick plant. In case of necessary levelling work a cost estimation should be added to the study.

3) The most outstanding combination between 1) and 2) which occurs, when the clay mine is a soft hill in a flat landscape. In this case, investment and production cost will be at minimum. Cheap draining of flat area is desirable.

4) Public roads in the neighbourhood of the brick plant. Therefore, seeking of a clay mine should always be concentrated in narrow contry belts on both sides of public roads, which connect primary and secondary markets.

5) Supply of electricity of about 600 Kwh/h together with telephone connection to primary and secondary markets. If such facilities exist in the area they properly would be found near public roads.

6) Supply of workers for the factory. This is normally no problems for factories near public roads.

7) The final selection of clay mine and place for factory, which clearly also depends on clay quality and price of land. Here, the price of land in different cases should be related to the transportation cost of finished products to the markets.

As a rule it is very important to have a look at all possibilities on roads from primary to secondary markets, making sure that the final selection represents the best situation in the area in question. Therefore, sampling of clay should at first time be primitivo and the clay should by small tests be clasified in two groups, promising and unpromising. The capacity of clay mine migth be clasified by the same terms in relation to the desired capacity. Because of the many determining factors only few places will stand as promising after the first round.

Then the second round is started with a rough drilling net on the most promising place in relation to local conditions. The clay samples are exposed to precise laboratory tests. If the capacity, uniformity and quality steadily seems good, a close network of drilling holes is applied on a sufficient big area and all the clay samples are investigated carefully in a good ceramic laboratory. If third round makes the capacity and the quality sure, the last test should be a practical one done on the clay at an existing factory. The result of this decisive production test will be a very great help in selection the best production line for the new factory.

This important preliminary study should be presented by a team of an economist, a geologist and technicians in ceramics. The team shall where it will be possible work in close collabobation with local authorities and institutions.

General Considerations about Decisions related to Production Process.

Determination of production programme is considered as the second decision of importance because upon this choise depend the sale, the investment and the production cost as wellas it has influence on the following decisions. As a rule it will be wise to determine a broad production programme in areas where the market is insure. It should be emphasized. that,when the factory is established it could later be very difficult to change its production programme to a more broad one.

Selection of the materials handling system is considered as the third decision of importance because it has the greatest influence on the production cost. This is easily seen from the fact that inside a well planned brick factory with natural drier and of an annual production of 12 millions of normal bricks the daily weigth movement is approximately 800-1000 ton done in various handling operations and over different distances. In a bad planned factory the daily weigth movement could easily reach 1500 ton , which also is moved over longer distances. A good materials handling system is characterized by simplicity, uniformity, flexibility and cheapness in investment and in maintenance. The decision about the materials handling system has influence on the following decisions.

The fourth decision of importance is selection of kilns and burning system since from it the quality of product depends in respect to resistance and appearence. Investment andproduction cost also depend very much on this selection.

As a rule, if a very broad production programme is wanted a battery of intermittent kilns should be at least part of the kiln equipment, but here it must be remembered that a periodic kiln use 5o- loo per cent more fuel than a continuous kiln. It will not mean that it is a bad business to use a periodic kiln to the special products, on the contrary, it could be a very good one because of the high prices payed for such products.

Therefore, the selection should be in accordance to local conditions. If the market permits a combination between the two types of kiln this would properly give the best economic result in isolated areas. Such a kiln combination also gives the plant a high grade of flexibility on the production rate, which easily could be changed in accordance with the demand from the Building Industry. Therefore, this combination also lowers the industrial risk in comparison to a plant with only a continuous kiln.

If the plant is projected to use a mechanical setting system it will be wise to build the periodic kiln with the same square dimensions as the continuous kilm, because then a higher grade of flexibility is obtained.

In the subscriberś opinion, the only feasible continuous kilns for a developing country are the zig-zac kiln and some types of the Hoffmann kilns becausse those kilns could be built for about 1/2 to 1/4 of the cost of the tunnel kiln. Furthermore, those kilns have approximately the same fuel economy as a tunnel kiln with only aligth more manpower spend on the total operation of the kiln. The proposed types of kilns have as additional advantage that they could be built of national semi- refractory bricks.

The selection of the burning system depends very much on local and national sources of fuel, but when we are discussing production of clay building materials throughout a country, normally only wood, carbom and heavy fuel oil would be in mind. Here again, only for small isolated factories, the wood will be a real solution because of the amount used and the well known difficulties with its use in ceramic kilns.

