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15857

DP/ID/SER.B/534
28 July 1986

RESTRICTED

ENGLISH

ANALYSIS OF RAW MATERIALS FOR NON-METALLIC MINERAL BASED INDUSTRIES

DP/BGD/85/006

BANGLADESH

Terminal report

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

Based on the work of Henshall, Barnford and Partners, subcontractors

United Nations Industrial Development Organization
Vienna

V.86-58382
3174T

Explanatory notes

The monetary unit in Bangladesh is the taka (Tk).

References to tonnes (') are to metric tonnes.

Besides the common abbreviations, symbols and terms, the following have been used in this report:

BCIC	Bangladesh Chemical Industries Corporation
BCSIR	Bangladesh Council for Scientific and Industrial Research
BISF	Bangladesh Insulator and Sanitaryware Factory

ABSTRACT

Following a request by the Government of Bangladesh for technical assistance to the country's non-metallic minerals based industry, the project "Analysis of raw materials for the non-metallic minerals based industries" (DP/BGD/85/006) was approved in January 1985. A team of two experts, working under a subcontract, was assigned to carry out a preparatory assistance mission, starting on 28 October 1985.

The experts, who were attached to the Ministry of Industry, reviewed all relevant information and data made available by the Geological Survey of Bangladesh; evaluated existing laboratory facilities; identified the requirements of the refractory and ceramic industries to improve their production methods and product quality; assessed the market potential for refractory and ceramic products; evaluated the possibility of other industrial applications for an increased utilization of indigenous raw materials; identified the skilled manpower requirements of the industries concerned; and examined the possibility of introducing an energy-conservation programme.

They concluded that the main factor restricting the development and reducing the efficiency of the refractory and ceramic industries is a lack of well-trained staff in the areas of clay mining, materials testing, training and fuel conservation. They therefore recommend, as the most cost-effective way of obtaining significant improvements in those areas, to field a team of experts who would give advice in their respective field of specialization by means of seminars and practical workshops. The experts have elaborated a detailed draft project document to that effect.

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INTRODUCTION

A. Project background

In a meeting held early in 1984 between the Department of Industries, UNIDO and manufacturers of refractories, the possibility of developing the refractory industries was discussed. Three firms, namely Dacca Refractories Limited, Mirpur Ceramics and Calcutta Tiles, involved in the manufacture of refractories, were represented in that meeting and indicated that they were the only ones producing refractories. These representatives stated that at present a large percentage of the country's requirement for refractories is imported from abroad. They explained that one of the operational problems continuously encountered is their inability to predict the type, grade, quality and composition of the raw material which they buy from the clay deposit operated by the Government. The reason for this is that the area is not geologically classified, and that the raw materials are therefore taken from the same area which is currently being mined to fill orders of all types of users, such as brick manufacturers, refractory manufacturers and ceramics manufacturers.

It was therefore agreed that the Department of Industries, in collaboration with the Ministry of Minerals and Energy, should undertake a geological survey and laboratory tests of the clay deposits in order to classify them, to assess their suitability for the manufacture of refractories, and to recommend better methods for the mining and beneficiation of raw materials, if the latter is necessary. The possibility of establishing a laboratory within the Government to service the requirements of the manufacturers for testing their raw materials and products was also discussed.

The Department of Industries would then request UNDP/UNIDO to send a preparatory assistance mission for a period of three months to undertake the two tasks identified above, and also to visit the three manufacturing plants for refractories and submit specific recommendations on how their operations could be improved. This would enable the formulation of a proposal for technical assistance to develop the refractory industry. Finally an analysis would have to be made to estimate the potential market for refractories.

While reviewing this proposal, in order to optimize the benefit from such a mission, UNIDO suggested that while undertaking the geological survey and laboratory tests of the clay deposit, the possibility of utilizing these raw materials for other industrial applications such as production of aggregates should also be evaluated. It is already known that the demand for aggregates is increasing and the supply is coming from only one area, Sylhet.

The other important area which would be examined by the mission is energy conservation. Plant visits to major energy users such as cement, fertilizer, ceramics and steel factories, would be conducted to identify specific activities where energy savings could be achieved.

The terms of reference of the consultants fielded under the subcontract are given in annex I.

B. Official arrangements

The document for the project "Analysis of raw materials for non-metallic mineral based industries" (DP/BGD/85/006) was signed in January 1985.

