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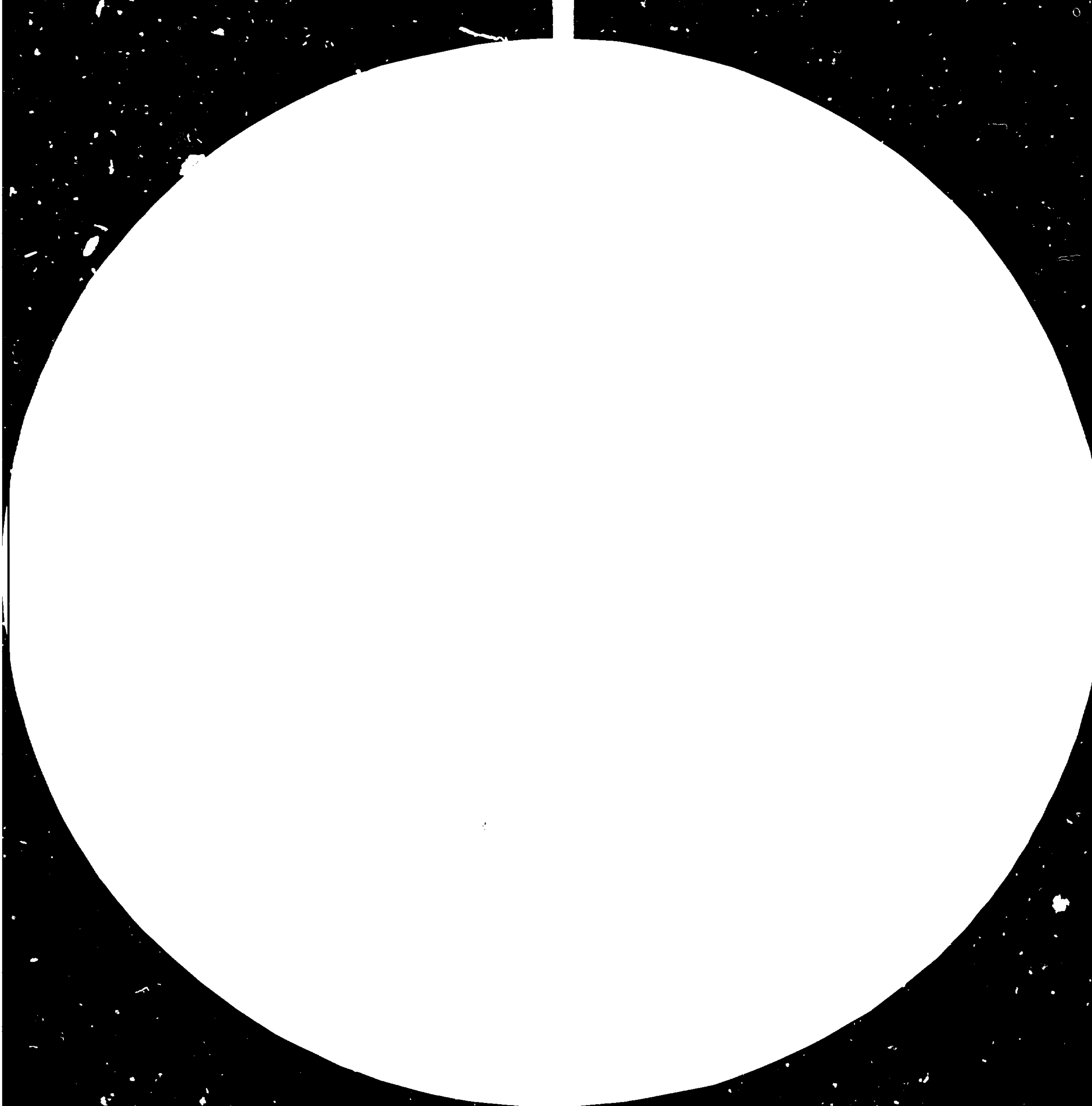

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DP/ID/SER.B/390
17 December 1982
ENGLISH

DEVELOPMENT OF CERAMICS INDUSTRIES

DP/FIJ/80/005

FIJI

Terminal report

Prepared for the Government of Fiji
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Miska F. Petersham,
ceramics expert

United Nations Industrial Development Organization
Vienna

V.82-35064

<u>Explanatory notes</u>

The monetary unit in Fiji is the dollar ($F). During the period covered by the report the value of the Fiji dollar in relation to the United States was \$1 = \$F 1.[illegible]12.

In addition to the common abbreviations, symbols and terms and those accepted by the International System of Units, the following have been used:

WD dry weight

WW wet weight

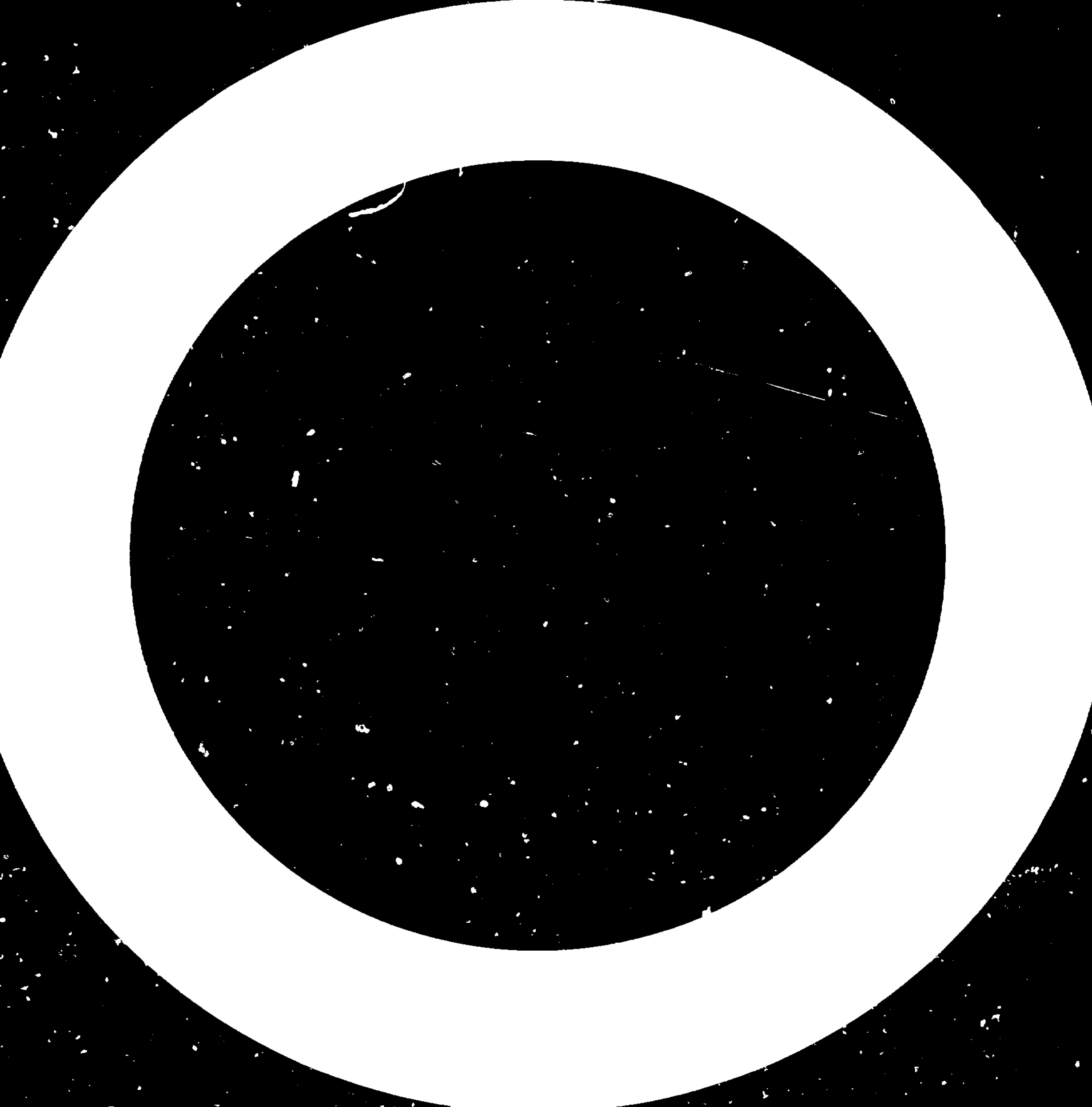
ABSTRACT

Following a request by the Government of Fiji for assistance in the erection and operation of a pilot plant to demonstrate the viability of a ceramics hollow-ware industry in the country, the project "Development of ceramics industries" (DP/FIJ/[illegible]) was approved by the United Nations Development Programme (UNDP) in June 19[illegible] and the United Nations Industrial Development Organization (UNIDO) designated as executing agency.

The expert in ceramics development and technology took up his assignment of two years on 1 September 1981. An additional post for a United Nations Volunteer was established and filled on 24 October 1981.

During his assignment the expert assisted in the establishment of the pilot plant at Kalabo; designed together with another expert most of the necessary equipment and supervised its local manufacture; provided on-the-job training for worker trainees; and designed a curriculum for a two-year ceramics technology course which was proposed to the Fiji Institute of Technology. He further made a survey of some 130 local clays; prepared a manual for clay determination and processing; developed a procedure for the testing of local clays, conducted research for glaze raw materials and tested a wide range of new fritts and glazes.

The expert's recommendations focus on the future role of the Kalabo pilot plant, which should in the near future provide the necessary assistance and follow-up to selected new ceramics industries and pottery villages. By 1984, given the availability of adequately trained staff, the pilot plant should be developed into a regional centre for research, development and design of ceramics products and some new functions added to its present ones.



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INTRODUCTION

Following a request by the Government of Fiji for assistance in the erection and operation of a pilot plant to demonstrate the viability of a ceramics hollow-ware industry in the country, the project "Development of ceramics industries" (DP/FIJ/80/005) was approved by the United Nations Development Programme (UNDP) in June 1980 and the United Nations Industrial Development Organization (UNIDO) designated as executing agency.

The expert in ceramics development and technology, whose job description is given in annex I, took up his assignment of two years on 1 September 1980. An additional post for a United Nations Volunteer was established and filled on 24 October 1981.

The development objective, as stated in the project document, was "to develop new business options for Fiji by establishing the base for a ceramics industry. This industry, once established, should prove its viability by attracting private investment either in joint venture with the Government or to be taken over by the private sector."

The major objectives of the Fiji development plan no. 8 are:

(a) To strengthen and further diversify the economic base of the natione by emphasis on increasing production of other commodities both for export and internal market development;

(b) To appraise carefully the countries total of natural and human resources;

(c) To promote policies and attitudes to increase self reliance;

(d) To assess appropriateness of technologies imported and used;

(e) To develop greater local capacity to design and manufacture simple tools.

The ceramics industry and its ancillary industries such as equipment-making or clay-processing can be labour-intensive and still be economically viable. They make use of local sources of raw materials as well as of locally-designed and manufactured equipment. They reduce dependency on imports and provide export commodities. They can be set up as small-scale up to large-scale industries and are thus ideally suited to promote rural growth. They can provide a wide range of items from building materials to gifts. The ceramics production process requires at every level manual skills, good judgement and decision making, thus leading to increased self-reliance.

The immediate objectives as stated in the project document were the following:

(a) To establish a ceramics production pilot plant;

(b) To produce ceramic utiliarian hollow-ware and to manufacture a limited range of hand-stamped tiles for interior decoration thereby using a high percentage of local raw materials. Both types of items will be test-marketed by local retailers and on export markets;

(c) To provide on-the-job training for both supervisory personnel and workers. The training will consist of:

(i) Clay forming and casting methods

(ii) Firing procedures

(iii) Clay and glaze technology

(iv) Marketing and promotions;

(d) To establish a workshop which can be a focal point of ceramics technical information and render advisory services to traditional pottery villages.

The Fijan market is sophisticated enough to absorb products of advanced Methods in ceramics technology. Ceramics worth more than one and a half million dollars where imported into Fiji in one year. Given an abundance of raw materials and with technical assistance available, there are entrepreneurs wishing to enter this new field which offers a wide range of products and business options. The fact that the majority of ceramics equipment can be manufactured locally is an added incentive.

RECOMMENDATIONS

1. A ceramics center, for which there is a need in Fiji and in the region, should have a broad basis and provide assistance in research, development and design to both, new and existing industries. The assistance required in the field of ceramics will change over the next few years; with proper management the Kalabo facility can continue to fill these needs.

2. The original objective having been achieved, the emphasis should shift to certain other project activities in order to provide the necessary follow-up. During the next year assistance should primarily be extended to new ceramic industries and to traditional pottery villages. The details for the implementation of this recommeriation were laid down in the experts' interim project report.

