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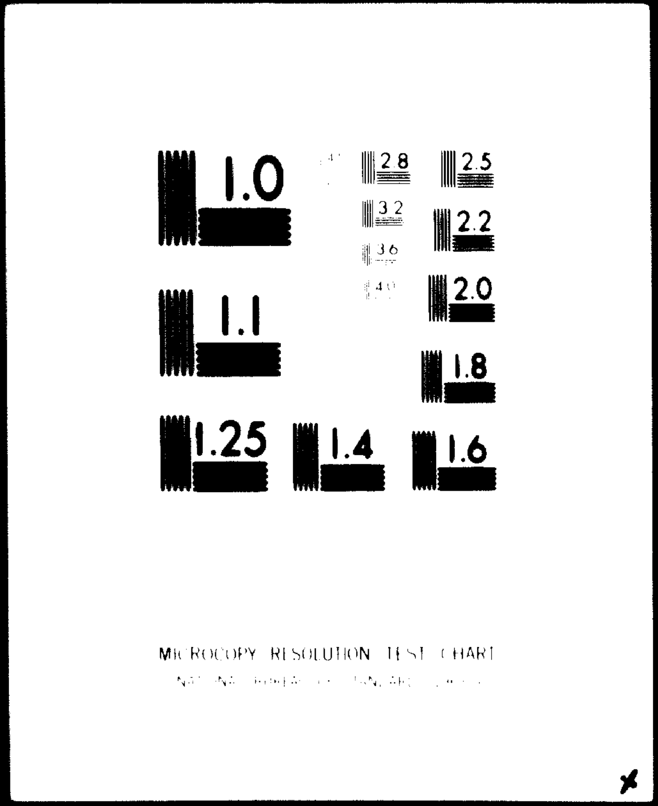

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UNITED NATIONS INDUSTRIAL
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FINAL REPORT

CERAMIC INDUSTRY AND RAW MATERIALS IN TRINIDAD AND TOBAGO 1/

by

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UNIDO Expert

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D-1940

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INTRODUCTION

1. **Following** a request from the Government of Trinidad & Tobago, the expert was appointed by the United Nations Industrial Development Organization (UNIDO) as a consultant in Ceramics and Glass for a period of three months which was extended for one month more. According to the Job Description TRI-68-SFD (SF/ID) the duties of the expert are stipulated as follows:

"The expert will be a member of a professional team of international experts working under the leadership of the Project Manager of the Caribbean Industrial Research Institute (CARIRI). He will co-operate with the other international experts and the local counterpart staff in:

a. Undertaking a survey of the country's ceramic industry, and especially the brick plants.

b. Assessing the availability of raw materials both locally and in other neighbouring countries, for the expansion or establishment of the ceramic and glass industries including an assessment of the market in the country and the CARIFTA region for ceramic and glass products."

I. SUMMARY

7. The clay building brick industry in Trinidad is a developed one generally. However, to cover future demands, extension of the three existing factories rather than installing new ones is suggested. This is mainly because of the experience gained by these factories. Reconditioning and renewal of two of the three factories is essential, i.e., Oropouche and Rio Claro brick factories. Source for the siliceous clay, sand or equivalent near the Rio Claro factory to be mixed with the plastic one, is to be seeked rather than getting it from far away. The third factory in Longdenville is a renewed one with proper technology. Extension of this factory to produce split tiles, and sewer pipes is suggested.

8. Trinidad is a country of clays. However, [illegible] heterogeneous. Homogenisation before use is important, especially when [illegible] some of the fine earthenware industries. Estimation of the reserves has to be

carried out. It is suggested that CARIRI, through the help of UNIDO, starts making this survey in connection with the Ministry of Petroleum and Mines. This survey will cover already quarried areas and new areas, especially those for the whitish burning clays near Arima and Valencia.

4. Concerning the fine earthenware industries, there is only one factory in Diego Martin glazing imported biscuit fired wall and floor tiles with imported glazes. There is a possibility for this factory to have a production process for the body mass with local raw materials. A preliminary feasibility study was prepared which justifies this possibility. However, the fluxes needed, especially in the case of floor tiles, i.e., potash feldspar, are not found in Trinidad and Tobago and have to be imported. Use can be made of the abundant limestones in Trinidad and the dolomite of Pt-Gourde in the body mass for wall tiles. The waste undersize quartz sand, amounting to thousands of tons in the concrete and glass

industries, causing storage problems for the firms concerned, can be used in the ceramic industries and in the cellular concrete manufacture, as will be mentioned later.

5. Guyana is a nearby country to Trinidad and Tobago and is one of the CARIFTA group. In this country there are big resources of ceramic raw materials of average good quality. These raw materials are the kaolin, the quartz sand, the feldspar as pegmatite, the bauxite and the refractory clays. Trinidad can make use of those raw materials in developing new ceramic industries, taking into consideration the availability of cheap liquid gas fuel.

6. The suggested industries are:

1. A plant for the production of table ware, sanitary ware and electric insulators.

2. A plant for the production of aluminous fireclay and alumina refractories.

A feasibility study will indicate the suitable size of these plants.

7. The new washing and screen plant for glass sand in Matura has to be sheltered as corrosion and iron scales arising from the dryer contaminate the prepared sand. The rejected undersize quartz sand, amounting to about 12% of the total consumption, can be used in the ceramic industries.

8. The problem of not having enough reserves of glass sand for the glass factory, especially when expansion is concerned, can be solved in the following ways :

1. Proper geological survey and plan for estimation of reserves for the white glass sand.

2. In case of containers for beer, alcoholic and soft drinks, the possibility of using coloured glass is to be considered, and in this case it is not only possible to use available ordinary quartz sand, but also local limestones.

3. Use of the huge reserves of glass sand in one of the nearby CARIFTA countries, i.e., Guyana.

9. It is suggested that a feasibility study taking into consideration the external factors be made for the extension of the glass factory to manufacture:

a. Sheet glass.

b. Pressed glass table ware, e.g., tumblers, cups, saucers, and manual blown glass ware.

The experience gained by the workers in the existing factory helps in the start up of these new products.

10. Gypsum deposits of average good quality are found in Trinidad, near St. Joseph. Preliminary tests have proved that it is suitable for the manufacture of Plaster of Paris needed for moulds in the ceramic industry. Dwelling areas are extending over some parts of the deposit. It is suggested that the Ministry of Petroleum and Mines take the necessary steps for :

a. Stopping buildings in this area.

b. Proper estimation of the reserves, say, by core drilling.

If there are enough reserves, it is suggested to install a small unit for the production of Plaster of Paris.

11. The massive hard limestones abundant in Trinidad, e.g., Laventille, Gasparee Island, Pt-Gourde, have good physical properties and are suitable for firing in shaft or rotary kilns for the manufacture of lime. It is suggested that the one lime factory in Trinidad (Port-of-Spain), extends its capacity for the

purposes of introducing sand lime bricks and cellular concrete manufacture. The waste sand in the adjacent readymix concrete plant, amounting to about 100,000 tons/year, can be used successfully in the manufacture of cellular concrete. A feasibility study is suggested for such a product which could not only be competitive in price to the concrete blocks, but have heat insulation advantage in the form of cellular concrete.

12. As there is a cement industry in Trinidad the possibility of making cemented asbestos products may be considered (e.g., corrugated sheets, pipes and pillars).

13. In all these industries the preventive maintenance awareness is important. Essential spare parts for the machinery and equipment must be secured. Regular training of personnel must be carried out.

14. The market condition and demand projection within the CARIFTA region of about four million people is a small one. This is why when considering the new

industries, semi-automatic and intermittent rather than continuous processes are chosen in some cases which are at the same time labour consuming. Naturally, the machinery and equipment should be of high efficiency and of the latest development. Their size will be rather small and adapted to less maintenance using the available cheap not highly skilled labour to work on.

15. I think for the flourishing of such projects co-operation and co-ordination between the countries within the CARIFTA region are necessary. The size of the market is too small to accommodate more than one production unit of any of these suggested new industries apart from building bricks.

16. The extension of the ceramic industries existing in Trinidad and Tobago, as well as the introduction of new industries, justifies the installation of a ceramic laboratory in which fundamental, applied and development research are carried out.

Also it will carry out control tests on request. The running of this laboratory can be co-ordinated between CARIRI and the University of the West Indies (Dr. R. O. W. Fletcher, Head of the Physics Department).

II. SURVEY OF THE TRINIDAD AND TOBAGO CERAMIC INDUSTRIES

17. The Ceramic and Glass Industry in the country is confined in the following:

1. Building clay bricks and blocks.
2. Glazed wall and floor ceramic tiles.
3. Cottage pottery and ceramic art ware.
4. Glass containers (bottles) - incandescent lamps assembly based on imported glass bulbs and other accessory materials.
5. In a broader sense Lime and Portland cement.

18. Building clay bricks and blocks:

There are three factories in Trinidad for the production of clay building bricks and blocks. These factories are :

1. Alstons Building Enterprises Ltd., Longdenville Factory.

2. Rio Claro Brick Factory, South Trinidad.

3. Oropouche Brick Factory, South Trinidad.

The production is mainly of hollow blocks for walls and ceilings. Perforated or solid bricks can be produced on demand. The main size produced is 4 x 8 x 12" with an average weight $10\frac{1}{2}$ lbs. each. Other sizes are produced also. The capacity of the three factories is about 490 tons/day.

19. The first factory is a renewed one with proper technology having a capacity 380 t/d equivalent to about 80,000 hollow blocks 4 x 8 x 12". The stiff mud process is used for manufacture. It began operation in the year 1934 and was updated with new equipment in 1962, 1966 and again in 1969. The raw materials employed are dug from pits nearby, one for siliceous clay and the other for plastic clay. The stiff mud process is used for manufacture. There are three lines for manufacture, two for standard hollow blocks which are fired in two car direct fired tunnel kilns, the

third is for special shapes and are fired in seven down draught kilns. The hot air from the cooling ends of the tunnel kilns and the waste heat from the down draught kilns are used for drying. The firing is with natural gas. The firing temperature is about 1120°C in the tunnel kilns and in the down draught kilns. There is laboratory in the factory for routine tests and quality control. The quality of the production is generally good.

20. The second clay brick factory at Rio Claro in South Trinidad has certain technical difficulties. The plastic clay is quarried from an adjacent hill. The siliceous clay and sand are brought from far away in Longdenville. The main production of the factory is hollow blocks, size 4" x 8" x 12". The output of the mass preparation (one shift) is 2,000 - 2,500 blocks per hour. There is one de-airing auger machine. The soft mud process rather than a stiff mud process is used in manufacture. The bricks are dried on shelves on a multi-channel dryer.

The firing is in a car direct fired kiln using liquid fuel. The firing temperature is about 950°C. The percentage rejects in drying and firing are high.

21. The third clay brick factory at Oropouche South Trinidad is a very old factory. The raw materials, plastic clay and sandy clay, are excavated from a nearby quarry (pit). The daily output (on 8-hour shift) is 3,000 hollow blocks dimension 4" x 8" x 12" and with three holes. The soft mud process is used rather than stiff mud process. The blocks are put on shelves and left to dry in the open air under sheds. The firing is in two down draught kilns fired by fuel oil. The firing temperature is about 1150°C.

22. There is a fourth small factory called Caribbean Clay Products in Iere Village in South Trinidad. It has not been installed yet, although some trials were done eleven years ago with some machinery and equipment which were bought at that time.

More details about these factories are found in Appendix No. 1.

23. **2 - Glazed wall and floor tiles:**

There is one factory in Trinidad and Tobago producing glazed wall and floor tiles; it is a new factory which started about three years ago. In this stage of production the factory is importing the biscuit fired wall and floor tiles and the glazes. In the second stage of production the biscuit tiles will be manufactured locally, first using imported raw materials and then using local ones.

The daily output of the factory (mass preparation one shift) is about 350m^2 glazed tiles with a dimension 10 x 10 cm, thickness 9 mm for floor tiles and 15 x 15 cms, thickness 6 mm for wall tiles. Floor tiles represent about 20% of the total production.

For firing, a pushing slab muffle tunnel kiln is used. Liquid fuel is used for firing, the firing temperature is about 980°C.

According to a preliminary study (Appendix No. 2) it is feasible to produce these tiles from local raw materials based on the expected market defined by the manufacturing company. The preliminary tests of the local clays, e.g., clays from Wallerfield, Longdenville and marl clays from Mayo, show that these clays are suitable for the manufacture of wall and floor tiles.

More details about this factory are seen in Appendix No. 1.

24. 3 - Cottage Pottery and Ceramic Art-Ware:

The cottage pottery in Trinidad and Tobago is a primitive one, but covers a certain requirement of the local market in products such as, plant pots, saucers, dias (used by Indians in Holy occasions), vases and lamp shades. There are about 13 workshops in Trinidad for this type of production, four in the south near Rio Claro and eleven in the north in Chaguanas. The total annual consumption of the clays and sand used hardly exceeds 1,000 tons.

More details about these activities are found in Appendix No. 1.

25. **4 - Clear glass containers (bottles):**

There is one factory in Trinidad for the production of clear glass containers (bottles) for beer, alcoholic and soft drinks. The new factory started production in April 1972. The designed capacity of the plant is 120 tons glass/day, while the actual production now is about 60 tons glass/day. The designed capacity is taking into consideration a consumption growth in the local market and some export to the nearby islands and Guyana.