The field activities started with the arrival of a team of two specialists of the subcontractor, on 26 October 1985. The Geological Survey of Bangladesh acted as the counterpart.

The input by the United Nations Development Programme (UNDP) was $US 35,500.

RECOMMENDATIONS

In each of the four areas dealt with in this report, i.e. clay mining, materials testing, training and fuel conservation, the most cost-effective way of obtaining significant improvements in the level of knowledge within the refractory and ceramic industries would be to field a team of experienced international experts, who would give advice in their respective field of specialization by means of seminars and practical workshops. The seminars and workshops should be attended by members of the educational establishments, students and the managers and technicians of the industries.

The experts should also be available for direct consultations with the industries, giving ad-hoc recommendations on ways to improve quality and to solve specific production problems.

The length of each assignment would be determined specifically by the requirements of the industry.

I. REVIEW OF GEOLOGICAL DATA AND CLAY MINING OPERATIONS

A. Existing deposits

Flood plain alluvium

These are abundant in Bangladesh, the flood plain covering several thousand square miles north of the Ganges. The alluvium consists of sand, silt and clay with sand, silt being dominant.

Deltaic alluvium

This alluvium extends over the complete area south of the Ganges to the Bay of Bengal and also consists of sand, silt and clay, with clay being the dominant component.

Both of these alluvium deposits are widely used for the manufacture of low-quality red bricks generally fired in Bull's trench kilns using wood, coal or gas as fuel.

Modhupur clay

Modhupur clay forms the low hillocks in some parts of Dacca, Mymensingh, Sylhet, Comilla and Rajshahi districts and mostly underlies a thin mantle of recent alluvium in the districts of Rangpur, Bogra and Dinajpur. These red- and yellow-coloured clays are also used occasionally for low-quality red bricks.

White clays

Sizeable deposits of white kaolinitic clay are located in the Bijaipur area, Mymensingh district and smaller deposits in various localities at the Sylhet district and Chittagong Hill Tracts near Patia.

Small deposits of white clay were also discovered in the Ambati area of Rajshahi district at depths of approximately 1,350 feet in seams varying from 14 to 39 feet in thickness. No estimate of reserves of that deposit was possible due to the insufficient number of drill holes; but its depth makes economic extraction unlikely.

By far the most important deposit of white clay for the refractory and ceramic industries is that in Bijaipur. The Geological Survey mapped the area in the period 1957-1958 and produced a detailed publication titled "Report on the white clay and ferruginous rocks of the Bijaipur area, Mymensingh district, East Pakistan" by A. B. Roy (information release no. 17, June 1960).

The Geological Survey initially worked closely with the Minerals Development Corporation, identifying two distinct grades of material and arranging clay analysis. But once commercial extraction commenced the geological survey became less involved and has carried out no further detailed work on the deposit since that period.

The deposit of white clay continues for about six and a half miles between Gopalpur and Bhedicura, two small villages four and a half miles and two miles east and west, respectively, of Bagaria. The white clay is a part of the Dihing series and is interbedded with various clay and sandstone beds generally comprising ferruginous sandstone, pebbly sandstone and yellowish-brown clay. The average total thickness of the white clay beds is 10 feet and the quantity of the white clay occurring in the hillocks above the level of the plains was estimated to be about 200,000 tonnes at the time of the survey and has recently been reassessed at 450,000 tonnes up to a depth of 150 feet down the dip. However, the true reserves can only be estimated accurately by carrying out a comprehensive drilling programme in the area.

The white clay does not occur as a single bed but as several beds of varying thicknesses interbedded with yellowish-brown clay and pebbly sandstone. The maximum thickness of a single bed is approximately seven and a half feet and the minimum thickness is ten inches, with a dip varying from 40° to 75° in the majority of the deposits.

The physical and chemical tests carried out at that time indicated that the clay was suitable for the manufacture of a good type of pottery but was not suitable for making fine-quality china.

Compared with Indian and English china clay, the plasticity of the clay is very low because of the high percentage of fine sand in the deposit i.e.:

Clay	Water of plasticity (percentage)
Mymensingh clay	20
English china clay	42
Indian china clay	36

Due to the relatively high iron content in that clay, Mymensingh clay is not a white-burning clay. On firing to 1,300 °C the colour is cream, and with a shrinkage of 8 per cent the body remaining porous. The pirometric cone value is 28, which indicates that its refractoriness is lower than that of other china clay and is unsuitable as a material for high-grade refractories.