The final decision between carbon and fuel oil, as fuel to bigger factories depends on so many factors that only some headlines should be mentioned. If we compare an oil-fired continuous kiln to a carbon-fired one, we will observe that the oil- fired kiln produce bricks of a better and more uniform quality with less amount of spoiled bricks. the working conditions inside and outside the kiln are more clean and pleasant in the oil-fired one. Furthermore, in the oil-fired kiln we could use a mechanical setting and drawing system, which normally is not possible to use in the carbon- fired one. If we compare fuel economy on a calorific base, the oil-fired kiln would normally use lo- 2o per cent less fuel because of the better conditions for combination of fuel and combustion air. In addition we normally must mill the carbon before it can be used in a continuous kilm. This point has influence on the production cost.

Of the mehtioned reasons it should be clear that the selection between carbon and heavy fuel oil is not only a question about the price in relation to the calorific value of the two fuels. For the calculation it is important to remember that the transportation cost for the fuel oil is about the half of that of carbon, because the calorific value of fuel oil is approximately twice as that of the carbon.

Anyway, whatever we chose of these two fuels, semi-automatic and automatic stoking and firing systems are disponible on the equipment market, but the final selection between different burning systems is out of the limit of this paper.

The determination of drying process and the system are considered as the fifth decision of importance and it has great influence on the investment and the production cost.

Most of the developing countries lay in sub-tropic and tropic areas, therefore, only in high altitudes the nigth temperature will be below 0°C. This climate condition is a gift to the developing countries and gives them a great advantage in relation to most of the developed countries when we are discussing drying of heavy clay products because a natural drier could be used all the year around without frost spoilage of product.

A rough calculation show that for the drying of bricks we need approximately the same amount of heat as to burn them. Therefore, with the use of a natural drier we could cut down very much the production cost and at the same time we save a lot of fuel.

Furthermore, the investment in a good natural drier is only 1/2 - 1/4 of that of an artificial drier, which also is more complicated in operation. Because the natural drier normally could be built of local materials it does not ask for devices to the same extent as the artificial drier.

The natural drier reduces the industrial risk of a brick plant because the natural drier contains 3- 4 weeks normal production and therefore it also work as a stock of semi-products to the kilns in case of heavy machine repairs on the production line. This point has great importance in isolated places where machine repairs are slowly.

Anyway, natural drying has not been investigated very much in relation to tropic conditions. Therefore, I shall mentione some experiences accumulated on this field.

Natural drying of bricks depend mainly on temperature, relative humidity and amount of air moved to contact the bricks. On a selected place we can only change the amount of air . Therefore, if fast drying is wanted ,the drier must be a very ventilated one, it will mean with an open structure so the air easily can come in and out. The roof of the drier should be the Shed-roof type, which is the most ventilated one. the roof should be painted with a dark colour, which better absorb the sun heat making then the roof a heater, which accelerates the drying operation.

If we look at the drying of a pile of bricks in a natural drier, we will see that the upper part dries out first. The explanation is that the air in contact with bricks gives an amount of heat and receive proportionally an amount of vapor until it is completely saturated. Because of that new condition, the air is cooler than the surrounding air and it sinks down on the lower part of the brick pile, which therfore always is in contact with the most humid air.

If the floor of the drier is a clay soil, a very bad condition for natural drying exists because then the floor works as a water accumulator.

In the night where the relative humidity is high the clay soil, because of its hygroscopic properties absorb water from the saturated air in contact with the floor. In the day with lower relative humidity in the air, the clay soil gives water vapor thus maintaining humid cool air in contact with the floor and the lower part of the brick pile. Therefore, if fast and some kind of uniform drying is wanted in a natural drier, the brick pile must be lifted out of contact with the floor and the most humid air. Furthermore, the hygroscopic properties of a clay floor must be killed. This result is achieved by treatment of the floor with asphalt oil.

The drying capacity of bricks of a given natural drier depends very much the water content of the bricks delivered to the natural drier. The economic importance of the water content of bricks is seen from the fact that in a brick plant of an annual production of 12 millions of normal bricks every per cent of water corresponds to approximately 1,5 ton of water per day. A low water content of bricks is obtained by two different ways. First, by perforation of the bricks. The hollow structure itself accelerates very much the drying process. For modul bricks and blocks with a minimum tickness of 9- lo cm, perforation is a must. Second, by lower water content in the clay mix, which with the extrusion process is obtained by use of a high pressure (3o kg/cm^2) in the mouthpiece combined with a heat treatment of the clay mix in the extrusion machine so the bricks leave the mounthpiece with a temperature of about 5o C°. With those combined effects we obtain bricks with a water content of about 12- 15 per cent, which is about 5- 10 per cent less water compared to normal extrusion.