The factory uses local white quartz sand from Matura area, with a consumption about 60 tons/day. This sand is treated in a unit installed recently near the quarries where it is washed, screened and dried. The limestone soda ash (dense) and the other additions needed for manufacture are imported. A continuous glass tank with recuperation is used. The temperature inside the tank is about 1550°C. The firing is with natural gas arriving at the factory by a pipe line from Texaco. There are two automatic shaping machines for bottles with their annealing furnaces, fired also with natural gas at 550°C. A decoration kiln fired with natural gas is used for fixing the overglaze decoration and printings, on some of the production. The firing temperature is about 600°C. There is a small laboratory for quality control of the production. The percentage rejects amount to about 20% which is used again in the batch as cullet.

More details about the factory are found in Appendix No. 1.

26. 5 - Lime:

The lime factory in Port-of-Spain is the only factory in Trinidad and Tobago manufacturing lime. It is a very old factory. The hard limestone from nearby areas, e.g., Laventille, after crushing to suitable sizes, is burnt in two shaft kilns. Firing is with liquid fuel oil (grade No. 6) at a temperature of about 1000°C. Half of the amount of the quick lime produced is packed in steel drums, the other half is slaked and packed in multiply paper bags for local consumption and for export.

The factory is also grinding limestone (the undersize not used in the shaft kilns) for agriculture purposes.

This ground limestone can be used in the batch composition of some ceramic bodies and in glass, taking into consideration the amount of iron oxide in it.

The factory has no laboratory. If the production of lime is to be expanded for use in the manufacture of sand-lime bricks and cellular concrete, quality control of the raw materials, manufacturing process and finished products, is important. The determination of active lime, its temperature and time of slaking, must be a regular test. The values obtained must be in accordance with the specifications. The cellular concrete and sand-lime brick manufacture is recommended as a new field in building construction in Trinidad and Tobago, especially when there is waste sand available from other nearby industries (e.g., 100,000 tons/year fine quartz sand waste in adjacent Ready-mix Concrete plant).

More details about this factory are found in Appendix No. 1.

III. RAW MATERIALS AVAILABLE BOTH LOCALLY AND IN OTHER NEIGHBOURING COUNTRIES FOR THE EXPANSION OR ESTABLISHMENT OF CERAMIC AND GLASS INDUSTRIES

A. Local Raw Materials

1. Clays

27. Clays are generally abundant in Trinidad and Tobago. In Trinidad in the north, e.g., Wallerfield near Arima and near Valencia, in the middle, in Longdenville, Carlsenfield and Mayo, in the south, in Oropouche and Rio Claro. They vary in colour from black, greyish, yellowish, reddish and white. All these clays disintegrate in water having a very good plasticity. The mineralogical composition is mainly kaolinite, montmorillonite, illite and quartz in varying proportions. The marl clays, e.g., in the Mayo area, contains calcium carbonate in addition to the clay minerals. Apart from the marl clays used in the manufacture of cement, these clays are quarried mainly for the manufacture of clay building bricks, a very small amount is dug for the cottage pottery and the ceramic art ware. The annual

consumption of clay from the clay quarries for building bricks in Longdenville, Rio Claro and Oropouche is about 195,000 tons/year. The estimation claimed by the quarrying companies for the reserves is not a proper one. Proper estimation of the reserves by core drilling or augering is suggested to be carried out. It is suggested that CARIRI, through the help of UNIDO, starts making this survey in connection with the Ministry of Petroleum and Mines. This survey will cover already quarried areas and new areas including those for the whitish burning clays near Arima and Valencia. Examination of all these clays shows great heterogenity within the same pit. To overcome this heterogenity for proper production, sump installation in the factories using it is necessary. In these sumps the clay is spread horizontally and cut vertically for daily use. The size of these sumps can be for two to three months consumption. Apart from the Wallerfield and Valencia clays, which are siliceous enough, the other clays, e.g., in Londgenville, Rio Claro and Oropouche, are very plastic with a high shrinkage and sensitivity in drying and firing. This necessitates the addition of either siliceous clay, sand or equivalent to control the drying and firing behaviour at the same time keeping the workability and strength of the green mass reasonable. The added percentage varies between 40 and 60%. In firing the proper strength is attained at a timperature varying between 950°C as in the case of the clays from Rio Claro and 1150°C as in the case of the clays from Longdenville and Wallerfield. Above 1200°C vitrification occurs and possible distortion of the body. These clays have the advantage that they do not contain soluble or partially soluble salts to cause efflorescence. Also they do not contain any harmful nodules or particles of calcarious compounds which after firing converts to calcium oxide which hydrates with expansion causing bursting or flaking in the part it is present in. These clays high in iron content fire into a nice homogenous reddish brown colour.

The colour of Wallerfield clay after firing is buff colour. That from Valencia are is whitish. However, it seems that the reserves are small. The clay is not extending in thick layers. In some other parts it is in a sort of pocket with the other reddish clays which makes big scale excavation and separation difficult. For ceramic art work with low consumption it can be dug manually. For big scale work it has to be excavated with the other accompanying clays, and homogenised before use. At the moment there is a crew from the Ministry of Petroleum and Mines making augering there. The results will give a complete picture for the possibilities there.

These clays in the wet season may contain moisutre up to 18%. The samples of the different clays were fired as it is in lumps at different temperatures 900°C, 1000°, 1100°, 1200°, 1300°C for the preliminary information about texture, colour, porosity, sintering and strength. The drying shrinkage of the clay mix varies within 6%, the firing shrinkage is small in some cases it is 0.5 at 1100°C.

28. Concerning the marl clays near Mayo in the centre of Trinidad, there was no chance to visit the quarried areas and take samples to see its suitability for the manufacture of some ceramic products. Arranging this visit was tried but without success. However, a sample of this marl clay was brought from the quarry

during the writing of this report. From the preliminary tests, the clay is yellowish grey in colour, it disintegrates easily in water. By firing at 1000°C it is light brown in colour and develops good strength. One can identify few small white particles of lime. The percentage of calcium carbonate in this clay is about 10%. Estimation of the economic reserves is suggested. This clay can be used successfully in the batch composition of ceramic bodies like wall tiles. In using this clay it has to be ground in ball mills in order to finely divide and homogenise the limestone present.

29. The report connected with the finished Geological Map of Trinidad is not ready yet, so the information we have concerning the ceramic raw materials depends mainly on very old geological reports, reports accessible to the Ministry of Petroleum and Mines and the Technical Information Service of CARIRI. No information was available from Texaco.

30. In Tobago, according to the geological survey done by Maxwell, clay is found in different areas in the south western part, e.g., Rockly Bay near Scarborough, Old Government Stock Farm, Bishop's High School, Montgomery School and Dutch Fort Road. Samples were only taken from the first three places as proper samples of clays from the other areas were not accessible.

The clay at the sea-cliff about 1½ miles south of Scarborough has an overburden of about 60-100 cm, the height of the clay face is about 6-7 metres, in length it is more than 200 metres. It is said that it extends in the interior and there is a clay slide of 100 metres during the last 25 years. These clays, greyish yellow in colour, are plastic. The clay at Rockly Bay is a sandy one, disintegrating easily in water. By firing at 950°, 1000°, 1100°, 1200°, 1300°C; the colour is reddish brown, sintering at about 1200°C. Good strength attained at about 1100°C.

These clays after the estimation of the reserves can be used in the manufacture of heavy clay products, i.e., building bricks, glazed sewer pipes with the addition of sand if needed, e.g., undersize from the newly installed Mobile Goldsborough crushing, screening and washing plant for gravel and sand for building purposes. The possibility of adding the screened volcanic disintegrated tuff, e.g., John Dial area and Mount St. George may be studied. However, a feasibility study is suggested to see if it is justified to install a unit for their manufacture or if it is better to transport these products for the very small market from Trinidad.

2 - Quartz Sand (White)

31. According to the surveys and reports by Sutton, D. Thatcher and others, the reserves of white sand for the glass industry are small. These deposits are within the areas - Arima, Valencia, Matura. According to the estimation of the glass factory, the working area now used, 8½ miles from the washing plant on the Toco Main Road, there is a reserve for the factory for about 2½ years. There is another area to the east of the above-mentioned area which also contains glass sand. Taking into consideration that the annual consumption of glass sand by the glass factory is about 18,000 tons, the need for 30 years will be 540,000 tons. With a reject of 12% undersize in washing and screening, the

needed amount will be about 614,000 tons not treated sand. The already known reserves are not enough to cover the needs of the factory even without extension. It is suggested to carry out a proper geological survey and plan for the estimation of not only white glass sands, but also the other grades of quartz sand, e.g., higher in iron content which may be used in coloured glass. The clear colour for the glass containers is not important in a majority of cases. The possibility of using the huge reserves of glass sand in one of the nearby CARIFTA countries, i.e., Guyana is to be considered later when new glass industries justifies its use.

32. There is a recent sand treatment plant in Matura for washing, screening and drying of glass sand. It started operation about six months ago. The sand is brought from the nearby quarry by trucks and dumped into the open store. The sand is taken by a belt conveyor to a vibrating screen where a high pressure jet of water is applied. The oversize sand is separated. The fine particles floating over the sides of the receiver are taken to sedimentation tanks. A cyclone is used to separate most of the water from the sand. The wet sand is taken by a belt conveyor to a rotary dryer, heated by diesel

oil to a temperature of about 140°C. The maximum output of the plant is 60 tons per day. The average daily output is 40 tons. From the dryer the sand passes through a screen to the pit of the bucket elevator which feeds it to the storage silos, ready for despatch to the glass factory by trucks. The analysis of this sand is :

SiO_2	Al_2O_3	Fe_2O_3	CaO	
99	0.08	0.04	0.01	%

It was noticed that this unit was erected in the open air, subjected to the weather conditions, mainly rain. The rotary dryer and its accessories suffered badly. Its shell is already rusted. Some of the rust and iron scales, caused mainly from the connection parts of the burner with the body of the dryer, comes out with the washed sand. This is very harmful as it stains the manufactured clear glass when this sand is used.. A shed is suggested at least for the part affected by the weather conditions.

3 - Limestones

33. Limestones of different qualities, physically and chemically, are abundant in Trinidad. Corals are abundant in Tobago. The survey by the Ministry of Petroleum and Mines "Analyses of Trinidad & Tobago Rocks, Minerals and Ores" gives a description (location, colour, hardness) and chemical analysis of these limestones.

For the time being hard limestones, e.g., in the North of Trinidad, are quarried mainly for road and building construction. The softer limestones near Mayo in the Central of Trinidad, are used for the cement manufacture. The lime factory uses hard crystalline limestone from nearby quarries, e.g., Laventille for the manufacture of lime. The undersize is ground to 100 mesh sieve and used for agriculture. This ground limestone can be used in the body composition of some ceramic products also or in the batch composition of glass. Purer grades as regards iorn oxide may be used according to demand.

These hard limestones vary in colour from whitish through greyish to dark bluish colour. The average composition is about 98% calcium carbonate. The rest being mainly silica, magnesia, iron oxide and alumina. There are good qualities of of limestone with low iron content, e.g., in Gaspar Grande and Pt. Gourde. The physical properties of the above-mentioned hard limestones, whether before, during or after firing according to the preliminary tests done, are good for making lime whether in shaft or rotary kilns. Being of high cold crushing strength, also it does not break or disintegrate in firing and still of acceptable strength after firing.

4 - Dolomite

34. In Sutton report (1962) it was mentioned that there is a dolomite in some of the Pt. Gourde limestones. Samples were taken from four different areas in Pt. Gourde. The sample from Carenage bay police boat yard has, according to the chemical analysis done at CARIRI, about 44% $MgCO_3$, the rest being $CaCO_3$. This hard crystalline massive dark grey dolomite can be used after grinding in the ceramic body compositions, e.g., wall tiles as a source of CaO and MgO. Estimation of the reserves of this raw material is suggested to be done.

5 - Gypsum

35. Gypsum deposits occur near St. Joseph in Trinidad. This was reported by Sutton "The General Geology of Trinidad" 1952, by Sutton "The General and Economic Geology of Trinidad" 1960, by Thatcher "Economic Minerals in the Northern Range," Trinidad and in Tobago 1960 and "Analysis of Trinidad and Tobago Rocks, Minerals and Ores" gathered by the Ministry of Petroleum and Mines.

The quarry which is near dwelling areas is not working. The inclined strata of gypsum which is extending several metres up is continuing down into the ground. The material is crystalline massive. Two qualities are ascertained, one is white and the other greyish white. The material is mainly hydrated calcium sulphate ($CaSO_4, 2H_20$) with no anhydrite and little calcium carbonate, about 3%. Preliminary laboratory tests for making Plaster of Paris by heating the crushed gypsum to 170°C in a crucible with continuous stirring for about two hours and then grinding the final product and testing its setting and hardening properties, were successful. The plaster sets into a hard mass. This gypsum can be used for making the Plaster of Paris needed for making moulds in the ceramic industry. It is recommended to start a survey for estimating the reserves using core drilling or any other convenient method. If the reserves prove economical, it is suggested to stop dwelling in these areas and keep it for quarrying gypsum.

It was stated by Sutton that gypsum is found on the beach near Oropouche Lagoon in a crystalline form, but it is however uneconomical in his opinion.

6 - Procellanite

36. There is a lot of literature about porcellanite in Trinidad. However, there is no information about its use in the ceramic industries. Samples were brought from one of the biggest quarries near Buenos Aires. This natural burnt clay rock is reddish brown to yellowish in colour and is somewhat hard. In firing to temperatures 1000°, 1100°, 1200° and 1300°C, a slight change in colour with some cracks developed in the fired pieces. The raw porcellanite was ground and

and added to the ceramic mass as a part of the opening raw materials, reducing the drying shrinkage and as a source of K_2O in the mass. However, the thioxotropic behaviour of the slip was high and much water was needed for flowing properties. According to the reported X-Ray examination of this material, the phases identified are alunite, quartz, cristobalite, α Fe_2O_3, metahalloysite, traces of mullite, γ Al_2O_3 and possibly some kaolinite. The Alunite reported to be 18% may be the reason for this thioxotropy behaviour of the slurry. Further studies are suggested.