The original chemical analyses of the deposits showed a wide variation in the composition of the clay with an R_2O_3 value varying from 17 to 40 per cent.

B. Utilization of Bijaipur clays

The Bijaipur deposits are presently being mined in several locations by:

(a) Bangladesh Chemical Industries Corporation (BCIC) utilizing the management of Bangladesh Insulator and Sanitaryware Factory (BISF);

(b) Oxydental Ltd. (two open pit mines);

(c) Tajma Ceramic Industries Ltd.;

(d) Calcutta Tiles and Refractories Industries Ltd.;

(e) Peoples Ceramic Industries Ltd.;

(f) Dacca Refractories Ltd.

In all cases the mines are being developed where the white clay is exposed in the hillocks. All mining is carried out by hand, two grades being extracted, grade one being of a lower iron content than grade two, as shown by the following recent analysis carried out by BISF.

	Grade one	Grade two
	(percentage)	
Loss on ignition	8.53	7.70
SiO_2	66.62	67.38
Al_2O_3	22.02	20.99
CaO	0.52	0.71
MgO	0.32	0.70
Fe_2O_3	0.87	1.88
TiO_2	traces	-

Grade one is used in the manufacture of porcelain tableware, sanitary ware and insulators and while this grade would also be the best clay for the refractory producers, the quantity mined is insufficient for their needs and all of the second grade therefore has to be used by the refractory industry, as this is the only material available to them. Small amounts of the second grade are also used in the production of floor pavers.

C. Beneficiation of Bijaipur clays

Much work has been carried out in regard to the possibilities of beneficiating this clay by washing and magneting to remove the silica sand and iron oxide contaminants from the material, and a washing plant was actually built in the mine area. This plant never proved successful because much of the silica is of a very fine particle size (down to 2 micron) and could not be separated from the clay particles, which are of similar size. Similarly it was found that although the free iron oxide could be removed by a magnetic separator, the clay still contained chemically combined iron which cannot be removed by that process, hence this semi-beneficiated clay, although much more expensive than the raw clay, still was not suitable for high-quality porcelain tableware.

The manufacturers of the medium-quality tableware for the domestic market prefer to utilize the raw clay and, depending on the precise quality received at factory, adjust the body composition to maximize the use of the local material, while maintaining the fired body colour to an acceptable degree of whiteness for their particular price range of product.

Typical body compositions for this type of porcelain have been:

	I	II
	(percentage)	
Bijaipur clay	28	32
China clay (Indian)	16	14
Ball clay (Indian)	6	-
Ball clay (United Kingdom)	4	9
Feldspar (Sylhet)	23	23
Quartz (Sylhet)	16	14
Biscuit Body	7	8

Manufacturers of slightly higher quality ware, who have control of their own mine do carry out repeated washing and magneting at the factory to reduce the iron oxide content from in excess of 1 to 0.34 per cent, the majority of which is within the clay structure. The company has not considered installing any chemical treatment due to the high capital cost and subsequent high running costs involved. The policy is to utilize the maximum quantity of local raw materials, recognizing that the quality may be slightly inferior to the international standard and to supply products to all sectors of the local market at a reasonable cost.

In the manufacture of sanitary ware, the thixotropic nature of the Bijaipur clay limits its use to 15-20 per cent of the body composition which is typically:

	Percentage
Bijaipur clay	15
Feldspar (Sylhet)	44
Ball clay (Indian black)	8
Ball clay (Indian white)	4
China clay (Indian)	25
China clay (United Kingdom)	4
	100

The fired rejects are 4 per cent of total raw materials.

In the body composition for insulators the silica content of the Bijaipur clay reduces the need for a quartz addition to the body and therefore is no detriment to the product. As a refined clay would be more costly and additional quartz would also be required, there is no technical or economic reason for adding a refined clay to this body composition.

For the production of refractories, which are a relatively low-priced product, the benefits gained by removing the coarse fractions of sand within the clay would be more than outweighed by the additional costs of the clay, except for a small number of relatively high-quality products which are manufactured by a factory already possessing its own washing facilities.

Within all of the existing industries, therefore, there is virtually no product which would benefit to a significant degree by using an expensive semi-beneficiated clay.