Because of the low water content very little shrinkages of the bricks occur and therefore the risk of drying cracks is low even in a very ventilated natural drier. This effect is amplified because of the brick temperature of 50 C°, which makes the inicial drying fast and uniform. It should be noted, that only the inicial drying represents a danger of drying cracks. When the shrinkages stop the drying rate should be as fast as possible.

Because of the hygroscopic properties of clay natural drying stop with a water content of bricks of about 3- 5 per cent. This water content must be removed in the kilns by use of surplus heat from the cooling bricks. Therefore, when a natural drier is used, the kilns must be constructed to make possible this drying operation.

The green stiff production of bricks with low water content gives another advantage which makes natural drying economic feasible. The bricks could be stacked directly in a pile up to a heigth of 1,5 m without damage and sticking together, therefore a high drying capacity of bricks is obtained on a given floor area of the natural drier. This important feature signifies a low consume of stabling materials, which always has been a problem in relation to natural drying.

If we now make a summary of the conditions of natural drying in relation to the materials handling system, it will be seen that by means of pallets and fork-lift-trucks we could make avery simple and flexible handling system, which gives the necessary stabling materials for the drying process. Since we must lift the brick pile out of contact with the humid air near to the floor, the pallets should have legs of a heigth of about 40 cm, which secure a good air circulation underneat the brick pile. This very simple combination of a drying and a transportation system could be amplied, on an elegant way, to include also a mechanical setting and drawing system of bricks in the kilns. For this purpose the fork-lift-truck is equipped with a special fork-lift-tong, which permits handling of a whole pile of dried and burned bricks without using the pallets which bythe way are not needed when the bricks are dry.

Before such a system works, we must make some standardization of the elements. The products of the brick plant must be standardized on the building modul of 1o cm. The first dimension of a standard pile of bricks there allows production of products in steps of 1o cm up to 4o cm have the dimension of 12o x12o x 12o cm. Then the standard pallet should have the size 125 x 125 x 4o cm. The inside dimensions of the kilns should be in accordance with the standard pile or a multiplum of this with certain allowance for the truck operation. On the hacking or setting station it would be wise to put up a heigth guide as known from the tunnel kiln. The width of the standard pile with allowance is given by the standard pallet.

With this small standardization we obtain, as final result, a combination between natural drying and a materials handling system where the bricks are only touched by hand on the hacking station. Therefore, a high grade of prooductivity is obtained without loosing the advantage of natural drying. Furthermore, all feasible bricks and blocks up to 4o cm could be produced in accordance with the standard modul of 1o cm. This is an advantage inrelation to most of the known artificial driers. It should be mentioned that modul bricks give a better stability to the brick pile than normal bricks. Therefore, transportation by means of fork-lift-truck is feasible.

The size of a natural drier should be approximately 1ooo m^2 for every million of bricks based on annual production rate. The amount of standard pallets is about 3oo for every 1ooo m^2 floor area of the natural drier. In these measures, allowance is made for truck roads and ventilation channels within the drier.

The sixth decision of importance is the selection of the machine line for production of green bricks.

Production of bricks starts with the winning of clay and the following transportation of it to the plant. The machinery used, if any, depends so much on the pit or mine and other local conditions that it is impossible to give advice on this selection.

The stiff extrusion is chosen as the most universal production process for bricks, both in relation to different types of bricks as well as to various products. Furthermore, the stiff body is a must for economic natural drying.

The machine line used migth be the folowing: Box-feeder, Kibbling Rolls, Grooved Rolls, Smoot Rolls, Double-shaft Mixer, Differential High-speed Rolls, De-airing Extrusion Aggregate with device for heat treatment of clay mix, Rigid Automatic Cutting Table. The machines are arranged in convenient groups, which are connected by means of conveyors.

For easy work on the hacking station, a separation belt should be connected to the cutting table, and turn-tables for pallets should be arranged along this belt. The turn-tables should be at floor level.

The mentioned machine line is selected as a simple standard solution because of it deals with a wide varity of clays. However, the more special clays migth require some changes in this machine line.

Layout Proposals for Clay Building Materials Industries in Developing Countries.