B. Ceramic Raw Materials in Guyana - a nearby country within the CARIFTA Area.

37. A visit was arranged to Guyana to assess availability of raw materials needed for expansion or establishment of ceramic and glass industries in Trinidad and Tobago. The following are the raw materials found there :

Kaolin:

38. Kaolin extends under the bauxite belt in Guyana. It is reported that it extends about 30 ft. down. The area visited in Topira, near Ituni, is about 38 miles away from Linden. The face which is about 3 metres high is of white, soapy, plastic kaolin. Kaolin can be noticed exposed in the whole area where the bauxite was taken away. A sample was taken for testing. This kaolinite disintegrates easily in water. It is mainly kaolinite mineral. After burning at 1000°C, 1100°C, 1200°C, 1300°C and 1400°C, the material is white in colour and porous, texture is without any cracks. It begins to sinter at 1400°C, indicating that alkalies are very rare. However, this was indicated also by the following chemical analysis, done in Italy:

SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	L.O.I.
45.1	39.1-	0.5 -	0.55 -	-	0.06	-	0.02-	
	40.0	0.6	0.75		0.12	0.18	0.06	14 %

The reserves in one part, in Topira, Ituni, are estimated to be 300,000 tons. Particle size distribution indicated that about 75% is less than 2 μ and about 25% from 5 μ to 10 μ

The material is not yet in use. A study by Japanese experts on this kaolin is going on. Also, few dark spots, mainly due to iron contamination possibly from bauxite layers above the kaolin, can be noticed in some of the samples.

Feldspar:

39. Pegmative viens are common in the granites quarries in the Bartica area, about 40 miles away from Georgetown. The preliminary estimation of the reserves in one of the areas is about 10,000 tons of pegmatite. It is reported that potash and soda feldspars (microclin and albite) make up about half the rock, the balance being quartz with traces of black and white mica. No time was available to visit the area. However, samples brought to us after preliminary testing indicated that this pegmatite (pinkish in colour) is potash feldspar with some quartz in it. After firing to 1300°C it fuses to a white, opaque mass.

Quartz sand:

40. The hills of the left bank of the Demerara River, 30 miles south, are of white sand. One can observe also the white sand extending on each side of the high road on the way to Linden (MacKenzie) from Georgetown, where a sample was taken. Under the lens one can identify white grains of quartz, rarely discoloured grains are seen. It is reported that white sand can extend to about 100 ft. deep, covering considerable areas between Bartica, on the Essequibo River and the Corentyne River. The average grain size varies between the limits 0.25 to 0.5 mm. The average chemical analysis is 99.7% SiO_2. The Fe_2O_3%, before magnetic separation, is up to 0.14 and after magnetic separation 0.008. The heavy mineral fraction which is removed by magnetic separation is made up of the following main minerals in order of decreasing frequency :-

Ilmenite, magnetite, limonite, tourmaline, zircon, rutile.

The report by R.A. Dujardin, 1959, Geological Survey Department, Guyana, includes information about this white sand as a possible source of glass sand.

Bauxite

41. Raw bauxite production in Guyana for the year 1971 from all mines in the country is 4,166,709 tons.

	Production streams 1971, in tons	
	Demba/Guybau	Reynolds
Dried metal grade bauxite :	1,024,646	800,729
Chemical grade bauxite :	-	225,313
Calcined bauxite (refractory)	621,333	88,869
Alumina	305,320	-

The refractory grade of dried raw bauxite and the calcined bauxite are known worldwide, and are of interest in the refractory industry. Naturally, Alumina can be used if the price is acceptable. As we passed by the factory in Linden it was noticed that there is no electrostatic filters for the waste gases, the smoke from the chimneys is loaded with dust. This fine dust constitutes about 5% of the total production. In addition, it causes pollution of the air and land in near areas. The mining operations of the bauxite are huge. The over-burden can be up to 100 ft., mainly of sand. In the working area visited, Ituni Block 18, the thickness of the bauxite layers are about 12 ft. The minimum economic thickness of bauxite for quarrying is six feet. However, layers of bauxite up to 30 ft. thick are usually found.

Samples are taken continuously to the factory for quality control. The bauxite is about 90% gibbsite and 10% Boehmite.

The chemical analysis of the calcined refractory grade is :

Al_2O_3	Fe_2O_3	TiO_2	SiO_2	L.O.I.
86	3.25	3.25	5.5	-

The loss of ignition of raw bauxite is about 30%.

Refractory Clays:

42. Associated with the overburden above the bauxite belt. The area visited is the Old Montgomery Quarry for bauxite, near Linden. The refractory clays are of two types, one whitish in colour, with an average thickness of 2½ ft., and the second greyish-black with thickness that can reach 30 ft. Samples of these clays were taken for preliminary examination. These clays disintegrate in water, having good plasticity. By firing in an electric kiln at 1000°C, 1100°C, 1200°C, 1400°C. They are porous,

whitish in colour up to 1200°C. At 1300°C sintering occurs with the colour chaning to greyish. At 1400°C complete sintering with deeper colour. Further tests in combination with bauxite calcined and raw to indicate the optimum conditions for the needed qualities of refractories by the semi-dryprocess are suggested. Also, investigation for reserves and possible system for winning these clays economically when they occur in small thickness is suggested.

Steatite (Soapstone) Massive

43. Kauramembu Soapstone Deposits, Barama River. It is reported that the possible reserves are 3,155,00 tons.

The sample of massive soapstone was delivered to us. Owing to time limit we did not visit the area from which it was brought. Its colour is whitish-grey and it is soapy in texture.

By firing the sample at 1300°C it turns dark colour (blackish), indicating a high percentage of iron. This is confirmed also by the chemical analysis given by the Geological Survey Department of Guyana:

SiO_2	Al_2O_3	MgO	CaO	Fe_2O_3FeO	L.O.I.	
48-54	4.19 - 9.4	14-17	1-3	5-8	8-4	%

So the material does not confom with the specification of the ceramic grade steatite.

COMMENTS

44. In my opinion the kaolin under the bauxite belt is classed as grade one in the ceramic industry, i.e., for the manufacture of hard porcelain. However, to ensure constant composition of delivered batches in world market, simple concentration methods are suggested. These include specific gravity separation in settling tanks, de-watering, drying and packing.

The potash feldspar (pegmatite) is of a good quality. It can be used as a flux in the ceramic white ware industry. Its economic use is governed by its accessibility, homogenity of enough reserves. The statement in the Annual Report (1971) of the Geological Survey and Mines Department in Guyana, that pinkish colour of this potash feldspar indicates excessive iron is not right. As a matter of fact the pinkish colour of the potash crystals has no relation to the amount of iron, it fuses to a white, milky mass, indicating that it is a proper ceramic grade.

The white sand, abundant in Guyana (left bank of the Demarara River, between Georgetown and Linden) is pure quartz and can be employed in the production of highest grades of ceramic and glass ware. However, according to the particle size distribution curve of this sand, there is about 25% of over-size and under-size grains, useless to the glass industry, which have to be screeded away in quarry site before transport. Electromagnetic separation may be used in case of first-grade sand (for the highest grades of ceramic and glass ware) to separate the impurities containing iron, e.g., ilmenite.

Export of these three high grade raw materials, i.e., kaolin, potash, feldspar as pegmatite and white sand, to Trinidad and Tobago is possible as long as freight problems are solved.

The refractory clays above the bauxite can also be transported and used in conjunction with the trans-shipped bauxite to start a refractories industry in Trinidad. The production will be aluminous fireclay and alumina bricks (Mullite) with alumina content varying between 52 and 73% alumina. Depending on cheap local fuel, these high priced products (several times the price of the refractory grade calcined bauxite), I think will find a market locally and also in the nearby and far countries. However, feasibility studies have to confirm this.

The massive steatite sample delivered by the Geological survey department of Guyana was of a poor quality and this steatite cannot be used in the ceramic white ware industry.

IV. ASSESSMENT OF THE MARKET IN TRINIDAD & TOBAGO AND THE CARIFTA REGION FOR CERAMIC & GLASS PRODUCTS

Introduction

44. The twelve countries of the Caribbean Free Trade Association are Barbados, Guyana, Jamaica and Trinidad and Tobago, which became known as the More Developed Countries (MDCs), and the rest, Antigua, Dominica, Grenada, Montserrat, St. Kitts-Nevis-Anguilla, St. Lucia, St. Vincent and British Honduras, known as the Less Developed Countries (LDCs). These (LDCs) were forming themselves into the Eastern Caribbean Common Market (ECCM), an organization within the CARIFTA framework. The total population of them all is about four million. The biggest country in population is Jamaica, about 1,911,400, and then the second is Trinidad and Tobago, about one million.

Figures for expected market conditions and Government projects in the next ten years were not available from any of the official sources in the country.

However, if a market projection is made on the basis of the market size and its progress within the last six years (1966 - 1971) we arrive at the following :

1. Building Clay Bricks

Year	TOTAL IMPORT	
	Wt. in tons	Value TT$ CIF
1966	17.3	$1,317
1967	20.9	3,352
1968	222.3	10,303
1969	12.4	1,399
1970	49.6	3,323
1971	25.6	9,107

Data for the year 1972 was not available up to the time of writing this report. The total capacity of the existing three factories is about 147,000 tons/year, equivalent to about 30.9 million bricks and blocks/year (dimension 4" x 8" 12").

The total production of building bricks, clay and concrete, in the year 1971, is about 22,785,600. The figure given (the Economical Intelligence Unit Ltd. (1972), Eastern Caribbean and British Honduras Industrial Survey) of 30 clay blocks per head of the population for the Caribbean building trade if applied, will come to the same figure given. The average price of 1,000 hollow clay bricks (4" x 8" x 12") is TT$180 to TT$200 ex factory.

The average price for those in concrete is TT$200 ex factory. Naturally, bricks are an item which one never considers for export being heavy, bulky, fragile and cheap material. Its distribution area is usually for economic reasons within a radius of, say, 50 Km from the manufacturing plant.

A concrete hollow block size 3 5/8" x 7 5/8" x 11 5/8" weighs 15 lbs. The clay hollow block size 4" x 8" x 12" weighs 10.5 lbs., i.e., the concrete block of nearly the same size weighs about one and half times that of a clay block. Taking into consideration that the ex-factory price of the two is the same, it will be cheaper to build with clay blocks. The average price of transport depending on the distance, is about TT$6.00/ton. If realising that heat insulation of the clay hollow block is better than that of a concrete hollow block of the same size, the advantage of a policy for increasing the production of the hollow clay building bricks and decreasing those of concrete is clear. The excess cement is then saved, e.g., for export. A hollow sand-lime block can also be introduced, which is cheaper than the concrete block. A feasibility study is suggested.

Wall and Floor Tiles

46. Data concerning the size of market for floor tiles in the CARIFTA Region is not available. The following table shows the wall tiles and floor tiles imports during the years 1966-1971. The total local production of wall and floor tiles is consumed locally, i.e., about 1,250 tons/year. Then there is the possibility of exporting the same amount for the nearly million persons in the CARIFTA Region. The possibility of expanding the production, i.e., doubling the capacity, has to be taken into consideration. There is always the possibility of ceramic wall and

floor tiles substituting other used materials if the prices are reduced to be competitive with the other alternative. This may be achieved also by manufacturing biscuit floor and wall tiles locally using local raw materials.

WALL & FLOOR TILES

TOTAL IMPORTS

Year	Quantity in tons	Value T&T $ CIF
1966	893.8	424290
1967	575.8	257494
1968	721.7	334229
1969	853.7	422518
1970	1448.7	797283
1971	222.6	122847

Refractories

46. Data concerning the size of the market for refractories in the CARIFTA Region is not available.

However, if we consider the existing industries in Ceramic and those suggested as new industries in Trinidad and Tobago, we find that these industries consume refractories as saggars, pushing slabs, supports, shelves, repairs of tunnel kiln car bottoms. If we add to this the refractories consumed mainly in boilers of the sugar industry and in the petroleum refinery and cement industry, a consumption of about 2000 tons/year of fire clay, aluminous fire clay and alumina refractories is foreseen. The installation of a small unit may be considered after a feasibility study.

The following table shows the imports of refractory materials in the years 1966-1971.

REFRACTORIES

TOTAL IMPORT

Year	Approximate quantity in tons	Value T&T $ CIF
1966	821.7	361638
1967	891.0	221575
1968	563.4	269797
1969	882.9	287474
1970	1281.6	414929
1971	3277.8	926932

Table ware faience and porcelain, sanitary ware vitreous china, Electric insulators porcelain

47. Data concerning the size of the market in the CARIFTA Region is not available. However, in the industrial survey (1972) by Economical Intelligence Unit Limited (E.I.U.) for the Eastern Caribbean and British Honduras, it was suggested a plant for dinnerware with an ex-factory sales value of about 1.5 million EC$.

The size of the market for table ware in Trinidad and Tobago in the years 1966-1971 is shown in the following table.

CERAMIC TABLE WARE INCLUDING ART WARE *
FAIENCE, PORCELAIN, ETC.

TOTAL IMPORTS

Year	Approximate quantity in tons	Value T&T$ CIF
1966	519.3	473100
1967	410.4	454126
1968	337.5	476919
1969	288.0	588529
1970	370.8	662838
1971	389.7	693849

* Art ware about 2 to 3% of the total weight of the table ware.

If we take into consideration the possibility of export also to the CARIFTA Region, a plant with a capacity 1000 tons/year may be feasible for faience production. Later on it can be for porcelain and part of which can be electric insulators.