3. By 1984, when at least two new ceramics industries will have been started and three to five rural ceramic projects initiated, the function of the Kalabo centre should change again; it should then become an information, research and development centre to support the new industries. The training function should be phased out, except for on-the-job reinforcements, as the Fiji Institute of Technology will begin to produce graduates. A co-operative agreement by which the new graduates would gain actual work experience would be very worthwhile as it would ensure truly qualified staff for the new industries.

4. It is at this stage that the concept of a regional refractory materials (ceramics) centre begins to have a meaning. In order to fully develop the clay resources of Fiji or the entire region, a centre with suitable technical facilities and trained staff is a necessity. The existing pilot plant at Kalabo should be developed into such a regional centre as it has the basic elements to provide the required functions:

(a) The physical plant, with only small modifications, would be more than adequate;

(b) There are trained personnel who, in two years, should form the nucleus of an experienced staff. They will at that point in time have more knowledge and experience with the clays of Fiji and the region than anyone else;

(c) The basic equipment at the Kalabo facility covers most of the needs of even the expanded concept so that only a minimum of new items would be needed.

5. The following two functions should be added to the ones already covered by the Kalabo pilot plant:

(a) One major area not covered in the existing project is expertise in structural clay products. There has been considerable interest in Fiji and the region in such products and several studies have been made. Unfortunately these studies are of the "either/or" highly-technical kind and therefore ambiguous as to local relevancy. With the proper expertise, the centre should overcome such problems and be able to initiate some use of structural clay products. This would require that a local be sent overseas for training and that in the meantime an expert in the area be brought in. Since there is planning time of at least two years, this seems quite feasible.

(b) The second function that is badly needed is a designer. The term designer has different meanings to different people; it is certain, however, that an industrial designer trained in product design is much more than a stylist and would provide an invaluable service to both the refractory products centre and local business. This function can increase sales, create new product lines, revive old ones and therefore be a driving force for improving the economy. There again it would be necessary to bring in outside expertise until such time as a local person has been trained.

6. Other functions such as material research, equipment design, marketing analysis etc. which already exist, should be expanded or modified in accordance with the concept for the centre.

7. The supporting services which exist at the mineral resources section, can carry out chemical analyses and have the equipment for one kind of mineralogical analyses. Since at present there is no one in Fiji able to use that equipment, someone should receive the necessary training.

I. ACTIVITIES AND OUTPUTS MEASURED AGAINST THE REVISED WORK PLAN[1/]

A. Erection of pilot plant at Kalabo

The delay in the construction of the building was mainly due to a loss of the plan. The pilot plant, as originally envisaged, was subsequently extended by a storage shed, a showroom, additional office space and a packaging area. The size of the plant is now 1,[illegible] m^2 as compared to [illegible] m^2 of the original proposal.

The additions could be accomodated by using casual labour and a supervisor from the project team. This afforded savings both in time and money, and allowed construction to get back on schedule.

B. Kiln construction

The construction of one double-chamber downdraft kiln using oil as fuel, one medium catenary and one test kiln was completed on time. The double-chamber kiln is fired twice a week and serves as the basic production kiln. The medium catenary and the test kiln are used as needed. Two additional kilns are currently under construction, a small updraft kiln to test local insulating bricks made at the project and a 3 m^3 electric kiln for decorating tiles and special effects.

Under this project activity three kilns were thus produced on schedule and two extra ones will be added before the end of the project.

C. Material research

Material research has been an ongoing activity throughout the project. The original intention was to provide suitable clay bodies and glazes for use in the project. Following the desire expressed by the Government to open rural production units, it has been necessary to expand this activity considerably. All material research originally done by the ceramics expert has been taken over by Ms. Buksh, the manager trainee. The original goal of the materials research was reached in March 1981 and at the time of reporting the following has been achieved:

1/ See annex II for the revised work plan.

(a) A jigger-jolly body using a blend of two local clays and no imported material;

(b) A casting body using 10% imported clay additions;

(c) A hand-pugging body using a blend of two local clays plus grog produced at the project with no imported material;

(d) A tile body using tailings from Vatakola gold mine with no imported material;

(e) Three glaze fritts (see annex III) which are made from three different local materials using a small percentage of imported borax as a flux. From these three basic fritts the five standard glazes are produced. To make the glaze variations the primary import is approximately 5% zinc oxide and less than 1% of colouring oxides.

Over 130 different clays from Viti Levu, Vanua Levu, Tavua and Kadavu islands have been surveyed. In the final clay report each clay will be described in detail on two pages each, including technical data, location of deposit on map, owner, estimate of size of deposit and possible uses.

D. Accuisition and installation of equipment

Originally it was intended to use predominantly imported units, purchased through UNIDO, and to install them during the first few months. This system broke down completely. Information on available units was not obtained from UNIDO, and when suitable machines were found in Australia or New Zealand, that equipment was often no longer available when, after long delays, their acquisition was finally authorized.

Had the expert not been able to find a solution outside of UNIDO purchasing, there would still be no equipment and therefore no project. It is felt that this situation must be corrected, for not every project manager will be in the lucky position to have a solution at hand.

In the present case the problem was solved because Mr. Pagani, the project co-ordinator of DP/FI/80/003, "Assistance to small-scale rural industry," is an excellent and creative engineer. Thanks to his willingness to co-operate fully, he and the expert designed the necessary equipment, which was then tested, modified and a final version built at the Government workshop. There was input at every stage due to the excellent co-operation of all project personnel in the shop. In this way most of the equipment was designed and built locally, and the result was better suitable equipment for less money and, through consultation, to get precisely the machines that were needed. A description and drawings of the locally-produced ceramics equipment is available from UNIDO upon request.

It was that happy combination of skills, personalities and projects which allowed the project to get back on schedule and to get more and better suitable equipment than provided for under the original plan. This fact is of special benefit for Fiji, because it also demonstrated the viability of building such equipment locally.

E. Management training

The training programme for the three management trainees was three months late in starting due to the delay in the construction of the buildings. Only two individuals with suitable qualifications could be identified. One of them, Ms. Buksh, had previously undergone training in New Zealand and has proven to be an excellent choice, so that it was recommended that she be appointed manager. The second person left after several months and his replacement, Mr. Tikoduadua, was chosen from among the worker trainees. The Government is planning to send him to Australia for three months intensive training at the Bendigo Pottery with whom the expert worked out a co-operative venture. He should be able to assume responsibilities as shop foreman and training supervisor upon his return. It was very difficult to find a suitable person to handle marketing and the person selected, Mr. Arun, seems to be doing well but still has to grow into the job. In general, however, management training is on schedule and it is believed that all three trainees will be able to carry out their job responsibilities on their own.