The layout is based on the previous concepts in relation to production process, therefore, it will only be discussed to a certain extent.

The layout present a 18 millions bricks plant. On the left side of line AB is made a proposal for a 6 millions bricks plant with a battery of seven periodic kilns. On the rigth side of line AB is made a proposal for a 12 millions bricks plant with one continuous kiln. If we use line AB as symmetry line for the rigth side, then we have a proposal for a 24 millions bricks plant with two continuous kilns. Then if we use line CD as symmetry line for drier and kilns of the 6 millions bricks plant, we will have a proposal of a 12 millions bricks plant with 14 periodic kilns.

Therefore, this layout shows the 6 millions, the 12 millions, the 18 millions and the 24 millions bricks plants with natural drying combined with use of periodic and continuous kilns. The selection between all those possibilities depends on the market study and the local conditions on the place , where the brick plant is wanted.

The standard solution of brick plants does not include the winning method because this is impossible to standardize. For the purpose of making some estimation of the investment and production cost, we have in mind the combination of a clay hill and a flat country. Therefore, the excavating is thougth to be done by means of a bulldozer.

The purpose of the layout is to obtain maximum ventilation within the natural drier combined with the shortest possible transport distance within the plant. Therefore, all production activities and heavy transport are concentrated into a central cross. The natural drier is by this split up in four almost independent parts. In one cross-arm the production machine line is arranged in a streigth line so the green bricks are delivered in the center of the plant. Materials handling is then done in the following way:

The green bricks are set in the standard brick pile at the hacking station. Then, the pallets are moved to the natural drier by means of a fork-lift-truck, which move along the principal cross-arm, then entering the natural drier drier by fixed secondary cross-arms. When the plant is working, fresh made bricks are always replacing dried ones. Therefore, the truck returns with a pallet of dried bricks, which is left in the principal cross-arm near to the kilns. Then the truck pick up aempty pallet and return to the hacking station. Herewith, the truck has made a complete working cycle.

The kiln truck is equipped with a special fork-lift-tong, which permits setting and drawing of kilns in units corresponding to brick pile on pallets. When the kiln truck takes a brick pile from the pallet, this is left for the other truck. Loading of lorries with burned products is done with the kiln truck, which always should try to load lorries with products directly from the kiln. With the purpose of making this operation possible the ends of three cross-arms are destined to loading zones for burned products.

A particular feature of this layout is the very short transport distance inside plant and the very little interference between different types of transport. Even in the case of the 24 millions bricks plant transport distance is very reasonable and of this reason natural drying is feasible at least to this plant size.

It should be noted, that fork-lift-trucks require good roads at the same level.

The natural drier is in all parts covered by a shed-roof construction, which is assembled of modul of 6 x 5,5 m. By using standard elements, the natural drier has been constructed for about US $ 3,oo/ m². The free heigth inside the drier is about 3 m.

The central cross-structure, 25 m wide, is covered of a cement- asbentous roof, which has been constructed for about US $ 7,oo / m². Free heigth is about 5 m.

The standard pallet 125 x 125 cm with 4o cm legs is estimated to be about US $ 6,oo/ unit.

In summery good air circulation in natural drier is obtained by means of the open shed-roof-construction, the central cross-structure, the secondary cross-arms whish by the way serve also as truck roads and finally the pallets with high legs.

The continuous kiln is constructed as two straigth tunnels every one 6o m long. The tunnels are interconnected near to the ends. The kiln is charged and discharged only from the ends by means of the fork-lift-truck. Therefore, 25 per cent of the kiln should always be at disposal of this operation. The kiln is supposed to make a complete turn in 4- 6 days.

For a 12 millions bricks plant the total cost of such a kiln built of local materials with ventilators and oil-burner installation would be US $ 8o- 1oo,ooo,oo, which is only about 2/3 of the cost of a side loaded sic-sac kiln and only 1/2 to 1/4 of the cost of a tunnel kiln.

One advantage of the kiln in question, in relation to the sic-sac kiln is that only one kiln door is pulled down and set up every day. This is partly compensated of little longer distance inside the kiln.

The intermittent kilns are constructed as short tunnels, which can be loaded from the ends by means of trucks. The kilns are side- fired by means of oil-burners and they are interconnected by ducts or channels so heat from cooling bricks could be used to dry the fresh set ones. The total cost of a battery of periodic kilns is estimated to be 5o- 1oo per cent more, in relation to the continuous kiln with the same production.