Sanitary ware consumption in Trinidad and Tobago from a preliminary investigation is about 5000 pieces/year of mainly closets and closets with cisterns, wash basins, urinals and possible few bidets. Taking an average weight approximately 15 Kg. each, therefore total consumption/year is about 75 - tons. Taking into consideration an export in CARIFTA market in the same amount, therefore a pilot unit with a capacity about 150 tons/year, i.e., about 40 pieces/day is suggested, an intermittent shuttle kiln with two cars is considered for firing. A feasibility study is suggested.

The size of the market of the sanitary ware for the years 1966-1971 was not available at the time of writing of this report.

Drainage ceramic pipes and glazed sewer pipes

48. Before the production of concrete pipes in Trinidad for sewerage, glazed clay sewer pipes were imported for the same purpose. So the use of concrete pipes does not mean that the production of glazed clay sewer pipes is not feasible.

The market size for concrete pipes for sewerage during the years 1966-1971 was not available during the writing of this report. It is suggested that CARIRI will continue this survey.

Cottage pottery and ceramic art ware

49. The consumption of the 13 cottage pottery workshops in Trinidad is about 1000 tons per year clay including the amount of sand added. This amount of raw materials produces about 800 tons/year saleable products in the form of pots for plants different sizes 3" up to 14", lamp shades, vases, dias (small vessel used by the Indians in the holy occasions) etc. For regular production the price of each piece varies between $1 TT for bigger pieces and 12 cents for smaller ones.

If the policy of the authorities is to protect them rather than diffusing them in the new suggested ceramic industries, the Crown Land from which they are digging the clay must be kept for them, and not sold for farming or building purposes. In this policy, however, advice for improving the quality of the product using these primitive methods will be more convenient rather than increasing the efficiency of the process, say, by partial mechanisation. For the latter one means that all have to close except one workshop which can handle all the work done by the 13 workshops.

The amount of material used for the ceramic art ware is negligible. Ceramic artware is generally done here by the craftsman as a hobby in which he shows his skills and creations. She (he) works usually in her (his) home. There are about one dozen of them in Trinidad. Their output is small but usually high in price.

<u>Glass containers (bottle)</u>

50. The production of clear glass bottles in Carib Glassworks is about 21,000 tons per year of bottles for beer, alcoholic drinks, soft drinks and others. The average

weight of the bottle is about one pound. 65 gms. up to 650 gms. bottles can be produced. The selling price per 144 glass containers weighing each one pound is 20 TT$. The following table shows the total glass containers imported during the years 1966 - 1971. The total local production of the glass containers is consumed locally.

Data concerning the size of the market in the CARIFTA Region for clear glass containers is not available. However, in the E.I.U. survey is indicated that the CARIFTA demands for coloured glass containers could be met by a plant which will produce 5000 ton/year containers. A feasibility study for the use of the idle unit in the glass factory for this production is suggested.

GLASS CONTAINERS (BOTTLES)

TOTAL IMPORTS

Year	Weight in tons	Value TT$ CIF
1966	974.9	415,294
1967	1197.5	478,110
1968	1293.3	671,447
1969	4427.7	1,873,580
1970	2529.6	1,351,963
1971	6142.9	2,547,470

A feasibility study for the expansion of the clear glass container production is suggested taking into consideration that Jamaica produces its own glass containers.

Sheet glass

51. The E.I.U. in its survey of the industry in the eastern Caribbean and British Honduras suggests a plant of a capacity 6000 tons/year, putting the precaution "viability would require careful investigation".

The market size for the sheet glass in Trinidad and Tobago is given in the following table for the years 1966-1971.

SHEET GLASS

TOTAL IMPORT

Year	Approximately quantity in tons	Value T&T$ CIF
1966	1130.7	736898
1967	1379.4	529854
1968	1209.2	534802
1969	1961.4	899825
1970	1888.2	943177
1971	1682.0	857171

So, for a plant with a capacity 6000 tons/year, the possibilities of exporting part of its production may be considered. A feasibility study is suggested.

Pressed and blown glass table ware

52. The Eastern Caribbean Countries imports according to the survey done by E.I.U. is in an order of 2.75 million E.C.$ and considers about 1000 tons as a basic table glass ware.

The consumption of glass table ware in Trinidad and Tobago in the years 1966-1971 is shown in the following table :

TABLE WARE IN GLASS

TOTAL IMPORTS

Year	Weight in tons	Value TT$ CIF
1966	623.8	$ 501,373
1967	578.6	578,793
1968	531.9	616 ,930
1969	803.6	820,859
1970	655.1	833,062
1971	636.8	783,659

The feasibility study of a plant with a capacity of 1,500 tons/year is suggested.

Market assessment in Trinidad and Tobago and the CARIFTA Region for ceramic and glass, which has started in CARIRI is suggested to continue to cover all the suggested expansions and the new ceramic and glass industries in Trinidad in detail with the corresponding feasibility studies.

V. SUGGESTED NEW PRODUCT CERAMIC AND GLASS INDUSTRIES IN TRINIDAD BASED ON LOCAL RAW MATERIALS AND THOSE IN NEARBY COUNTRY, GUYNAN, TAKING INTO CONSIDERATION MARKET CONDITIONS AND DEMAND PROJECTION

1. Extension of a Ceramic factory for the production of biscuit wall tiles and floor tiles from local raw materials

83. A preliminary economic study was made for a factory for the manufacture of 190,000 m^2/year of biscuit wall and floor tiles from local clays, Appendix No. 2. These biscuit tiles are imported for the time being from Venezuela and Brazil, in the case of wall tiles, and from Italy, in the case of floor tiles. The total daily production of glazed tiles is about 350 m^2; this is to be increased in the extension to reach 180,000 m^2/year. The clays, e.g., in Wallerfield and Longdenville are suitable for the manufacture of these tiles. The marl clays in the middle of Trinidad, i.e., Mayo area, are suitable also according to the preliminary tests done on samples received when writing this report. In the case of the wall tiles, the colour of the biscuit will vary between buff to brownish colour which has no effect on the quality of the finished product. The colour of the imported biscuit tiles is white, that of the floor tiles is reddish brown, which will be the same with local raw material. The percentage of clay in tho batch

will be up to 80%. It is suggested that the balance will be mainly potash feldspar in the case of floor tiles (porosity less than 1%), and quartz sand plus dolomite or limestone in the case of wall tiles (porosity about 15%). The firing temperature will be around 1100°C. Firing cycle and conditions of firing depend on the final composition of the batch. It is suggested that the final body composition and conditions for drying and firing be done by the supplier of machinery and equipment. This, in future, could be done in the suggested Ceramic Laboratory.

2. Extension of the clay brick industries to produce:

54. (a) Glazed porous split tiles and later vitreous split tiles

This production can be started, e.g., in Alstons Building Enterprises Ltd., Clay Division, due to the experience they have developed, as an extension of the clay building bricks and blocks they produce. The plastic clays and siliceous clays in the quarries of this plant can be used successfully. In the case of vitreous mass feldspar up to 20% can be added. In the case of the porous type, dolomite or limestone can be added to the batch. Part of the existing machinery and equipment in the mass preparation will be used in the second shift.

The following machinery and equipment are to be added :

Shredding machine for the shredding of the clay coming from the quarry.

Plunger for plunging the clay into a slurry.

Propeller mixer in which the additions from the ball mill are added to the slurry.

Ball mill for grinding the harder materials, e.g., limestone, dolomite, feldspar, if not delivered fine.

Filter press and pump for dewatering of the slurry.

Glazing machine and accessories for preparing the imported glaze (later locally prepared) for the glazing of the tiles.

The filter press cakes pass through the rest of the operations, as in the case of the extruded hollow bricks, the mouth piece being changed by that for split tiles (two double split tiles). The small rolls are eliminated during this shift. Use will be made only of one of the three extrusion machines in the second shift. A tunnel kiln with the proper capacity and time temperature curve is suggested. The capacity for these split tiles, which will be one-third the existing capacity of the factory, must be justified first by a market study, taking into consideration that this is a new product never used before in Trinidad and Tobago. However, the cheerful colours and durable condition, with nearly no maintenance by using them as facing tiles for the walls internally and externally, if the price is competitive, with decorative coatings or covering materials, may open a market for them.

55. (b) Drainage pipes unglazed and glazed for sewer pipes

The same technology of machinery and equipment used for hollow clay building bricks will be used here, with the exception that a vertical deairing auger machine is used instead of the horizontal. One extruder for pipes from 4" to 12" is suggested. The same raw materials used for the hollow bricks will be used for the manufacture of the pipes. In addition, the up to 10% rejects in the fired bricks will be crushed in a crusher and used as a grog in the batch composition of the pipes. Three or more similar down draught kilns as those existing in the factory will be erected using salt glazing.

In these kilns also will be fired the special shape needed in connection with the pipes, e.g., T&Y connections, bends, gully traps and stoppers in the case of glazed sewer pipes. For the same diameter these pipes are less in weight than concrete pipes, and more acid resistant. They are not attacked by the root of the plants.

The possibility of making part of these pipes in clay is to be considered as long as the manufacturing costs are competitive to those of concrete. A feasibility study is suggested.

This extension can be taken care of by one of the e isting clay brick factories, or installed as a separate independent unit.

3. <u>Aluminous fireclay and Alumina Refractories</u>

56. There is a transhipment of raw and calcined bauxite in Trinidad. Plastic fireclays are available also in Guyana. For the industrialisation of some of the countries within CARIFTA, refractories are needed for these industries, particularly, e.g., the metallurgical, cement, petroleum, sugar and ceramic industries, for the lining of kilns and furnaces. It will also be used for the manufacture of kiln furniture, i.e., slab supports and saggars, to serve the existing and new ceramic industries. The installation of a factory with a proper capacity for the manufacture of bricks, standard and

special shapes, with percentage alumina - 52, 63 and 73, is suggested. The semi-dry process is to be used. Cheap liquid and gas fuels are available in Trinidad. The standard methods of manufacture are used in which Guyana bauxite for the refractories industries is exported to several countries all over the world. A feasibility study to indicate the size of such a market is suggested. Use is made of the refractory clays, also abundant in Guyana. A slurry of these clays will be mixed with the graded calcinated bauxite to form a semi-dry powder for pressing. Firing temperature for these refractories will be around 1500°C.

4. Plant for the manufacture of table ware, sanitary ware and electric insulator

87. This is based on raw materials from Guyana, i.e., the kaolin, potash feldspar, quartz sand. Also, the limestone (purer quality) will be imported from Barbados. Investigation for the use of the corals of Tobago as a source of calcium carbonate with less contamination of iron oxide has to be carried out as regards qualities and economic quantities. The table ware will be in hard porcelain and the sanitary ware in vitreous china. Some low tension electric insulators and fittings from porcelain can be made according to demand.

The base of the body batch composition will be about 50% kaolin, 25% feldspar and 25% quartz sand, in the case of porcelain. Limestone will be added in the glaze composition. The strength of the green body can be increased if needed by adding amounts up to 10% binding clay which is white burning; biscuit firing at 900°C and glost firing at 1380°C.

The size of the market justifies a small unit semi-automatic in the mass preparation and shaping of table ware. The firing of the table ware will be in a tunnel kiln, with a small cross-section and length. The firing of the sanitary ware will be one firing in a batch kiln, as the size of the market does not justify a continuous kiln. In case of faience production, the batch composition will be about 60% kaolin and clays, with the balance quartz sand and one or more of the following: limestone, dolomite, steatite, feldspar. The firing temperature will be around 1230°C.

A feasibility study concerning the size of the market is suggested.

5. Extension of the Glass industry for :

58. (a) Clear glass containers

The present daily output of the only existing glass factory in Trinidad and Tobago is about 60 tons clear glass containers. However, the capacity of the glass tank can be increased to double the capacity, i.e., to 120 tons per day. This necessitates the addition of another two lines for shaping and annealing. A market assessment has to be completed to see if extension is needed now, also the projection for future demands.

It is suggested that the extension will cover the range of sizes not included in the current production and which are imported. A feasibility study will then justify or not this extension.

59. (b) Coloured glass containers

There is an old idle glass tank in this glass factory, capacity which possibly can be used for the manufacture of coloured glass containers. Survey of the possible use of any of the accessory machinery and equipment left for working this glass economically is suggested; or, according to the study, newer machinery and equipment will be bought.

The output will be within the needs of the local and CARIFTA markets, as will be mentioned later. However, a feasibility study will indicate whether the running of this old unit or the installation of a new independent unit is better.

6. Pressed and blown glass table ware (tumbler, cups, saucers, dishes) and crystal glass.

60. It is possible to install a new factory or extend the existing one to make pressed glass table ware. The experience the factory has in manufacturing the glass containers makes such an extension easy. However, it is important to take into consideration the following :

1. The local white sand reserves may not be enough for such an extension.
2. The continuous supply of white sand from Guyana may not be stopped for any reason.
3. A proper market survey.

A small daily tank for decorative crystal glass is suggested. The batch composition contains usually lead oxide, in addition to some other oxides not usually used in soda-lime glass. The firing temperature is usually lower. Such a small manual unit is labour consuming in the manufacturing method, e.g., shaping, engraving, grinding and polishing. However, the workers have to be well-trained. It is suggested that this be installed in Tobago being a Tourist island. Such products can find acceptance to tourists as souvenirs, especially when the prices will be much lower than imported ones due to lower wages.

7. Sheet Glass

61. All the sheet glass consumed in Trinidad is imported. There is no country within the CARIFTA region producing sheet glass.

In the E.I.U. Industrial Survey 1972, it is indicated that Guyana has been considering the production of sheet glass. Now as the CARIFTA market is small, the capacity of one small factory for sheet glass can cover the needs of all the twelve countries. It is suggested that a study of the possibility of installing an economic unit be made based on feasibility study in Trinidad, in which Trinidad will be supplying the fuel, Guyana supplying the glass sand and Barbados the limestone. Countries within the CARIFTA region are allowed as shareholders of such a factory. The firm supplying the machinery and know-how allowed for a certain percentage of investment agreed upon.