D. Existing mining operations at Bijaipur

The oldest and largest developed mine is that operated by BCIC, and the main working section is now 70 feet below the surface of two plains having commenced in the outcropping in a 30 feet high hillock. In this location the dip of the clay bearing strata is approximately 70-75° and the present method of exploitation is to work horizontally through the clay and sandstone, which results in excessive amounts of overburden and sandstone being removed in comparison with the cross-section of clay. The first quality clay, containing the lowest iron oxide content, is found beneath the second, lower-quality clay, and the difference between the two is clearly discernible.

As no detailed geological survey of the area has been carried out with a comprehensive drilling programme, it is difficult to establish with any degree of certainty the areas containing the largest deposits of the better-quality clay, which can be most economically worked. The present method relies more on the intuitive guesswork of the mine manager than on any sure knowledge.

In situ the clay is very hard and difficult to break, and although facilities do exist at BCIC's mine for using jack hammers, the compressor is out of order due to a lack of spare parts. Hand-winning with pick and shovel is the only alternative and is the method used in all mines in the area.

Other possible methods of winning the clay, such as the high-pressure water blast method or the more expensive shaft mining system, could only be considered once the complete characteristics of the deposit and reserves have been accurately identified and this can only be achieved by a properly organized drilling programme. Within this project the Geological Survey of Bangladesh who have all required machines and personnel, will undertake this programme in conjunction with an expatriate mining engineer.

E. Accessibility of the Bijaipur clay deposits

Accessibility to the clay deposits is extremely difficult. Bijaipur is 16 miles north of Jaria Jhanjail, a railway terminus linked directly with Mymensingh junction. The distance on rail from Dacca to Jaria-Jhanjail is 116 miles. The clay deposits can be reached from the Jaria-Jhanjail terminus only in the dry season, partly by four-wheel drive vehicles, and the last few miles by bullock cart, small motorcycle or by foot through rice fields.

During the rainy season which lasts from June to October, large country boats can travel to Bijaipur along the Someswari river to within a few miles of the mine sites and the mines must utilize that period to move as much clay as possible to the railhead. During the dry season only small country boats can travel to Bijaipur and these are sometimes used to transport clay to Jaria, although this is considerably more expensive.

To ensure the maximum production during the dry season and the maximum deliveries during the wet season therefore requires good mine management in regard to clay extraction, clay stockpiling, pumping operations and maintenance of equipment. Good organization of delivery schedules to meet the requirements of customers is also necessary, as any shortfall in output or deliveries has to be met by an increased level of imports into the country.

The current level of output of 4,116 tonnes per year is insufficient for the needs of the country, and should be increased to a level of 8,000-10,000 tonnes per year based on current needs and planned expansions in production capacity within the refractory and ceramic industries. In order to achieve this target this project provides for an expatriate clay mining advisor to reorganize the present mining operations to increase the efficiency of all mines in the area. The adviser will formulate a detailed mining plan, based on the information from the drilling survey to be carried out by the Geological Survey, to enable the mines to increase their recovery of good-quality clays for the industry. Part of this plan will include an assessment of both the practicality and economic benefit of utilizing a low-cost light-weight overhead cableway system to transport clay from the mine stockpiles to the river to overcome the serious transportation difficulties in this region.

F. Production of china clay from Bijaipur

Period	Quantity (tonnes)	Value (thousand taka)
1976/77	4 186	1 145
1977/78	5 870	1 404
1978/79	7 422	1 775
1979/80	10 442	5 755
1980/81	9 982	5 443
1981/82	5 862	3 196
1982/83	2 269	1 275
1983/84	2 613	1 435
1984/85	4 116	6 124

II. EVALUATION OF EXISTING LABORATORY FACILITIES

Laboratory facilities relating to the refractory and ceramic products industries exist within government organizations at the Bangladesh Institute of Glass and Ceramics, at the Geological Department of Dacca University and at the Bangladesh Council for Scientific and Industrial Research (BCSIR).

The laboratory at Dacca University has full facilities and trained people for carrying out the chemical analysis of raw materials and works closely with the Geological Survey of Bangladesh in the evaluation of these materials, although in recent years the amount of work specifically related to the refractory and ceramic industries has been rather limited.

At BCSIR the work is primarily of a reseerch nature and while it has all the facilities to carry out the chemical testing of raw materials and occasionally carries out these tests, the policy of BCSIR is not to become too involved with the specific production problems of the refractory and ceramic industries.