F. Training of workers

The worker trainees' training programme is on schedule and there are currently seven people who have acquired the necessary skills. Two have shown enough skill and initiative to be recommended for supervisory positions, namely Mr. Tikoduadua, currently acting as a managerial trainee, and Ms. Nuku who is being recommended as a counterpart for the rural development scheme.

The project workers are: Mr. Tikoduadua, general production supervisor; Mr. Sitiveni, mould and model maker; Mr. Tupou, fireman; and Mr. Savanoca, clay processing. Three persons were trained in general production and have learned all methods but specialized in one each: Ms. Luku in casting, Ms. Bale in jiggers and jolly and Ms. Nuku in tiles and hand pugging.

G. Design and production planning

The number of designs envisaged, originally 350, was much too high. The actual output is close to 50, with continuous modifications and redesigns. The demand was surprising so that it was necessary to reduce the number of models. Orders are of such a magnitude that, even with a reduced number of designs, it is a problem to fill them.

It was felt that the designer's efforts could be used more profitably in other areas. New designs will continue to be made, but more thought will be given to developing a stock of possible products for the new business.

H. Test run to full production

Runs of limited quantity were achieved on schedule and the demand was found to be high enough to warrant that all effort would go into production. The stated goal, however, was the involvement of the private sector and at that time enquiries about setting up a ceramic business began to come in. It was therefore decided to continue production at a reduced level in order to be able to assist the new business by providing training for new workers, assisting in planning of plant layout, equipment design and anything else the new enterpreneurs required.

In general, the team of managers and workers has proved that it is possible to establish a profitable ceramics industry in Fiji. The major problems are quality control and productivity. Both, however, respond to good management practice and although it may take some time until full industrial potential will be realized, it is certainly feasible.

I. Market testing

In the project document much more importance was given to market testing than was necessary in practice. Due to the quick initial response and high sales, the market testing activity was reduced in scope. That decision was again influenced by the prevailing situation and the desire to assist the private sector. The function therefore would be shifted to long-range activities, such as research into new products, market feasibility studies in new areas, costing procedures (see annex IV) and all possible marketing assistance to the new ceramics industry.

J. Assistance to traditional pottery villages

Although listed in the project document as one of the objectives, assistance to traditional pottery villages was not included into the work plan. It was activated during the tripartite review in August 1981 and has been part of the project since that time. The initial phase was one of planning and establishing communications with the villages. The activity is now ready to move into its second phase which is to respond to the needs formulated by the villagers.

Three groups of villagers will be brought to the Kalabo pilot plant within the next three to four months for a three-week training session. Subsequently there will be follow-up by the project personnel at the villages, to assist people in the application of the newly acquired skills.

II. ACHIEVEMENT OF IMMEDIATE OBJECTIVES

The first objective, to establish a pilot plant for the production of ceramics, has been achieved. The plant covers an area of 1,020 m^2 and consists of the following units:

General manufacturing
Mold shop
Laboratory
Packaging and product storage
Warehouse
Showroom
Offices

The plant is furnished with the equipment listed below:

(a) The clay-processing area has storage for raw clay, slaking barrels, high-speed mixers, a clay separator, a mix muller, a large ball mill, a jaw crusher, drying bats and storage for plastic clay;

(b) The mold shop has a plaster wheel, a scale and small tools;

(c) The laboratory has storage for chemicals, a gram balance, large scales, a test kiln, a jar mill, mortars, screens and assorted small equipment;

(d) The casting area has mold storage, casting racks and two blungers;

(e) The turning section has jiggers and jolly mold storage, two jiggers and jolly machines and two potters' wheels;

(f) The hand-work section contains large work tables, wedge boards and a mechanical tile press;

(g) The glaze area has a compressor, a spray gun and a spray booth, wet glaze storage, work tables and a grinding wheel;

(h) The kiln area contains one 70 m^3 double-chamber, spring-arch oil-fired downdraft kiln, one 10 m^3 catenary kiln and one oil-fired fritt furnace. One test kiln for local bricks and one 3 m^3 electric kiln are under construction.

All equipment except motors, blowers, mill jars and spray equipment, was built locally by the project or by DP/FI/80/003 at the Government workshop.

The second objective was to set up a production of hollow-ware and decorative tiles. A line of hollow-ware was designed and has gone into production. As there was great demand for such accessories as lamp bases or ash-trays, most of which are for hotels, and special designs for local manufacturers such as ginger jars for the national marketing authority, design and production concentrated on those items. The project did not have enough capacity to fill all the orders received and new designs were therefore not actively saught. For example, a tentative order for 1,000 lamp bases was turned down as it would have meant to stop all project activities, except production, for six months. Sample tiles have been produced and buyers are interested. A full line has not been put into production because of two requests by local entrepreneurs to set up tile factories. Here again, it was felt that it was in the better interest of Fiji to concentrate the efforts on assisting the private sector rather than on increasing the production capacity of the project.

The training objective has been reached, with skill levels from good to excellent. A major problem was the fact that no overseas-training component was included in the project document. At the time of project formulation it was felt that there would be time and opportunity for on-the-job training at the low supervisory and foreman's levels. This, however, has not been possible for many reasons, the main handicap being that no associate expert, who should have joined the project within the first six months, was found. The United Nations volunteer who arrived in October 1981 has been of immeasurable help to the project, but his assistance came too late for the initial training phase. It is now hoped that Mr. Tikoduadua will be se- Australia for a three-month training.

The final objective of establishing a focal point for technical information and services to traditional pottery villages is being acted upon. Mr. Kramer, the United Nations volunteer, will be responsible for that activity and progress has already been made. This objective was not a part of the original work plan since it was considered secondary to the aim of industrial development. When the project was conceived and the project document written, the major emphasis was put on the pilot plant. In part this was done so that the project, which was a relatively small one, would not be over-extended. It was felt that after the centre became active was the time to consider other aspects. During the tripartite review in August 1981 it was decided that, since all other objectives were on schedule, the rural development objective should be initiated. Over the past two years it has become apparent that the establishment of smaller rural industries is of primary importance. Had this aspect been seriously considered at an earlier stage, the project would have had to be expanded to accomodate it. At present this component is being implemented and should provide the right thrust and scope for future development. With the Kalabo centre a reality, there is a focal point from which can come all of the functions necessary to develop rural ceramics industries.