8. Glass fibre and glasswool for reinforcement and heat insulation

62. This can be considered in long term policy after the fulfillment of the glass extensions mentioned above and in which the raw materials used will be the cullet from these factories and other consumers. These factories are small ones with simple machinery and equipment. A feasibility study will indicate the size of such a unit.

9. Plaster of Paris

63. The gypsum in St. Joseph is of an average good quality. A small economic unit for the manufacture of plaster of paris is suggested. The lump material of gypsum is crushed, feeded to the kettle and heated to about 170°C for partial dehydration with continuous stirring where the hemihydrate, i.e., plaster of paris, is formed. The material is then ground, seived and packed. Two grades are suggested for production, one plaster as a modelling plaster, the other for moulds. A feasibility study is suggested.

64. Extension of Lime Manufacture

It is suggested that either a new plant or an extension of the existing one should be taken into consideration. This is to cover the suggested new sand-lime and cellular concrete blocks manufacture. The physical properties of this limestone, abundant in Trinidad, permits its use successfully in this industry. It has a high cold crushing strength. It does not make fines or breakdown in firing, clogging the channels for combustion gases in the shaft kiln and hence a non-homogenous fired product, or loss of much dust, in the case of rotary kiln. It is of acceptable crushing strength in the firing and cooling zones of the kiln.

65. Sand-lime bricks, hollow blocks and cellular concrete

It is suggested to start an industry based on sand and lime. Ordinary quartz sand for buildings and concrete industries, is available in Trinidad. However, the reserves have to be confirmed. Use is made of the undersize sand not usable by the concrete factories and causing them storing problems, e.g., the Readymix Concrete Factory adjacent to the lime factory near Port-of-Spain, has a reject of undersize quartz sand amounting to about 100,000 tons annually. It has the following chemical analysis :

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	L.O.I.
97.60	1.90	0.04	0.05	-	0.31
98.44	1.13	0.05	0.0[illegible]	-	0.41

It is suggested that such a factory be adjacent to the Readymix Concrete Factory and the Furness Ltd. lime factory. In the manufacturing process for sand-lime bricks and blocks, the sand after separating the oversize if any is mixed with about 7% quick lime, water being added to hydrate the lime, the mixture is kept in the reactor to complete hydration. The moist mix about 6-7% moisture is pressed in to either solid or hollow blocks and autoclaved at about 16 atmosphere where a bond between the grains of sand is developed by the formed calcium silicate which contributes strength to the bricks and so they are ready for use.

In the manufacture of cellular concrete the lime used must be of a proper slaking time (about 20 minutes) and slaking temperature (about 70°C). The active must be not less than 80%. These conditions can be easily attained with the local manufactured lime. The amount of lime in the batch composition is about 20%.

5% of Portland cement, about 0.04% aluminium powder with some detergent. The rest is sand, part of which has to be wet, ground to a fine powder. The mixture with the added water to form a thick slurry is poured into moulds forming the tops of rail cars. The cars are then pushed into a dryer where the mass expands due to the liberation of hydrogen from the reaction of calcium hydroxide with the aluminium powder forming a cellular structure. The whole car block is wire cut according to the required sizes and put into autoclaves at about 12 atmosphere to develop the strength and be cured. This cellular concrete has the advantage of being light with a specific gravity about 0.7 and has good insulation properties. These blocks are to be used as partitions and non-bearing walls and ceilings in buildings.

66. Suggested Production Unit for Sand-lime, Hollow Blocks and Cellular Concrete Blocks

Cellular concrete	-	4,000 cubic metre/year
Wall blocks -	0.7 Sp.Gr.	
Raw Materials		Yearly Consumption
Sand		1,340 cu.m.
Burnt lime		640 tons
Aluminium powder		1.2 "
Make-up water		1,400 cu.m.
Oil for mould		6 tons
Portland cement		160 tons
Fuel oil		85 tons
Electric energy		140,000 K.W.h.
Water		4,000 cu.m.
Sand-lime perforated blocks	-	22,500,000 blocks/year
Raw Materials		Yearly Consumption
Sand		50,400 cu.m.
Burnt lime		6,300 tons
Make-up water		10,000 cu.m.
Fuel Oil		740 tons
Electric Energy		500,000 K.W.h.
Water		15,000 cu.m.

A feasibility study is suggested.

Cemented Asbestos Products

67. Corrugated sheets for roofs, pipes for water and pillars production can be suggested for a study based on the cement industry available and imported asbestos. The use of these cemented asbestos products eliminates the corrosion problems met with in the case of iron and steel sheets and pipes used under the prevailing humid weather conditions. A feasibility study is suggested for production to cover other countries within the CARIFTA market. The required handling equipment and training for handling such a fragile material as compared to the metal ones, must be taken into consideration.

VI. THE CERAMIC LABORATORY FOR FUNDAMENTAL RESEARCH, APPLIED RESEARCH, DEVELOPMENT AND CONTROL

68. The extension of the ceramic industries existing in Trinidad and Tobago and the introduction of new industries, justifies the installation of a ceramic laboratory in which fundamental, applied and development research are carried out. Also it will carry control tests on request and especially when any disputes arise between the consumers and producers. New projects, raw materials, batch composition and new products will be studied by this laboratory. This ceramic laboratory with its main divisions, tests to be carried out and machinery and equipment needed, are shown in Appendix No. 3. The University of the West Indies is suggested to share CARIRI in establishing and running some of its divisions. It is suggested that the chemical department of the University of the West Indies do some of the tests as mentioned under Chemical Analysis in Appendix No. 3. Also some of the other tests needed, and for which they have the apparatus, e.g., Differential Thermal analysis. The physics department of the UWI, which have great interest in Ceramics, can do all the examination concerning crystal structure, e.g., X-ray diffraction examination powder pattern for the identification of phases. Also, they can measure some of the important thermal properties as thermal conductivity and specific heat.

Some of the electrical properties of ceramics, e.g., volume resistivity can also be done in the physics department. This department according to its interest can study the drying, firing and melting behaviour of ceramic bodies. The electrical department at the UWI can measure the other electrical properties as mentioned in Appendix No. 3.

It is suggested that the pilot plant will be a part of the general pilot plant of CARIRI which is concentrating mainly at the moment on the foodstuff industries. The unit operations and unit processes suggested in the pilot plant for the ceramic industry are naturally of general use and can be used for other industries as well, e.g., the crushing, grinding, screening, drying, firing, etc. It is possible to share some of the machinery and equipment needed with the Chemical Engineering Department of the U.W.I.

69. However, it is noticed that the spare parts for the existing machinery and equipment are not enough as well as not complete. Also preventive maintenance is not taken care of well, so in the new established laboratory, stress must be put

on the following :

1. Spare parts needed for, say, three years including all the wearing parts of the machinery and equipment, especially the heating elements and refractories of the kilns and furnaces.

2. Training courses of local qualified staff and technicians to run and maintain these apparatus and equipment.

3. Preventive maintenance system adhered to, to ensure proper functioning.

VII. RECOMMENDATIONS

70. 1. The market nature, structure, size and demand projections for the different ceramic and glass products in Trinidad and Tobago and the CARIFTA region which CARIRI started to assess, is suggested to continue until completion. This fulfillment will be very helpful in the feasibility studies of new projects.

2. Geological activities of the Ministry of Petroleum and Mines are suggested to be extended to cover an evaluation and estimation of reserves of the ceramic and glass raw materials, mainly, clays, white quartz sand, limestone, dolomite and gypsum, in co-operation with CARIRI and UWI. Protection from using the promising areas for quarries as building areas, is necessary.

3. Guyana is a nearby country to Trinidad and Tobago and is one of the CARIFTA group. In this country there are huge resources of ceramic and glass raw materials of average good qualities. These raw materials are the bauxite, the kaolin, the quartz sand and the feldspar as pegmatite. Studies to fulfil the use of these capacities economically, in the extension or new ceramic and glass industries in Trinidad and Tobago, are suggested.

4. The extension of the ceramic industries in Trinidad and Tobago as well as the introduction of new industries, justify the installation of a ceramic and glass laboratory in which fundamental, applied and development research, is carried out. This laboratory is suggested to be installed and run jointly by CARIRI and concerned departments of the UWI. The financial help by the government then is considered necessary.

5. The market condition and demand projection within the CARIFTA region of about four million people is a small one. This is why when considering the new industries, semi-automatic and intermittent, rather than automated and continuous processes, are suggested to be chosen.

In the new established industries stress must be put on :

(a) Spare parts needed, say, for three years.

(b) Training of local graduate staff, technicians and laboura to supervise, run and maintain these machinery and equipment.

(c) Preventive maintenance system adhered to, to ensure proper functioning.

6. The manufacture of cellular concrete and sand-lime perforated blocks as a new field in building construction in Trinidad and Tobago, is suggested to be studied.

This is based on the following :

(a) Availability of good raw materials and waste materials needed for manufacture.

(b) Better properties, e.g., cellular concrete is lighter in weight and better in heat insulation when used in non-bearing walls and ceilings.

(c) Cheaper in price, e.g., sand-lime blocks compared with concrete blocks.

Also there is a developed cement industry in Trinidad; the possibility of making cemented asbestos products may be considered (e.g., corrugated sheets for roofs, pipes and pillars).

ACKNOWLEDGEMENTS

71. The writer wishes to express his thanks to the Project Manager and Staff of CARIRI, to the Head of the Physics Department, U.W.I. and his Staff, and to Mr. John Scott, Chief Geologist, Ministry of Petroleum and Mines, for their assistance. Also, to all industrial enterprises and governmental sections who made information possible.

APPENDIX I

1. **Building Clay Bricks and Blocks**

There are three factories in Trinidad for the production of clay building bricks and blocks. These factories are:-

1. Alstons Building Enterprises Ltd., Longdenville Factory
2. Rio Claro Brick Factory, South Trinidad
3. Oropouche Brick Factory, South Trinidad

The production is mainly of hollow blocks for walls and ceilings. Perforated or solid bricks can be produced on demand. The main size produced is 4 x 8 x 12" with an average weight 10½-lbs each. Other sizes are produced also.

The capacity of the three factories is about 490 tons/day.

The first factory is a renewed one with proper technology having a capacity of 380 tons/day, equivalent to about 80,000 hollow blocks 4 x 8 x 12". The stiff mud process is used for manufacture. It began operation in the year 1934 and was updated with new equipment in 1962, 1966 and again in 1969.

The clay is dug from two pits near the factory, one is a siliceous clay and the second, is a plastic one. The clays are heterogenous. One can identify three qualities visually, one greyish, the second yellowish and the third reddish. The area of the pit is about three acres, the depth about 25 feet. The overburden soil is about 3 feet.

The factory has made a boring in the area up to 50 feet down and still finds clay. They think that the clay still extends to further depths. The clay is won by drag excavations and put into dump trucks which transfer it to a box feeder, from there the material is transferred by a slate conveyor into two adjacent storage areas, each of a capacity about ten days production. One storage area is for the siliceous clay and the other for the plastic clay. Using a proportioning box feeder (60% siliceous clay and 40% plastic clay) the material is blended and conveyed to the edge runner mill with a perforated bottom (wet pan mill). Here water is added and the clay is crushed, kneaded and homogenised, having a moisture content of about 18%. After that it passes through a differential smooth roll to crush any remaining big particles. Three deairing auger machines (extruders) with shaft mixers and wire cutting machines are used for shaping the products. Two are used for standard shepes and the third for special shapes.

The standard shapes are set on the tunnel kiln cars manually for predrying and drying using hot air from the cooling end of the tunnel kiln. The firing is with natural gas. The firing temperature is about 1120°C and the cycle is about 24 hours.

The special shapes are left to dry for one day outside and then passed in the old channel dryers without temperature or humidity control, using waste heat from the down draught kilns. There are seven down draught kilns (beehive kilns). The firing temperature is about 2050°F. The firing cycle is about one week with about 60-70 hours heating up and three days cooling down. The factory uses natural gas for firing.

The factory makes control tests for proportioning the two clays in the box feeder and also makes control tests on moisture content of the batch and sieve analysis after homogenisation and before extrusion. The fired articles (60-70% from tunnel kilns and the rest from the down draught kilns) are sorted for dispatch into first quality, second quality and rejects. The estimated rejects are 5-8% in drying. The rejects in firing are about 5% in the tunnel kilns, and 8-10% in the down draught kilns. The selling price per block ex factory is 20 cents.

The factory is producing occasionally a very small amount of glazed tiles and one side glazed bricks which amounts to about 0.5% of the total production. There is a laboratory in the factory in which the routine tests are carried out.

Samples of the clay from the two pits, the storage area and from the batch before being extruded, were taken from preliminary tests, also some blocks of the finished products were taken for examination.

COMMENTS

The factory, apart from the down draught kilns and its dryers, is a recent one with proper technology. However, the high percentage of rejects and second choice products can be mainly attributed to heteroginity of the clays quarried from the two pits and to the drying system used.

This clay is generally good for the industry, not being contaminated with harmful nodules such as, calcarious or siliceous material, and not having harmful soluble or partially soluble salts. But it is a heterogeneous clay and this can lead to varying fluctuating behaviour of the batch during drying and firing, causing part of these rejects. A sump installation with cross excavation with a capacity of about 30,000 cubic metres in which the material is fed horizontally in layers in the sump and taken vertically will ensure better homogeneity than the system used now.