The question of one or two production machine-lines may be raised in relation to the 18 millions and the 24 millions bricks plants. As a rule one machine-line is cheaper and more efficient and it should be preferred in most cases. The additional industrial risk with only one production line is very low because of the great stock of bricks in the natural drier.

The efficiency of the proposed brick plants is seen from the following estimation of personnel related to production:

24 millions bricks plant : 3o- 35 men

18 millions bricks plant : 26- 35 men

12 millions bricks plant : 2o- 25 men

6 millions bricks plant : 18- 25 men

The efficiency of about 3 man-hours/ 1ooo bricks obtained at the big plant is worthy of comparison to any modern brick plants in Developed Countries, specially if the comparison is done also in relation to investment.

Because of the open structure of the natural drier , the whole plant is easy supervised from the center, where also the great amount of personnel are working. Control of daily amount of bricks produced at any place is easy and fast because of the standard brick pile unit.

Investment and Cost Estimation for The Proposed Brick Plants.

The investment depends very much on local conditions, but for the high per cent of the proposed standard brick plants, it migth be between the following limits:

24 millions bricks plant with two continuous kilns, one production line, production of only few products.

Total investment US $ 500- 600,000,00

18 millions bricks plant with one continuous kiln and a battery of seven periodic kilns, one production line and varied production programme.

Total investment US $ 450- 600,000,00

12 millions bricks plant with one continuous kiln and one production line. Normal production programme.

Total investment US $ 300- 450,000,00

6 millions bricks plant with a battery of seven periodic kilns and one production line. Varied production programme.

Total investment US $ 200- 300,000,00

The investment used to any of the mentioned brick plants is less than half of the normal investment used to semi- automatic brick plants with artificial drying at the same production capacity.

The total production cost of bricks produced at the mentioned brick plants migth be found in the range of 8- 15 US $/ 1000 bricks.

It should be mentioned too that no bricks in Developed Countries could be produced at this low cost. This is due to low investment, the use of natural drying, and the low salary of personnel.

The lowest production cost corresponds to the 24 millions bricks plant which is a very efficient one. The relative high cost of about US $ 15/ 1000bricks is for the 6 millions bricks plant. The much higher production cost is due to the high relative investment, the high fuel consume in periodic kilns, the high relative administration cost and the many man-hours per thousand bricks....-

Statements and Recommendations.

Building Industry and Building Materials Industries together must be considered as the most important industries in Developing Countries, since their activities represent an amount equivalent to at least 30- 50 per cent of national income. Further development of those industries is from all viewpoints of great interest because their final product, houses and apartments, is a primary necessity for the people. Furthermore, those industries employ a great amount of workers on a very small relative investment.