Requests for technical assistance have been received from three areas: the Tavua island in the Mololo group, potters from Nayawa and Yadua village and a youth group from Natasiri. Training schemes are being designed with due regard to the specific needs of the different groups. The first group will be brought to Kalabo for three weeks of training. The project personnel will then visit the villages or areas to assist in the application of the new skills.

III. UTILIZATION OF PROJECT RESULTS

Since no ceramics industry existed in Fiji, it was necessary to prove its viability at every level. It meant starting from zero; all materials had to be located, identified, tested and sources secured for those to be used; all facilities and equipment had to be either imported or built, the workers trained in basic skills, the future products designed, marketed, tested and evaluated. Only then could the factory start production. It was expected that after starting-up the factory would have to be in operation for one year or more to prove viability.

It has been gratifying and somewhat surprising, therefore, to find that even before full production was reached, the private sector realized the potential for such an industry. Three written and four verbal requests for Government assistance in setting up ceramics production facilities have been received. These requests will have to be carefully analysed by the Government and the project personnel, because only the most promising ones should be encouraged at this time. Once it is ascertained that they are serious, aware of the problems and have sufficient financial backing, they should be given every assistance. This evaluation and administrative decision must be taken at the Government level, while the project should provide all technical information as needed.

There exists a great danger of moving too fast in order to exploit what is obviously a good potential market. Both, the Government and prospective entrepreneurs must understand that workers cannot reach a certain level of skill without several months of training, and even after training it will take months for them to reach proficiency. Ceramics technology is a complex field and there are many pitfalls into which the unwary may trip. It will therefore be necessary to move slowly and build solidly, so that the new industries will have a good chance of success.

The project personnel are becoming very adept at their jobs. However, as there is only a small number of them, they should not be spread too thin or pushed too far if problems are to be avoided. Therefore, a maximum of two new industries should be started the first year. This should allow the project to be of maximum assistance and still meet its other commitments.

A proposal has been submitted to the Fiji Institute of Technology to add a two-year ceramics technology course to its curriculum. The proposal is under consideration, but results from such a programme, if implemented, will not be felt until late 1984 or 1985. Until that time the ceramics project will constitute the only resource for technical assistance and workers' training.

IV. CONCLUSIONS

The first conclusion to be drawn is that in Fiji there has been a gross underutilization of a good, abundant local resource, which is clay.

There are several reasons for this circumstance and perhaps the most obvious lies in the clay itself. Tropical clays, and volcanic clays in particular, are quite different from clays found in the temperate zones, they behave differently and present some unique problems in their use. Most studies are conducted by people with a background in classic clay theory based on temperate clays. They often have little understanding of the local varieties. It takes time to learn how to overcome problems inherent in local clays. If an assessment of its potential uses is based on the behaviour of temperate clays, misjudgements and wrong conclusions are quite probable.

The second general conclusion based on experience at the project is that it is quite possible to overcome these difficulties inherent in tropical clays and make good-quality ceramic products out of them.

Another factor leading to underutilization of the clay resources is the "either/or" concept of western technology, according to which a ceramics factory should either be large and technically sophisticated or it is considered hobby work. In small island countries a big factory is too large and the other alternative not worth bothering with.

The third general conclusion therefore is that a serious appraisal of small- to medium-size industries with appropriate technologies must be made. Production units in a country like Fiji should make use of local energy resources wherever possible, be labour intensive if economically viable, and be flexible in their output.

A problem inherent in many highly-technical, industry-oriented approaches is the rater narrow view of what the product should be. It is another manifestation of the "either/or" syndrome: either bricks or tiles, hollow-ware or insulators etc.

The fourth general conclusion therefore is that a more flexible approach to industrial development, appropriate for a small country like Fiji, is needed. Industries that can to some extent be integrated into the communal-oriented culture and which do not impose a rigid western pattern have a much greater chance of success. Although this may be at the expense of some efficiency, it is preferable to have a unit that is working well rather than a factory with built-in efficiency, which is not functioning. The production planning for a small- to medium-size unit can, moreover, be more flexible in the product range and more easily be adapted to fill needs for different items at different times.

Annex I

JOB DESCRIPTION

Title	Expert in ceramics development and technology
Duration	Twelve months, with possibility of extension
Date required	As soon as possible
Duty station	Suva, with travel within the country
Purpose of project	To provide the Government with new business options by establishing the base for a ceramics industry and to help create new employment opportunities

In co-operation with the Ministry of Commerce and Industry, the expert is specifically expected to:

1. Establish a ceramics production pilot plant in the building which will be completed by the Government;
2. Provide on-the-job training for three (3) management personnel for twelve months and five (5) workers for three months;
3. Supervise the personnel who have already been trained;
4. Prepare on-the-job training programmes which will be based mainly on the following:
   (a) Clay forming and casting methods;
   (b) Firing procedures and kiln maintenance;
   (c) Clay and glaze technology;
   (d) Mould/product design and production planning;
   (e) Marketing and Promotion.
5. Help survey the local clay and glaze materials in order to establish and determine usable clay compositions in the middle temperature range;

6. Conduct research for glazes from local materials suitable for the clay bodies selected;

7. Establish a workshop which can be the focal point for a ceramic technical information service for traditional pottery villages.

The expert will also be expected to prepare progress reports every six months and a final report, setting out the findings of his mission and his recommendations to the Government on further action which might be taken; this report will be made available to UNDP four months before the completion of the project.