As to the drying before feeding the tunnel kilns, a humidity drying system with the hot air fans moving like the system used by the firm Lingl, ensures better drying conditions and less rejects. Naturally the drying system used before feeding the down draught kilns is an obsolete one.

Sometimes the fired rejects in such an industry can be crushed, ground and added to the batch as grog whenever feasible. But it seems, from the discussion with the Director of the Factory, that in his case it is not economical to do so.

It seems that the smooth rolls need maintenance for its rollers surface by use of roller grinding machine. It was .oticed that somewhat bigger particles of clay or contamination are passing through the smooth rolls without crushing.

It is suggested that the factory makes geological surveys in the area to estimate reserves of the clays, to be used for the existing industry and its extension, also for introducing new production of already imported articles, e.g. floor tiles and glazed split tiles.

The second clay brick factory at Rio Claro, South Trinidad, started operation in the year 1961, according to the information it has been going down and had acquired a loan from the IDC. No augering or drilling have been done by the factory in this area for estimating the reserves, but the Manager believes that the clay extends to about 4,000 ft. deep, according to information from Texaco.

The quarry (cutting from hill face, which is about 30 ft. high down to ground level) for the plastic clay is adjacent to the factory. Two qualities of this plastic clay can be identified, one is yellowish-grey and the other is blackish. There is no sand in the area, and the factory has to get it from Longdenville in North Trinidad. The plastic clay and sand in the proportion 2:1 are mixed in the box feeder and taken by a belt conveyor to the edge runner mill with perforated bottom. The material is then transported by a belt conveyor to the smooth rolls and by a belt conveyor to the deairing auger machine with a wire cutting unit. The factory produces different shapes and sizes of bricks. The main size is 4" x 8" x 12" hollow bricks. The output is 2,000-2,500 bricks/hour. The factory, apart from the kilns, is working one shift.

The wire cut bricks are put onto shelves and transferred by the heap putting down rail truck into the multi-channel dryer. There are ten channel dryers heated by the combustion gases of an oil burner. The combustion gases pass through the top of each of the channel dryers and are distributed by two fans inside each channel. The temperature used for drying is about 120°C. Drying takes two days. The Manager changed the old system of drying in open sheds because this takes about 14 days. After drying, the bricks are set on tunnel kiln cars for firing. There is one direct fired tunnel kiln which is

240 ft. long with a cross section 7 ft. x 8½ ft. The firing temperature is about 950°C. There are thirty-four cars inside the kiln, each carrying 850 hollow bricks (size 4" x 8" x 12"). The shifting time interval is 1½ hours. Fuel oil No. 6 is used for firing. The consumption is 250 gallons/day for firing and 200 galls/day for drying. The daily production of the above mentioned bricks, excluding about 10% rejects, is about 8,000 bricks first choice and 2,000 second choice. The trucks carrying the bricks to market in the North, loads the sand from Longdenville on their way back to the factory. The price per 1,000 bricks (size mentioned above) is TT$170 ex factory, nearly a quarter of this is added for transport.

Samples of the clay, sand and product were taken for preliminary testing.

COMMENTS

Inconvenience for bringing one of the raw materials, i.e. sand representing about 1/3 of the total mass from far-away. A privilege for the plastic clay quarried is the low cost for its excavation. Also, from preliminary tests done, it has low vitrification point, i.e. it can be fired at a lower temperature compared with Gumbo clays of Longdenville. It is suggested to search for siliceous clay or equivalent in the nearby areas. It was noticed also that body mixture is not properly homogenised, also its composition and water content is not constant, as can be seen from the colour of the green products. The single or double shaft mixer usually used in this factory before, as part of the deairing auger machine, has been eliminated.

There is no proper quality control. The inefficient and improper system of drying can be seen from the high percentage of cracks in the green product. It is supposed that in running a tunnel kiln efficiently to use hot air resulting from the cooling of the product in drying in addition to its use as primary air in the burners. Also it is not a good practice to use combustion gases for drying the products. The firing in the tunnel kiln is not homogeneous as can be seen also from the colour of the outcoming products, which have developed more cracks in firing. It seems to me that cold crushing strength of the bricks are lower than expected. The preventive maintenance of tunnel kiln cars seems improper. The factory uses the soft mud process in manufacture. Better results can be obtained by steam heating the mass in the deairing auger machine before extruding.

The third clay brick factory is at Oropouche, South Trinidad. It is thirty-six years old. The raw materials, clay and sandy clay, are excavated from a nearby quarry (pit). The material is heaped in the stockyard in the proportion of two full truck loads of clay and one full truck load of sand (siliceous clay). The mixed material is transferred by a belt conveyor to a double roller crusher (smooth rolls) and then passed through the single shaft mixer of the deairing auger machine, where it is mixed with water. The extruded hollow column of clay is cut by a wire cutting machine into bricks.

The daily output (one 8-hour shift) is about 3,000 hollow bricks with a dimension 4" x 8" x 12", and three holes. Occasionally, the factory produces solid bricks, dimension 2" x 4" x 6" (4,000 pieces) per day (one 8-hour shift) to be used in the factory for the repair of the kilns.

The bricks are set in open end sheds and left to dry for about a week. There are three down draught kilns, each of a capacity of 25,000 pieces of the above mentioned hollow bricks. Presently two kilns are used. The cycle in the kilns is eight days, three days heating up and five days cooling down. The factory uses fuel oil, grade 6, for firing. The firing temperature is about 2100°F (1150°C).

The selling price of one thousand hollow bricks, with a dimension 4" x 8" x 12", is TT$180. Samples of the clays used and produced were taken for examination.

COMMENTS

From preliminary investigations it can be seen that the workability and green strength of the clay mix are good. The texture and colour of the bricks after burning are also good. The bricks are sound. However, investigation for the percentage of rejects and the result of the tests to be carried out will indicate how far improvements can be achieved under the existing conditions of the factory.

This old factory lies in the South of Trinidad, having a convenient position for distributing its production in these areas. Estimation of the reserves of clay and sand (siliceous clay) has to be done, taking into consideration homogeneity for future extension. A better technology and new machines are suggested for this factory to obtain higher efficiency and improved quality which, after testing the clays, may be used for the manufacture of other products, in addition to hollow bricks.

There is a fourth small factory called Caribbean Clay Products in Iere Village in South Trinidad. It started eleven years ago, the production of hollow clay bricks was in experimental stage using clay from an adjacent hill. But it was closed due to the death of the owner. It was bought by another one who is trying now to build a down draught kiln for firing, using a forced draught. The machinery and equipment seen there are idle, some of them are in a bad corroded condition. They are - one high forklift truck, two bucked trucks, one deairing auger machine with shaft mixer and wire cutting machine. We were informed that the owner is considering buying the rest of machinery and equipment needed to start running this plant again.

2. Glazed Wall and Floor Ceramic Tiles

There is one factory in Trinidad & Tobago producing glazed wall and floor tiles. The factory "Ceramics Trinidad" in Diego Martin started its first stage of production about three years ago. In this first stage of production biscuit floor and wall tiles are glazed only.

The tiles come in two types, floor tiles which are 10 x 10 cm, and sometimes 10 x 20 cm, thickness about 9 mm, and biscuit wall tiles, 15 x 15 cm, thickness about 6 mm. The total daily production is about 350 m^2.

The biscuit floor tiles are imported from Italy (firing temperature 1080-1100°C). The biscuit wall tiles are imported from Venezuela and Brazil. The frit and colours for the glaze are imported from the firm Ferro in Mexico.

The Italian firm, Sacmi, holds about eleven percent of the total shares, and also provides technical advice.

The second stage of production, which is expected to start by the end of 1973, includes the mass preparation and the local manufacture of the now imported biscuit products. The factory has already received a quotation for the machinery and equipment and technical know-how from the firm Sacmi.

The system to be used, as seen from the flow sheet shown to us by the Director, is adapted to fit the local clays, using a spray dryer for dewatering.

The factory has contacted CARIRI asking for assistance in the investigation of local clays and the possibility of using these clays for the manufacture of wall tiles and floor tiles.

The factory works one shift, the kiln three shifts.

The biscuit wall and floor tiles are glazed by an automatic glazing machine. Five different coloured glazes are used. The glazed tiles are put in saggars and set on the slabs of the tunnel kiln. For firing, a pushing slab muffle tunnel kiln is used. The length of the kiln is about 27 metres. Internal cross-section of the kiln is 55 cm x 60 cm. The refractory saggars which are imported, are either two-channel with a capacity of 20 wall tiles or three-channel with a capacity of 39 floor tiles. Liquid fuel is used for firing at a temperature of about 980°C with a firing cycle of 14 hours.

The products from the kiln are sorted out and packed in the carton boxes in which the biscuit tiles are imported. Fifty wall tiles or seventy-eight floor tiles can be packed in one box.

The factory sometimes makes decorated glazed wall tiles using the silk screen method.

The production is sorted into two qualities, first and second choice and rejects. The total amount of rejects is about 3%. The amount of the second choice quality varies between 10-15%.

The average selling price for one glazed wall tile is 22 cents, and for one glazed floor tile 16 cents.

COMMENTS

The factory is a recent one with new machinery and equipment and proper technology. There are no problems in production apart from the rare occurrence of small cracks in the glaze of wall tiles, which can be related to the fluctuations of the properties of the imported biscuit wall tiles. The machinery and equipment to be contracted for with the Italian firm, Sacmi, for the second stage of production, are intended for use with imported raw materials. However, in my opinion, these machinery and equipment can also be used with local raw materials. A contract between the company and CARIRI have been accomplished to carry out a feasibility study based on the use of local clays for the manufacture of biscuit wall and floor tiles with a capacity 180,000 m^2/year final product. The preliminary study as attached Annex No. 2 shows that it is feasible to produce these tiles with the local raw materials based on the expected market defined by the company. The preliminary tests of the clays of Wallerfield and Longdenville* show that these clays are suitable for the manufacture of wall and floor tiles. The first one giving a buff coloured body and the second reddish brown body. In case of floor tiles, the addition of potash feldspar up to 20% is considered at a firing temperature about 1150°C. In the case of wall tiles addition of quartz sand and limestone, dolomite or steatite is considered at the same firing temperature. However, the final composition and firing temperature which is related also with the cycle of firing are left to the firm which will be delivering the machinery and equipment for this plant.

* The Mayo marl clays in middle Trinidad containing about 10% Calcium Carbonate can be also used successfully for the manufacture of wall tiles.

3. Cottage Pottery and Ceramic Art-Ware

The cottage pottery is concentrated in two parts in Trinidad, in the north in Chaguanas and in the south near Rio Claro. It is a primitive one, the production is mainly pots for plants, saucers, dias (used by Indians in Holy occasions), vases and lamp shades. There are four workshops in the South and nine in the North, all belonging to one east Indian family which started work in Trinidad in the year 1884. These workshops are usually in open yards under their houses. The clays used in these workshops are obtained from nearby pits. The consumption of each workshop is about 7.5 tons/month. In some of these workshops the water needed for manufacture has to be transported from a nearby river or from the nearest pipe line.

The clays which they are using whether from the Rio Claro in the South or from Carlsen Field in the North are plastic ones, with high shrinkage and fire to a reddish brown colour. Sand is added to adjust this high shrinkage. They get their sand from Longdenville area "Ravine Sable".

The method of manufacture is as follows:

The clay is soaked with water in a basin capacity about half a cubic metre for about four days. It is then taken and spread on the ground with the addition of the requisite amount of sand according to their practice (no measurement) the clay is kneaded manually using their feet and left overnight covered with water soaked cloth. Next day it is shaped by throwing on a potters wheel operated manually. The output of the manual potter wheel depending on the sizes of the pots produced is about 60-70 pieces in 6 hours. More pieces are produced in case of other smaller items. The articles are put on wooden shelves and left to dry in the open air under a shed for about three days to be leather hard for retouching. Sometimes they reduce this time by putting the articles directly in the sun. After retouching, the articles are left for about four days for drying. The articles when dry are set in a sort of updraught kiln. It is a round shaft built of bricks about one metre high and two metres internal diameter with perforated bottom underneath which is the fire place. After setting the articles in the shaft, the top part is plastered by clay, leaving holes for the combustion gases to escape. The kiln is fired with wood, the time of firing about 12 hours. The temperature of firing is above red heat and it is not measured. After cooling, the articles are inspected and taken for sale. The percentage rejects (i.e. broken articles) they say, is about 5%. The partially cracked articles are sold at a lower price.

The average number of potters wheels in each of these workshops is about three. The number of kilns vary from one to two. Some of these workshops change the manual working of their potters wheel by using electric motors, also instead of using wood for firing the kiln, they use liquid fuel flowing by gravity from an upper barrel to a simple form of a burner. Steam from a sort of steam raising kettle is used for the atomisation of fuel.

The ceramic art-ware in Trinidad & Tobago is done mainly as a hobby by about a dozen artisans. These artisans have small electric chamber kilns in their homes, where they practice this art by creating the shapes of clay and firing them with and without glaze. Some of them have studios in which they exhibit and sell their articles, the others give it directly to the wholesaler or retailer shops.

COMMENTS

I think in future, part of this cottage pottery and ceramic art-ware production can be done in a proper way in one of the extension industries suggested later. The people already working in this field can, if they like, be attached as full-time or part-time employees in these factories.