By far the most important facilities exist at the Bangladesh Institute of Glass and Ceramics, but these are currently not being utilized fully due to a lack of trained personnel and qualified teachers and a reluctance of the refractory and ceramics industries to properly support the Institute.

Manufacturers of refractories, tableware and heavy-clay products therefore still rely on overseas testing laboratories for most of their raw material testing. The Institute has complete facilities for both the chemical and physical testing of refractories, including refractoriness-under-load, cold crushing strength and reversible thermal expansion machines. A full range of kilns is available, some of which require minor repairs such as replacement of elements.

Facilities for the testing and development of ceramics are also commplete, including all necessary equipment for the production of porcelain and earthenware bodies, casting slips and glazes.

Within the Institute is a complete ceramic production plant including all grinding equipment, mixers, extruders, presses, pottery machines, dryers and kilns suitable for all types of ceramics. Extensive mould-making facilities are also available in that production plant.

Much of the equipment was supplied under the Colombo Plan when the Institute was first established in 1951 and more laboratory equipment has since been supplied under UNDP projects.

Although that production facility is ideal for providing practical training for students from the refractory and ceramics industries, it is used infrequently due to a lack of trained staff. Similarly the fully equipped laboratories are also underutilized with much of the equipment having never been used since delivery.

However, it is this Institute which should have the greatest potential for satisfying the needs of the industry in terms of training technicians, supervisors and senior managerial staff, offering consultancy services on specific factory problems and in the development of new products, body compositions and glazes. If the Institute could act as the focal point for the refractory, ceramic and glass industries, in full partnership and collaboration with all companies within these industries, it would become a more effective organization in developing these industries.

The Institute offers two courses for the industry, a one-year artisan course in ceramics technology for new entrants to the industry which is presently suspended due to lack of staff, and a three-year diploma course in glass and ceramics technology for entrants at the supervisory level, which is presently being taught by junior instructors of diploma level. A total of 45 students are enrolled in the three classes of that diploma course.

The shortage of professional staff at Dacca University and the Glass and Ceramics Institute, and the lack of training of some of the existing staff in the use of certain testing equipment requires that this project provide the necessary expertise to broaden the technical knowledge of these staff. This will be achieved by providing training workshops and seminars in all forms of chemical and physical testing. These workshops will be based at Dacca University, Geological Department, but will utilize equipment both at the University itself and also at the Institute, dependent on the requirements of the workshop.

To add to the quality of existing refractory and ceramic courses and to improve the consultancy service which can be offered by the University, this project provides for short-term courses of an intensive nature, which will be given by expatriate advisors, expert in their particular industry i.e. refractories, ceramics, clay mining and combustion engineering. These courses will be industry-biased so that they can offer immediate assistance in solving technical problems occurring in local factories, while at the same time they will offer up-to-date knowledge of modern production techniques.

It should be noted that in addition to the three aforementioned government laboratories, a modern laboratory, supplied with all the latest testing equipment by UNIDO, is established at the Bangladesh Insulator and Sanitaryware Factory (BISF) and is fully equipped to carry out the full range of tests required for the sanitary ware, insulator and tableware industries. As the BISF factory is operated by BCIC, a government corporation, these testing facilities could also be utilized by industry in co-operation with Dacca University.

III. IDENTIFICATION OF THE REQUIREMENTS OF THE REFRACTORY AND CERAMIC INDUSTRIES TO IMPROVE PRODUCTION METHODS AND PRODUCT QUALITY

A. Refractory industry

The refractory industry of Bangladesh consists of three firms with the following approximate production capacities:

Dacca Refractories Ltd.	8 000-9 000 t/year
Mirpur Ceramics Works Ltd.	1 500 t/year
Calcutta Tile and Refractories Industries Ltd.	1 000-1 500 t/year

Two other companies, Savar Refractories Ltd. and Conforce Ltd., are in the process of erecting small plants. Both Mirpur Ceramics Works Ltd. and Conforce operate much larger works producing building bricks.

The bulk of the refractories produced fall under the classification of low-alumina or fire-clay grades and are manufactured from Bijaipur and imported clays to which a varying proportion of grog (chamotte) is added. Bricks and shapes are moulded by hand or using light friction or screw presses. Both soft-mud and stiff-plastic processes are employed depending upon the shape being manufactured.