Qualifications: University degree in ceramics, ceramic engineering or equivalent; extensive experience in the small-scale manufacture of ceramic utility ware and gift items; experience in assessment of raw materials market analysis

Language: English

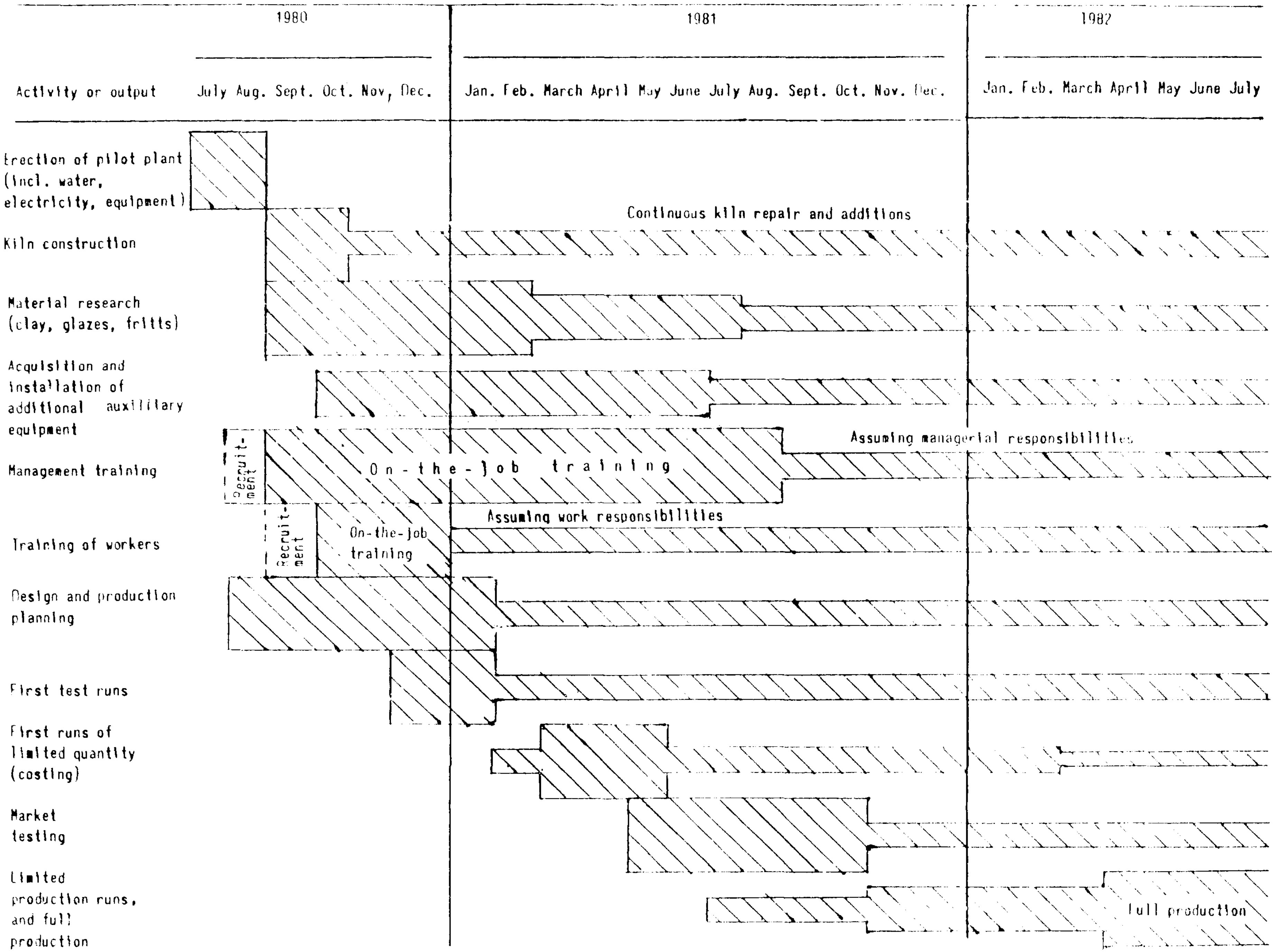
Background information: The country has a history of ceramic production going back to the Lapita pottery of 3,000 years ago.

The presently produced ware has lost some aesthetic and technical skills over the recent historical past. All of it is brush-fired to a temperature of approximately 700°C, which makes it very fragile and this limits transport, even within the country.

The long-term goal of several projects and surveys conducted since 1975 was to establish a viable ceramics industry for hand-made products. The results of an extensive research undertaken in 1978 to survey the potential in the country, indicated promising signs of a local market for locally-made glazed ceramic products like hollow-ware. Thus a decision was taken by the Ministry of Commerce and Industry to establish a project for the pilot-plant production of ceramics.

Annex II

REVISED WORK PLAN



Annex III

GLAZE MATERIALS AND GLAZES

An attempt has been made throughout the project to utilize as much local material as possible. This decision was based on the request of the Government to ascertain the viability of these materials in practice. The reason for making own fritts was not only to use the local material but also to produce glazes unique to Fiji. In order to get a true white it was necessary to use one imported fritt because of the iron content of all local materials.

Three different fritts have been developed using borax as the flux. From these three base fritts a range of six unique glazes was produced which can easily be altered as needed. Twenty-two different glaze materials were tested and subsequently reduced to seven that looked promising. Out of the seven three were chosen for their wide character difference, although several others would have made excellent glazes as well.

The expert started by picking up small samples of anything that seemed even remotely a potential glaze base. During his clay prospecting he covered a major part of the island and collected such samples like weathered stones, black sands, tailings from the gold mine and sugar cane ash. Care was taken to choose material that required little or no processing since at that time the prospects of a big ball mill seemed remote. Clay slabs with finger depressions were made up, one for each material. Starting with a 50/50 blend test material and borax, the borax content was reduced in steps of 10% down to 10%. The slabs were fired in the test kiln to 1,200°C which had been determined as the maturing temperature of the clay being used. Results were sorted out and a selection made according to fusability and glaze characteristics.

For example, a weathered stone of whitish colour (sample 52) with 40% borax produced a shiny, yellowish transparent; sugar-cane ash with 30% borax an opaque, creamy tan which broke nicely; and a greenish semi-clay (sample 95) with 20% borax a dark, red and black opaque semi-matt. Samples of these materials were sent for chemical analysis to the government laboratory to enable the expert to calculate the material and fritt formulas. Based on that information a series of trial glazes were produced from the Merrit Limit formulas and the best results recorded for testing in larger batches.

Consequently larger amounts of the fritt had to be produced. The initial tests had been made in a cup-sized crucible in the test kiln and the material had been ground by hand.

A simple furnace was made from a 44-gallon drum, lined with fire-clay and sand, using a fire-clay and sawdust mix as insulation. The burner, also a simple home-made design, using diesel and a vacuum cleaner as blower, worked very well. Plans are afoot to convert it to waste-oil, thus cutting the glaze costs substantially. The biggest problem was finding a suitable mix for the larger crucibles. In the beginning a crack appeared already after one or two melts. This was solved by using a 50/50 mix of fire-clay with a proportional mix of three grades of home-made fire-brick grog and the resulting product is still fine after more than a dozen melts. The material, in powdered form, is dry-mixed with the proper proportion of borax and the crucible filled. After the batch is melted it is dumped into water and the crucible refilled, the furnace started up again etc. The shattered fritt is dried and ground to approximately 200 mesh.