4. **Glass Containers (bottles)**

There is one factory in Trinidad, CARIB Glassworks Limited, Eastern Main Road, for the production of clear glass containers (bottles) for beer, alcoholic and soft drinks. The capacity of the plant is about 120 tons glass/day. The new factory started production in April 1972. The older factory started production in 1950, with small melting tanks, capacity 5 and 10 tons/day. In 1960, a unit melter was introduced, capacity 30 tons/day, which is still existing and not in use. The actual production of the plant which is 60 tons glass/day for bottles, is covering the local needs. The designed capacity takes into consideration a consumption growth in the local market of about 30%, and some export to the nearby islands and Guyana

The factory uses from 60-70 tons of glass sand/day. The SiO_2 in this sand is > 99% and the acceptable limit of the Fe_2O_3 is 0.04% maximum. The particle size used is from 0.1-0.6 mm and there is a rejection of about 12%, mainly fine sand, which they cannot use and which is therefore causing storage problems. Apart from the survey done by Sutton on the Melajo deposit of glass sand, there is not proper survey done to estimate and secure the reserves needed by the glass factory. The factory management indicated that there is a reserve of quartz sand in the quarrying area now used for about 2½ years. There is another area to the east of the above mentioned area which also contains glass sand. The quarried sand is washed, screened and dried in a unit installed about six months ago at Matura, before transporting it to the factory.

The limestone, amounting to about 15% of the batch composition, is imported from Barbados. The soda ash (dense), amounting to about 20% of the batch, is imported from the U.S. Alumina, which is added to the batch composition in small amounts is imported from Jamaica, same as with calcium sulphate (gypsum) which is imported from England. Naturally the chemical additives, e.g. Selenium, Cobalt Oxide and Arsenic Oxide are also imported.

The raw materials, mainly, silica sand, limestone and soda ash are put into four silos, two for the sand, one for limestone and the fourth for soda ash; underneath the silos there is a semi-automatic scale to weigh the different materials of the batch, which are transferred by gravity and taken by a skip elevator to a rotary mixer. The cullet is crushed by a jaw crusher and taken by bucket elevator to the cullet silo. From there the crushed cullet is added in the required proportion (about 15 to 40%) to the pre-mixed batch. The final mix is taken by a belt conveyor to the batch bin, feeding the furnace. The glass tank recuperation furnace is of a capacity of about 80 tons/day, and can be increased to 120 tons/day by slight adjustment. The temperature inside the melter is about 1420°C near the feeding end and about 1550°C in the other end (fining end).

The working tank temperature is 1260°C, with 1150°C at the gob feeder. There are eight burners on each side of the furnace, fired with natural gas arriving to the factory by a pipe line from Texaco. The consumption of the gas is about 650 m^3/h.

There is automatic control of temperature. There are two automatic shaping machines, i.e. two lines of production for two different types of bottles at the same time. The moulds used for press and blow shaping are imported, but CARIB anticipates that some time in the future they will have to be made locally. One line produces 72,000 bottles per 24 hours. The other, 57,600 bottles per 24 hours. The average weight of each of the bottles is 1 lb (65 gms up to 650 gms bottles can be produced). The hot, shaped glass bottles from each shaping machine are taken to two annealing furnaces, fired with natural gas, at a temperature of about 550°C, and with a firing period varying from 1-2½ hours. The machinery and equipment are of West German manufacture, apart from the shaping machines which are manufactured in England. The annealed bottles are inspected and packed in carton boxes, each containing 24 bottles. The percentage of rejects is about 20%.

There is a decoration kiln fired with natural gas at a temperature of about 600°C. There are three semi-automatic silk screen machines for applying over-glaze colours to the bottles. One machine is used for single colour, the other two for applying two colours at the same time. The amount of rejects in this type of decoration process is about 5%.

There is a small laboratory for the quality control of production in which the following tests are carried out:

1. Disc cutting machine for making sections of the bottles to measure:

    (a) Regularity of the thickness of the glass
    (b) Density of the glass

2. Thermal shock resistance.

3. Water pressure test.

4. Strain test.

The selling price for finished glass products is about TT$20 per 144 one pound bottles (for example). The investment is about $4,000,000 including the sand treatment plant.

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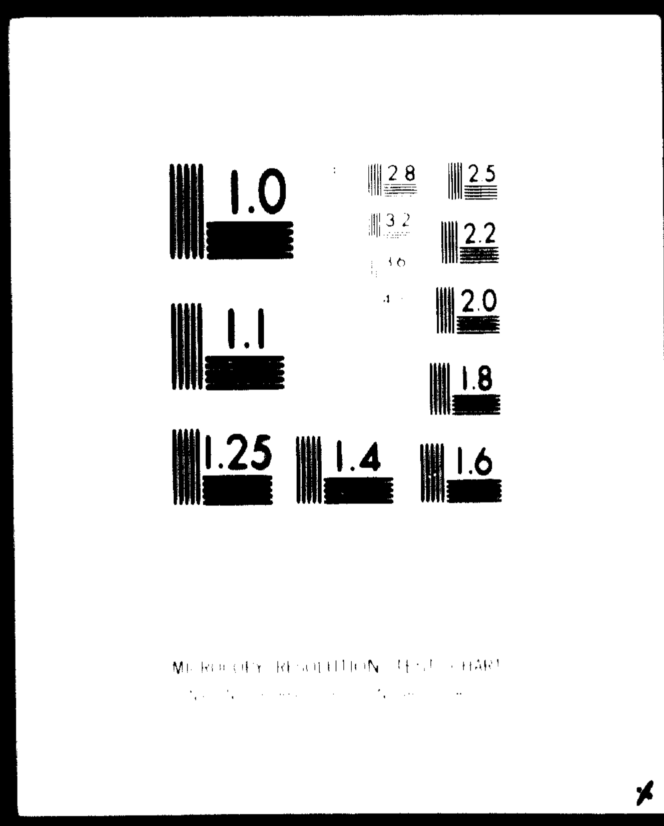

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COMMENTS

1. The fine glass sand (less than 0.1 mm size) representing 12% of the quarry production, is creating problems for disposal. It can be used successfully in the manufacture of cellular concrete and as additive in the ceramic industry batch composition.

2. Taking into consideration that in nearby countries, e.g. Guyana, there are considerable amounts of silica glass sand, a feasibility study is suggested for use of this sand in the future extension of the glass factory in clear glass products.

3. Local limestone, especially soft ones, after investigation can be used in this industry. Also quartz sand with higher iron content can be used. The colouration produced by iron in glass for making bottles used for soft drinks and beer has no harm or significance on the quality of the product and, as a matter of fact, a lot of producers all over the world use coloured glass bottles for these drinks. I think it will be easy also for the consumers here to get accustomed to these coloured glass bottles.

4. There is a possibility of making new products in the factory:

   (a) Glass table-ware, semi-automatically by pressing and manually by blowing. The latter is a desirable labour intensive industry. This also is the case with the art of glass engraving, grinding and polishing.

   (b) Sheet glass for building construction. All the sheet glass in this country is imported. A feasibility study will indicate the possibility of manufacturing it locally.

   (c) Pin and Cap disc insulators in toughened glass for 12KV. The Trinidad & Tobago Electricity Commission's consumption for the last two years, is about 10,000 pieces.

   (d) Glass wool and glass fibre. A feasibility study will indicate the priorities and capacities.

5. It was noticed that recording instruments on the control board for the glass tank furnace are not working. Shortage of small items in such a recent plant, which are needed for the proper function of these instruments, can make explanation of anomalies which may occur in production difficult.

6. Study of the possibility for using economically the unit melter capacity 30 tons/day for the manufacture of coloured glass containers is suggested.

5. LIME

The lime factory "Furness Limestone Products Ltd.", in Port of Spain, is the only factory in Trinidad & Tobago manufacturing lime.

It started the production of lime by burning limestone using wood for firing in 1892. In 1936 the factory was bought by Furness Limestone Products Ltd., which installed two-shaft kilns, American design, for the burning of limestone.

The capacity of each kiln is 10 tons/24 hours. Discharge is every 4 hours. The firing temperature is about 1000°C. Bunker heavy oil grade No. 6 is used for firing, steam being used for atomisation of the fuel in the burners. There are four burners on each kiln. The consumption of liquid fuel is about 50 gallons/ton of Calcium Oxide.

The hard limestone from the nearby areas Laventille (five qualities can be detected) is brought by trucks to the ramp near the top of the kilns, where it is stored and broken by sledgehammer into sizes from 4 in. to 9 in., approximately. From there the material is taken by hand tilting rail car to feed the shaft kilns. One shaft kiln was working at the time of the visit, the other was under repair. Half of the production is sold as quicklime in steel drums. The other half is hydrated, mainly in a hydrator. The bulk of the quicklime is used in the sugar factories for the purification and clarification of sugar; some is also used for water treatment. The slaked lime (300 mesh) is packed in 3-ply paper bags, 56 lbs each, for local use and 5-ply paper bags for export. About 10-15% of the total slaked lime produced is for export to the nearby islands.

The Manager informed us that the quality of the lime produced, according to the analysis, is about 94% Calcium Oxide.

The factory is also crushing and grinding limestones for agricultural purposes. A jaw crusher and two ball mills are used for this purpose. The material is ground so that about 85% passes the 100 mesh sieve.

The ground material is taken by a bucket elevator to the storage bin. From the bin, the material is packed for shipment in multi-ply paper bags, capacity 112 lbs each. There is a third small ball mill used for grinding quicklime according to demand. The factory has also a separate unit for drying and screening quartz sand, mainly, in five grades, for the use of the petroleum industry (in the secondary recovery of oil from oil wells) and for sand blasting.

The naturally washed (by the river at Matura) sea sand is brought to the factory, fed to a rotary dryer by means of a bucket elevator, and the dried sand is separated by a 3-deck vibrating screen into different grain sizes. Each size is packed in multi-ply bags with a capacity of 93 lbs. The capacity of the plant is about 17 tons/day.

The prices of the products ex factory are as follows:

Type of Product	quicklime		slaked lime		pulverised limestone	quartz sand
	bulk	pulverised	by hand	by hydrator		
Price $ TT	90	110	80	110	25	60

The analysis of the lime produced is as follows:

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	L.O.I.
1.87	0.29	0.39	94.2	0.07	1.89

COMMENTS

The factory has no quality control on the production, and has no laboratory. Occasionally the chemical analysis of the limestone and produced lime is done outside, at the Government Chemistry Department or at the laboratory of Trinidad Cement Limited Company. It seems that the factory is satisfying the customers' needs regarding quantity or quality of product. However, if the manufacture of lime is to be extended to cover the needs for the manufacture of cellular concrete and sand-lime blocks, which is recommended as a new field in building construction in Trinidad & Tobago, especially when there is waste sand available from nearby other industries (e.g. 100,000 tons/year fine quartz sand waste in adjacent Readymix Concrete Plant), it is recommended that the factory has a proper quality control on raw material, manufacturing, and routine testing for active lime, time and temperature of slaking.

Samples of the limestone and quicklime were taken for preliminary testing. The active lime was about 87%. The time of slaking about 16 mins. However, the temperature of slaking was somewhat low, not reaching the specified temperature of 70°C.

APPENDIX II

CERAMICS TRINIDAD LIMITED
PROPOSED PLANT EXPANSION FOR
THE MANUFACTURE OF BISCUIT WALL
AND FLOOR TILES FROM TRINIDAD CLAYS

CAPACITY: 190,000 m^2/year
i.e. 2,300 tons/year

1.0 PRODUCTION ASSORTMENT AND CAPACITY

1.1 Glazed Wall Tiles: dim. 150 x 150 x 6 mm
80% of the total production, i.e., 144,000 m^2/year
White glazed wall tiles 80%, i.e., 115,200 m^2
Coloured glazed wall tiles 20%, i.e., 28,800 m^2,
4 colours are considered.

1.2 Glazed Floor Tiles: dim. 100 x 100 x 9 mm
20% of the total production, i.e., 36,600 m^2/year,
white and coloured according to demand.

2.0 SUGGESTED TECHNOLOGICAL PROCESS

The main raw material, i.e. local clay, is brought to the factory by means of tipping trucks. Use is made of a sump installation with cross exacavation where the material is discharged and spread horizontally in layers. For manufacturing purposes the clay is cut vertically. The capacity of the sump is sufficient for at least three months production. This system is needed to homogenise and improve the plasticity of the heterogenous clays of Trinidad, and will have a great effect on the quality of the finished products.

Other raw materials which may be used in smaller amounts, e.g. feldspar, quartz sand, limestone, dolomite and steatite are brought by trucks to the factory and stored in the respective storing boxes.

The raw materials are brought by a high lift truck fitted with a hydraulic shovel into the box feeder of the shredding machine. The correct raw material dosage is obtained by means of a tilting weighbridge equipped with scale and taring equipment. Smaller raw material additions are weighed on a decimal balance. Owing to the high moisture content of the local clays (reaching about 18% in the wet season) they are brought directly from the shredding machine to the high velocity blungers. With the addition of the requisite amount of water and deflocculants, the clay disintegrates into a slurry.

The harder materials,* e.g. dolomite, limestone, feldspar, quartz sand etc., are conveyed to the ball mills for wet grinding. Water is added from dosing tanks.

*A jaw crusher may be added here to crush the hard materials if they are brought in lumps, before entering the ball mill.

The exact water dose is obtained by the use of a flow indicator. The slurries from the blunger and the ball mill are discharged through vibrating screens and electromagnets into the storage tanks, equipped with rake mixers to prevent sedimentation.

To obtain efficient sludge mixing, two tanks are suggested. From these storage tanks the slurry is pumped through the vibrating screen and electromagnet into the serving tank (with a propeller mixer) for the spray dryer. From this the slurry is pumped by a high pressure pump into the spray dryer, in which it is dried into grains of about 6-7% moisture, suitable for pressing. The dried mass is brought by a conveyor into a bucket elevator and by a reverse belt to reservoirs. Three dust reservoirs are suggested: one being filled, the second left to homogenise the moisture content, and the third for supplying the presses. This procedure is repeated periodically in a continuous cycle. The press reservoirs are filled with the mass through rotary vane feeders, reversing belt and wipers. "In the system suggested by SACMI a big dust reservoir is used from which the material is raised by a bucket elevator to rotary screens". This latter feeds the two presses, using a belt conveyor and hoppers.