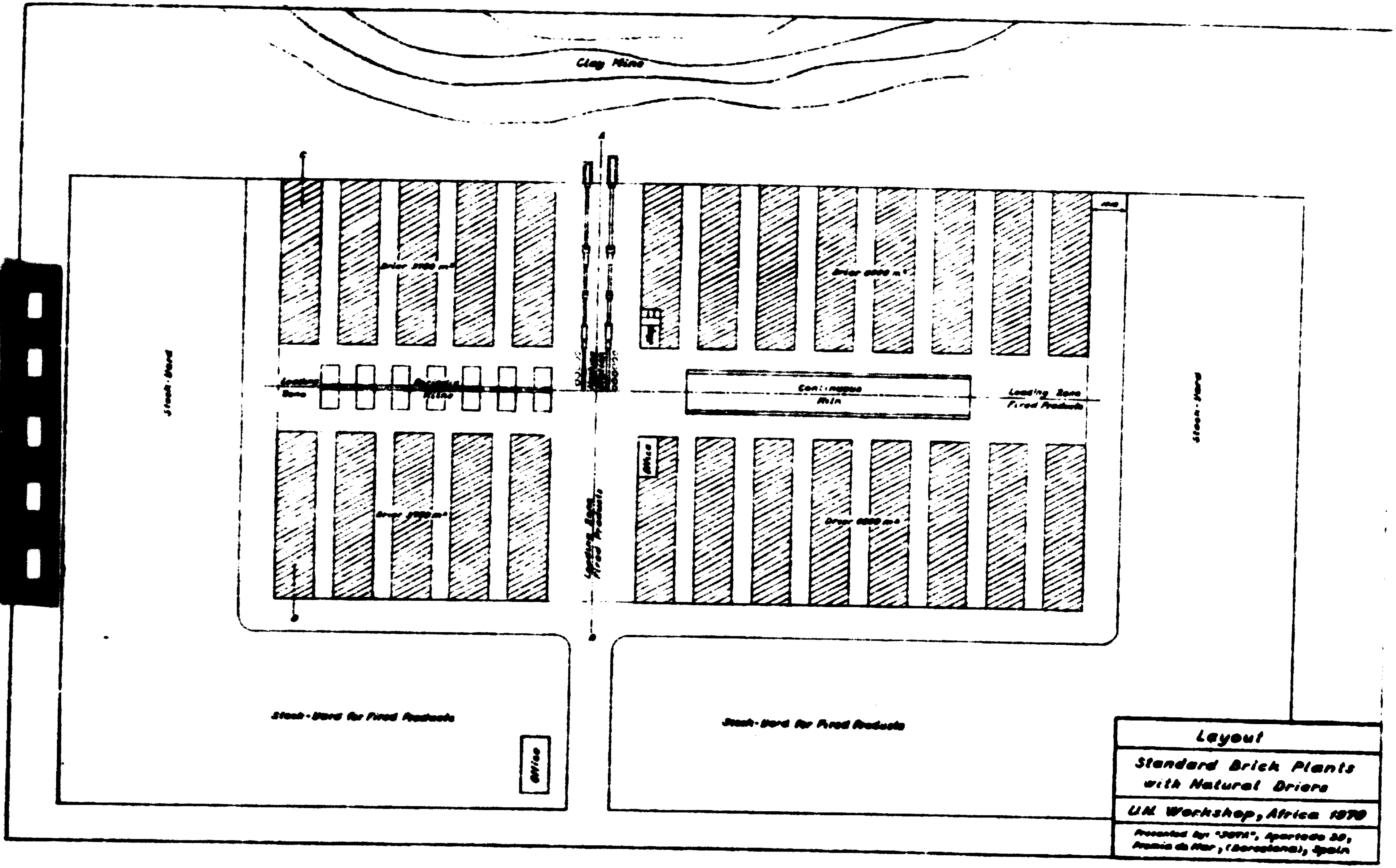
Development of Building Industry and Building Materials Industries are synchronised to a great extent. Therefore, if planning, administration and standardization are believed to be necessary for one of those industries, it will also be for the other one. Presentation of development planes for any of those industries to Governments and International Organizations should be done in close collaboration with each other. Because of the high impact by the combined action those important industries must be on top on every development plan for Developing Countries.

The Clay Building Materials Industries migth be an universal solution to cover the enermeous lack of building materials in Developing Countries, but this industry must demonstrate, that it is convenient and efficient. Therefore, establishment of Clay Building Materials Industries shall be done according to actual conditions in Developing Countries. For the reason of a fast development of Clay Building Materials Industries, it is recommended to standardise brick plants so they could be easy multiplied with a small industrial risk.

It is recommended, that every African country establish their own National Committee for Development of The Clay Building Materials Industries. The main purpose of this committee should be coordination of the efforts of the Clay Building Materials Industries to those of Building Industry. The Committee should also prepare for each Government and for the International Organisations a list of proposals dealing with the necessity of their economic and technical support for a fast development of the Clay Building Materials Industries.

The secretariat of the committee should employ a working group of national specialists, who could sample and prepare all facts about the heavy clay industries. The working group should present a detailed study for an efficient standard brick plant and it should be in charge of all kinds of technical assistance in relation to the settlement of the proposed standard brick plant. The first established plant should be used as pilot plant for practical test of the clays to the following plants and it migth also be used as training plant for medium level personnel. The working group should have at disposal a good library and a small ceramic laboratory, which in case of standard brick plants could be established for about US $ 20- 30,000,00.

An African Center for Development of Clay Building Materials Industries with the purpose of exchanging of experience could be very valuable, when the national groups have got some years of practical experience. Anyway, the establishment of the national group migth be the only realistic way to a fast development of the Clay Building Materials Industries in every country because of the magnitude of the related problems and the changing conditions from country to country.


Clay Mine
Stock-Yard
Drier 6000 m²
Continuous Kiln
Loading Zone
Fired Products
Kilns
Office
Stock-Yard for Fired Products
Layout
Standard Brick Plants
with Natural Driers
U.N. Workshop, Africa 1970
Presented by: "JOTA", Apartado 30,
Premia de Mar, (Barcelona), Spain

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