The glaze produced from cane ash is a typical example of the process. It consists of 79% ash fritt, 14% local clay and 7% zinc oxide. Since crushed cane is used as a fuel in the mill, sugar-cane ash is available in almost unlimited quantities.

K_2O	0.12				
Na_2O	0.08				
MgO	0.38	Al_2O_3	0.3	SiO_2	5.8
CaO	0.22				
Fe_2O_3	0.2				

The resulting fritt based on 30% borax is melted at 1,200°C

K_2O	0.075				
Na_2O	0.43	B_2O_3	0.75		
MgO	0.24	Al_2O_3	0.19	SiO_2	3.6
CaO	0.14				
Fe_2O_3	0.12				

The glaze which has a nice creamy opaque tan is fired at 1,180°C

K_2O	0.07				
Na_2O	0.4				
MgO	0.22	B_2O_3	0.7		
CaO	0.13	Al_2O_3	0.51	SiO_2	4
Fe_2O_3	0.11				
ZnO	[illegible]				

The fritt formula for sample no. 52 plus 40% Borax

K_2O	0.02				
Na_2O	0.6	B_2O_3	1	SiO_2	4.[illegible]
MgO	0.17	Al_2O_3	0.5		
CaO	0.13				
Fe_2O_3	0.05				

The fritt formula for sample no. 95 plus 20% Borax

Fe_2O_3	0.06				
Na_2O	0.07	B_2O_3	1		
K_2O	0.02	Al_2O_3	0.14	SiO_2	0.68
CaO	0.07				
MgO	0.10				

The batch formulas of the basic glazes now in use are as follows:

<u>No. 1, transparent</u>

I W S fritt	416
Portland cement	30
Clay	24
Zinc oxide	14

<u>No. 2, iron saturate</u>

I W S fritt	416
Cement	30
Red clay	24
Zinc oxide	14
Iron oxide	13

<u>No. 3, tan</u>

I W S fritt	416
Cement	30
Clay	24
Zinc oxide	14
Titanium oxide	24

<u>No. 4, cream</u>

Ash fritt	79
Clay	16
Zinc oxide	5

No. 5, blue

Ash fritt	7[illegible]
Clay	1[illegible]
Tin oxide	[illegible]
Cobalt oxide	.[illegible]

No. [illegible], red semi-matt

Y 3E fritt	[illegible]
Red clay	[illegible].2
Flint	[illegible]

The share of imported materials is very low and the manufacturing cost is below the cost of imported fritts. By firing the burner with waste oil and using a small, continuous furnace, costs can be further reduced. The furnaces have been designed and will be made soon.

Annex IV

FORMULA FOR THE COSTING OF CERAMIC PRODUCTS

	$F
Firing cost[a] per in^3 of kiln space	0.002
Labour per hour	1.50
Clay[a] (labour to process) per 500 g	0.14
Glaze[a] per 500 g	2.00
Overhead 25% of costs	

The profit on the wholesale price will depend on the market situation; it should be at least 10% and average 25%. The retail price should be reasonable. Some items will bring more profit, others less. However, it is important to offer a complete line of items. Once the production is underway and the market has been assessed, the range of products as well as the prices can be adjusted.

Example of calculating the retail price for a 8-inch perforated indoor lantern for a candle (in $F):

Firing	Labour	Material	Overhead	Profit	Wholesale	Retail
0.80	1.00	0.30	0.52	1.13 (43%)	3.75	7.50

a/ The firing and material costs are based on experience from the Sigatoka project. Figures from the current project will be available only after several kiln loads will have been fired and evaluated.

Annex V

PROCEDURE FOR THE TESTING OF LOCAL CLAYS

Much of the information which is required to evaluate a clay for its possible use can be obtained through simple tests and with a minimum of equipment. Some of this information requires a technical background and experience with clay, because it involves interpretation and judgement, while in other cases only accurate recording of measurings is needed. The final evaluation of a clay, however, calls for experience and actual work with clays since tests, at best, are only an indication of possibilities.

A. Equipment

The following equipment is required for clay testing:

One or more pails

Several bowls or plastic dishpans

A centimeter ruler

A gram scale (preferably beam balance)

Plaster bats or bisque slabs

A magnifying glass

30-mesh screen (window screen)

60-mesh screen

120-mesh screen

sponges

A small test kiln with pyrometer

B. Information to be gathered

1. Working qualities of clay

The collection of the following information on the working qualities of clay requires experience and judgement:

(a) Plasticity

(b) Body

(c) Grain

(d) Green strength at leather-hard stage

(e) Green strength at dry stage

2. Fired qualities of clay

The gathering of the fired qualities of clay also calls for experience and judgement. It includes:

(a) Maturing temperature
(b) Fired strength - ring
(c) Brittleness - chipping
(d) Aesthetics of colour, texture etc.

3. Qualities that can be measured

(a) Ease and length of time to slake
(b) 30-mesh and over-screening

 (i) Percentage of non-clay materials
 (ii) Make up of materials

(c) 60 to 30-mesh screening

 (i) Percentage of non-clay material
 (ii) Make up of materials

(d) 120 to 60-mesh screening

 (i) Percentage of non-clay materials
 (ii) Make up of materials

(e) Total sample percentage of clay and fine non-clay materials
(f) Shrinkage, plastic to dry
(g) Shrinkage, dry to 1,000°C
(h) Shrinkage, 1,000°C to maturity
(i) Shrinkage total
(j) Absorbtion at maturity
(k) Water of plasticity
(l) Casting properties

C. Test procedure

The test procedure involves the following steps:

1. Locate and collect clay. To obtain a truly representative sample of a deposit, the material should be a mixture of samples taken several feet apart or a quartered sample if using an already-dug clay. For quartering, divide the pile in quarters, take some clay from each quarter and mix together for the

sample to be tested. Any method that ensures a blended sample will always more acurately represent variations within a given deposit. Tropical, i.e. geologically fast-weathered clays, are more likely to have gross physical differences within a small area and therefore it should be ensured that a blended sample is used for testing.

2. Identify site on map by reference to known landmarks.

3. Break up lumps and spread out to dry. The smaller the lumps, the easier the clay will dry and slake. Clay is very difficult to slake when it is wet because the water cannot easily penetrate the plastic material; therefore thorough drying is important.