The tiles are pressed in two semi-automatic presses complete with dedusting system, fettling and stacking machine. The automatically stacked tiles are loaded on the tunnel kiln trucks (a two-channel tunnel muffled kiln with sliding plates is suggested in the Sacmi offer, where the tiles are dried on metal wagons.) After drying they are loaded on sliding plates and pushed into the kiln). The loaded tunnel kiln trucks are pushed into the tunnel dryer at the same rate as into the kiln. The kiln is muffle type, fired with fuel oil. The maximum firing temperature is 1150°C, for bisquit firing of wall and floor tiles. After firing, the bisquit tiles are transported to the glazing section where they are deposited on tables. The good tiles are put on the feeding band of the glazing machine. The tiles pass through the glazing machine where they are coated with the appropriate glaze. The glazed wall tiles are inserted into saggars and loaded onto the sliding slabs or plates of the glazing tunnel kiln, with maximum firing temperature 1050°C. The glazed tiles are sorted into first choice, second choice and rejects. The first and second quality tiles are packed in cartons and transported to the finished products store.

3.0 TESTING LABORATORY AND MAINTENANCE WORKSHOP

A laboratory for routine tests and control of raw materials, semi-finished and finished products is suggested. The maintenance workshop is for preventitive maintenance and small repairs. However, it is suggested that it also includes a section for making moulds, as these represent the major wearing item in presses, and need regular replacement.

NOTE

It is assumed that at this stage of production the glaze will be imported in a semi-finished condition, so that it is only necessary to grind the frit with the respective colours, and suspending and adhesive agent, e.g. China clay. This is usually done in a ball mill with a suitable vibrating screen and electromagnet. In future a small fritting unit can be contemplated, for making the glaze locally. A small unit for making the refractories needed in production, i.e. saggars and slabs may also be included in future plans. This would be based on the transshipment of Guyana bauxite and refractory clays.

4.0 MAIN TECHNICAL DATA

4.1 RAW MATERIAL REQUIREMENTS

4.1.1 GLAZED WALL TILES

Mass of one m^2 fired glazed tiles 11kg

Total weight of salable glazed wall tiles/year = 11 x 144,000 = 1584 tons

Weight of raw materials required to produce 1 m^2 of finished product plus 25% losses = 14.7 kg

With the following losses:

*Loss due to water of constitution etc.	13%
Loss due to firing and glazing	9%
Loss of raw materials and mass in preparation shaping and handling	2%
Loss of mass due to atomisation	1%
	25%

.'. Raw material consumption per year for wall tiles = 14.7 x 144,000 = 2116.8 tons dry material.

In the wet season moisture content in clay can be up to about 18%

.'. Wet raw material consumption per year = 2581 tons

4.1.2 GLAZED FLOOR TILES

Mass of one m^2 fired glazed floor tile = 20 Kg

Total weight of salable tiles/year = 36,000 x 20

= 720 tons

Considering that all the mass is nearly clay.

Weight of raw materials required to produce 1 m^2 finished product and 25% losses = 26.7 Kg

.'. Raw materials consumption per year for floor tiles = 26.7 x 36,000

= 961.2 tons

In the wet season moisture content can be up to about 18%.

.'. Wet raw material consumption per year = 1172 tons

.'. Total salable products of wall and floor tiles per year in tons = 1584 + 720

= 2304 tons

.'. Total consumption of raw materials for wall and floor tiles = 2581 + 1172

= 3753 tons/year

Based on 300 working days/year

.'. The needed amount of raw materials daily = 12.5 tons

4.2 MANPOWER REQUIREMENTS

4.2.1 NUMBER OF SHIFTS IN THE INDIVIDUAL PRODUCTION CENTRES AND LABOUR NEEDED.

	No. of Shifts	Workers
Raw material stores	1	2
Mass preparation	3	5
Tile pressing	1	6
Firing in kiln and dryers	3	6
Sorting of biscuit ware	1	4

Biscuit store	1	1
Laboratory	1	2
Maintenance	3	4
Total.		30

SUPERVISORY STAFF:

Two graduates:

One Mechanical Engineer for maintenance and the proper functioning of the machinery and equipment.

One Chemist for quality control. The two have to be trained in Ceramics. Either one of them according to back experience and abilities can act as a production manager.

4.3 WATER REQUIREMENTS

Deflocculants e.g water glass and soda ash in small amounts have to be added to the clay slurry to decrease the water requirement.

If we consider a mass composition of clay only, the amount of water needed will be about 40%

i.e. $\frac{(2116.8 + 961.2) \times 40}{60} = 2052$ t /y

The amount of cooling water for some of the machinery and equipment 100 tons/year

.'. Daily amount of industrial water required

$$\frac{2152}{300} \approx 7 \text{ tons}$$

The water for personal use considering 100L/person/ d is 32 x 100 = 3.2t

For washing down and miscellaneous use in the factory 1.8t /d

.'. Total amount of water required daily 12 tons

4.4 ELECTRIC POWER CONSUMPTION

Three phase, 230/400 volts, 60 cycles/sec.
Total installed electric power for motors and illumination 150 KW.
The power factor in the factory is more than 90%.

4.5 FUEL CONSUMPTION

Fuel oil will be used for firing in the tunnel kilns, and for the evaporation of water in the spray dryer, where the water content of the clay will be reduced from 40% to 6-7%.

Fuel consumption for spray dryer/year	200 tons
Fuel consumption for tunnel kiln/year	400 tons
Total fuel consumption/year	600 tons

4.6 BUILDING AREAS AND HEIGHTS

	Height m	Area m^2
- Raw material stores (shed)	4	400
- Mass preparation	3	400
- Shaping, firing, sorting, packing and finished products stores	6	2000

I FIXED CAPITAL COSTS

No.	Item	Cost $ TT
1.	Land	Annual lease
2.	Buildings including water, electrical connection, drainage	200,000
3.	Machinery and Equipment*	550,000
	Know how & Engineering	52,000
	Freight and Insurance	80,000
	Erection, start up & training	100,000
4.	Furniture	16,000
5.	Diverse expenditure	10,000
	Total	1,008,000

II WORKING CAPITAL

1.	Stocks e.g spare parts, raw materials auxiliary materials	40,000
2.	Liquid money (cash)	32,000

III Total Capital I + II = 1,080,000

* Based on SACMI offer

OPERATING EXPENSES
Production of 190000 m ^{2}/y
Biscuit Wall & Floor Tiles

Shedule of yearly manufacturing costs.

No.	Item	Cost $ TT
1.	Raw materials	42500
2.	Auxiliary materials e.g silex, deflocculents, refractory slabs and supports	25000
3.	Fuel oil 600t x 55 TT$	33000
4.	Electric energy 600000 x 0.015 TT$	9000
	+ Standingcharge 150 x 12 x 7.15	12870
5.	Water 3600 m^3 x 0.133 TT$	480
6.	Wages and salaries + 20% benefit	90000
7.	Repairs and spare parts	42500
8.	Depreciation costs	
	Machinery & equipment 10%	55000
	Buildings 4%	8000
	Land, annual lease	2680
	Furniture 25%	4000
9.	Interest	64260
10.	Diverse expenditure	20000
	Total	409210

∴ Manufacturing costs/m^2 biscuit tiles

$$\frac{409210}{190000} = 2.15 \text{ \$ TT}$$

REMARKS

1. It is considered that about 80% of the batch composition is clay, which will be excavated by the company itself from licenced areas in Longdenville, Wallerfield or Valencia. The cost of the excavation of one ton clay is considered 1 $ TT plus 6 $ TT for transport to the factory. The average price per ton of the rest raw materials is considered 40 $ TT.

2. Maintenance of machinery and equipment is 2% of the total value. Maintenance of buildings is 2% of the total value

Spare parts 5% of the total value.

3. The interest is 8½% for 70% of the Capital.

TOTAL WORTH OF PRODUCTION (Total sales price of biscuit fired wall and floor tiles)

The price per square metre of either biscuit floor or wall tiles delivered inside the factory is 4.4 $ TT.

∴ Total sales price

190,000 x 4.4	=	TT$836,000
Operating expenses	=	409,210
Yearly income		TT$426,790

$$\frac{\text{TOTAL CAPITAL}}{\text{Yearly income}} = \frac{1,080,000}{426,790} \simeq 2.5$$

i.e. return of Capital after 2.5 years

NOTICE

The values given are approximate and considered only as a guide. Exact figures cannot be given at this stage where some data are missing.

APPENDIX III

THE CERAMIC LABORATORY FOR FUNDAMENTAL RESEARCH, APPLIED RESEARCH, DEVELOPMENT AND CONTROL

A - GENERAL

Chemical Analysis Apparatus and equipment for:

1. Classical silicate analysis
2. Microchemical analysis
3. Colorimetric analysis
4. Spectrophotometric analysis (emission and absorption spectra) also atomic spectrometer
5. Electrolytic analysis with the polarograph
6. Chromatography

Rational Analysis

Physical Tests Apparatus and equipment for:

1. Moisture content*
2. Specific gravity
3. Grain size determination (sieving, elutriation, sedimentation, gravitational and centrifugal)
4. Relative specific surface
5. pH value
6. Viscosity
7. Plasticity
8. Castability
9. Differential thermal analysis
10. Differential thermo-gravimetric analysis
11. Cation-exchange capacity (electrodialysis, replacement leaching)
12. Drying behaviour
13. Firing behaviour
14. Melting behaviour
15. Hardness Mohs' scale
16. Hydraulic tests
17. Moisture movement
18. Calorific value and sulphur content (for liquid and gas fuels)

Other tests as under B.

* It is understood that latest speedy accurate testers are considered in addition to the classical ones. This applies also to the other tests.

B - FIRED CERAMIC BODIES

APPARATUS AND EQUIPMENT FOR INVESTIGATING AND MEASURING THE FOLLOWING:

- Mineralogical Investigation
  1. Microscope (transmitted light and reflected light)
  2. Polarising microscope
  3. Thermal microscope
  4. Electron microscope
  5. X-Ray diffraction powder app. using mainly the Debye-Scherrer technique with ordinary temperature and high temperature X-Ray camera.

- Colour
- Size
- Ultrasonic and X-Ray examination for internal faults
- Density (apparent and true specific gravity), bulk density
- Porosity (apparent and true)
- Moisture expansion
- Permeability

- Mechanical Properties
  - (a) Strength
    1. Compressive (crushing strength)
    2. Tensile strength
    3. Transverse strength (bending strength or modulus of rupture)
    4. Impact strength
  - (b) Abrasion Resistance
  - (c) Elasticity

- Thermal Properties
  1. Reversible thermal expansion
  2. Thermal conductivity
  3. Specific heat
  4. Permanent linear change on reheating
  5. Refractoriness
  6. Refractoriness under load
  7. Thermal shock resistance

- Chemical Properties
  1. Soluble salts
  2. Efflorescence
  3. Hydration resistance
  4. Acid resistance
  5. Resistance to slag attack
  6. Resistance to Carbon Monoxide attack

- Electrical Properties
  1. Flash over voltage dry and wet
  2. Dielectric strength
  3. Dielectric constant
  4. Volume Resistivity
  5. Power and loss factor

C - PILOT PLANT*

Will include the machinery and equipment for unit operations and unit processes needed in the ceramic semi-industrial scale investigation. It will include also the necessary equipment for sampling.

Equipment for sampling

1. Diamond impregnated disc cutting machine
2. Core drilling machine
3. Grinding machine (horizontal)
4. Rotary mixer

Crushing

1. Jaw crusher
2. Cone crusher
3. Double roller crusher

Grinding

1. Disc grinding machine
2. Edge runner mill (dry)
3. Fine smooth rolls
4. Ball mill

Water disintegration or dispersion

1. Plunger

Size Grading

1. Multi-deck vibrating screens
2. Velox screens
3. Rotary classifier

Mixing

1. Irish Mixer
2. Edge runner mill (wet)
3. Propeller Mixer

Magnetic separation

1. Electro-magnet
2. Permanent magnet

Dewatering

1. Thickener
2. Filter press
3. Vacuum drum filter
4. Heated drum
5. Spray dryer

Shaping

1. Hydraulic press and moulds
2. Deairing auger machine with wire cutting unit, double shaft mixer, steam heating devices, mouthpieces
3. Turning table
4. Storage tanks with propeller mixers
5. Plaster of Paris moulds
6. Electric or pneumatic hammer

Drying

1. Electric chamber dryer with control of temperature, humidity and velocity of air.

Furnaces and Kilns

1. Electric tilting pot furnace and refractory crucibles up to 1200°C.
2. Electric chamber kiln with automatic control of temperature 1200°C.
3. Chamber kiln semi-muffle gas or oil fired to a temperature of 1600°C, with automatic control equipment and gas analyser.
4. Dismountable in sections slab tunnel kiln with the purpose of changing the length of the preheating, firing and cooling zones, consequently time temperature curve, firing with gas or liquid fuel. Firing temperature up to 1600°C (about 10 metres length) with automatic control equipment.

Boiler

Steam boiler small capacity pressure up to 16 atmosphere

Autoclave

Capacity 2 cubic metres

Air compressor

Spraying booths and spraying guns

Automatic weighing machine up to 500 kg.

Material Handling equipment, e.g.

1. Feeders
2. Belt conveyor
3. Bucket elevator
4. Battery truck

* In long term future plans where the need for raw materials of constant composition economically justifies the installation of ore dressing centre, the machinery and equipment for the following operations would be needed:

1. Specific gravity separation
2. Heavy media separation
3. Froth flotation
4. Electro-magnetic separation
5. Electro-static separation

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