4. Slake, in two separate containers, by adding the dried clay to the water. Put 100 g into the first container and approximately three times as much into the second one. It is only necessary to weigh the 100-g batch. The clay should reach to just under the water surface. Allow it to slake until it is soft, noting the time required for this. Some clays slake within a few minutes, others can take 12 to 24 hours, and still others require mechanical stirring. Don't stir until satisfied that no further change will occur.

Clays that are difficult to slake may contain montmorillonite, but many other factors affect slaking action such as particle size, presence of non-clay materials etc., so that the time factor can only be used as an indicator when considered together with other clues.

5. Stir the 100-g sample to thin slip (thin creamy consistency) and add water if necessary. Screen through a 30-mesh screen. Retain and dry any residue. When dry, observe through a magnifying glass and note the kind of material present, such as rock fragments, quartz, feldspar etc. This is a good indication of what the fine non-clay material will consist of. Weigh this dry residue; the figure obtained in grams is the percentage of over-30-mesh material (e.g. 12 g of residue means 12% of the sample is over-30-mesh non-clay material).

Repeat this procedure with 60- and 120-mesh screens. Some clays will contain large amounts of coarse material and some almost none. It is usual that sedimentary or alluvial clays will contain more uniform particles and material quite different from the parent rock. Primary clays will contain more rock fragments of different size which resemble the clay in colour. Remember, there are many variables; therefore consider all the clues.

6. Dry on plaster or bisque tile until plastic. Make one or more test tiles approximately 2 x 10 x 5 cm from the remaining clay. Note plasticity, body colour etc. Mark a 10 cm line, put an identifying mark on the slab and set it aside to dry (gives a 120-mesh tile).

7. Screen the other (300 g) batch through a 30-mesh screen (or window screen) which will give a sample that can be fired safely. Rock fragments larger than 30 mesh will sometimes explode in firing. Note plasticity, body etc. Make at least five tiles with 10 cm lines and identifying marks (gives 30-mesh tiles). Since plasticity increases with the aging of a sample, semi-plastic consistency at intitial testing will probably be considerably better when male in quantity.

8. When the tiles are dry, note plastic to dry shrinkage, warpage, cracking etc. Compare 120-mesh and 30-mesh tiles.

9. Break one tile at leather-hard stage and note toughness.

10. Break again at dry stage and note toughness.

11. Fire remaining samples to 1,000°C. Before firing, prop one till so it can sag (if it is going to do so before this temperature) by bridging across two others just touching on either end.

12. After firing measure shrinkage and check sagging. If sagging occurs, the clay will not fire to that temperature. Take note of colour, ring (tap with metal object), warpage and surface or cracking.

13. Check maturing temperature by firing with pyrometer or a set of cones till sag occurs. Position the tile, supported on each end, in front of kiln peep hole so that one can see when sag occurs. Shut off at sag point and note temperature. The maturing temperature is probably about two cones lower.

14. Fire a tile to probable maturing temperature, again supporting so that sag can occur. If there is no sagging, note shrinkage, ring, colour etc.

15. Break the tile and record estimate of brittleness, hardness etc.

16. Test absorbtion by weighing a tile. Record its dry weight (W1) in grams. Soak the tile in water for twelve hours or boil for 1/2 hour, pat

dry and weigh it again (WW). The percentage of absorbtion is calculated as follows:

$$\frac{WW-WD}{WD} \times 100 = \% \text{ of absorbtion}$$

Standard clay theory suggests for a stoneware clay in the C/6-C/10-range a total shrinkage of less than 15% and an absorbtion of 0 to 1%, and for a C/06-C/02 earthenware clay a total shrinkage of less than 12% and absorbtion of below 10%.

Tropical and volcanic clays are quite different and do not react according to classic clay theory. However, if they are properly investigated, they may well be used to produce good-quality ceramics.

Their shrinkage was found to be high (plastic to dry from 10 to 17% and totals up to 30%); an acceptable range, therefore, might be anything up to 20% for total shrinkage.

The expert has not been able to classify tropical clays according to standard categories (i.e. earthenware, ball clay etc). These clays seem to have elements of several categories. Almost all contain iron and many are weathered by internal hydraulic action rather than by surface water. Kaolinite, when present, is usually in the structure of Halloysite and there is often some form of montmorillonite which no doubt accounts for the high shrinkage.

Absorbtion seems to be high and the vitrification range short so that even at high temperatures it is difficult to reduce the absorbtion below 5 to 8% without causing warping and bloating.

It is, therefore, suggested that testing done on tropical clays not rely too heavily on classic theory.

Firing bisque must be extremely slow since there is additional water given off both at 100°C and 550°C. In the case of some clays this can be four times as much as with normal kaolinite.

17. Additional information can be found, if desired, by testing shrinkage and absorbtion every 50°C up to sag point. This information when plotted on a graph gives a good indication of changes taking place.

18. The amount of water of plasticity is found by weighing a lump of the desired plasticity (WP), then drying that lump at 100°C, weighing it again (WD) and calculating it as follows:

$$\frac{WP-WD}{WD} \times 100 = \text{water of plasticity}$$

19. Casting qualities are determined by the effectiveness of deflocculation. Clays containing montmorillonite generally deflocculate poorly and thus have poor casting qualities. To identify the casting qualities one needs a 500 ml measure, a beaker, gram scales, an eye dropper, sodium silicate and a small plaster mold.

The procedure is the following:

Weigh out 100 g of dry screened clay and set aside. Weigh four or five batches of 25 g each. Record all amounts.

Measure 100 ml of water into container
Add 100 g of clay
Add additional clay in 25-g units till slip is
very thick
Add eight drops sodium silicate
(if slip thins at this point it may cast, if not
it will probably not cast)
Alternate additions of clay to thick state and sodium
silicate to thin state till no change occurs with
sodium silicate. Record quantities of each - this
gives the formula for that particular clay.

Most tropical clays that will cast average 175-225 g clay/100 ml H_2O/16-24 drops sodium silicate.

20. A chemical or mineralogical analysis can also be useful as an indicator of what to expect. It can confirm or reject certain physical properties.

11. However, nothing can substitute a trained observer, who is actually using the material to produce a ceramics item. The final proof, regardless of test results, is whether the particular clay works. If pots are to be made from the clay, several pots must be made by various methods, fired and glazed, only then can one be sure that the clay is suitable.