With only slight modification the process of manufacture involves grinding the clay, adding a quantity of ground grog, mixing with water and then extruding a column which is cut into suitably sized clots. Generally the clay and grog are wetted down and allowed to age on a soaking floor before being extruded. The clots are then used directly for hand moulding or placed on the floor or in racks to allow them to dry back into a suitable condition for pressing. Once moulded, the material is similarly dried on the floor or in racks before being set in the kilns. Burning is carried out in small batch kilns of the down-draft type, burning natural gas through simple inspirator burners. Occasionally a Hoffmann kiln is being employed and at one works there was a shuttle kiln using forced draft burners. The firing temperature varies between 1,200 and 1,350 °C with a temperature limit of 1,400 °C being imposed by the kiln brickwork. Measurement of temperature is by means of Seger cones and sometimes pyrometer.

Not unexpectedly it was found that manual labour was employed to a far greater extent than in European plants producing similar products. The works which were visited varied widely in their approach to manufacture and consequently there were considerable differences in the quality of material produced. Poor products showed a lack of uniformity in terms of shape, finished dimensions, degree of firing and composition.

Apart from indigenous Bijaipur clay other imported clays were being used and additions of high-alumina material, chiefly in the form of calcined bauxite, were employed to increase the overall refractoriness of the products when this was required. Where a works laboratory existed the equipment and skills necessary for its use were limited. One works could carry out the determination of refractoriness and two works had small high-temperature kilns. None of the facilities were employed on a routine basis and testing, when required, was obtained elsewhere. With the exception of one staff member who had a degree in ceramics, management lacked any theoretical training in the production of refractories. However, all were conscious of the fact and fully aware that such knowledge was necessary and must be acquired if high-quality materials are to be produced. It was felt that, given the present facilities, production improvements and therefore ultimate quality, could be achieved by paying more attention to the following:

(a) Control the incoming raw materials by means of simple tests which need not be quantitative;

(b) Control the batch on a routine basis;

(c) Use dry-press methods for standard sizes in order to improve the shape and produce a more uniform body;

(d) From the previous raw material and batch control procedures instigate the use of optimum firing temperatures for each product;

(e) Apply simple control systems, including final inspection to an agreed standard, to all finished products.

It must be appreciated that the Bijaipur clay is of relatively low alumina content and there are obvious limitations to its use as a refractory raw material. Management at all the works expressed a desire to have a reliable source of clay supply of constant composition. Indeed one works had installed a cascade system for washing the clay although it had seldom been used. There was a general belief that improved quality results from increasing the alumina content of the batch and to a certain extent this is true. However, although the refractoriness of the batch may be modified and the SK (Seger cone expressing refractoriness) value increased, there is a considerable difference shown in certain other properties. Bricks made from materials such as flint-clay, andalusite or mullite, to name some high-alumina minerals, possess much better hot strength and exhibit lower shrinkage in use than bauxite-doped clay bricks having equivalent alumina content. Some improvement could also be made to the existing products, including those with calcined bauxite additions, by relating the firing temperature more closely to the properties required for a specific application, e.g. thermal shock, density etc. The production of certain high-alumina grades from natural materials would be restricted by the firing temperature which is attainable with the existing kilns. Also the necessary burners required to produce higher temperatures employ forced draft which demands a steady power supply.

At one works attempts had been made to utilize the waste heat from the kiln for drying purposes. Apart from this, energy conservation was not practiced although the benefits to be gained were broadly appreciated. There was a shortage of instruments for measuring the energy consumed and monitoring the different stages of the process. Kiln design, especially with regard to insulation as a means of reducing fuel consumption, and burner design to obtain efficient combustion, are two areas which could after further study produce energy savings.

To summarize, quality could be improved by applying more technical controls to the production process. This requires that suitably trained staff are available and that management has the facility to obtain assistance from a reliable national source when necessary.

Future development of the refractory industry in Bangladesh

The present demand for high-grade refractories is given in chapter IV. Sometime in the future, depending on the rate of growth of the user industries, the demand for these qualities can be expected to increase. The future demand for low-alumina refractories is expected to remain static or even show a decline. The manufacture of high-grade refractories, to comply with international standards of quality, requires sophisticated plant and considerable technical expertise. Neither are currently available in Bangladesh.

B. Ceramic industry

The ceramic industry, consisting of the tableware, sanitary ware, insulator and heavy-clay sectors, has a number of common problems, which are seriously affecting the quality of their production.

Apart from few exceptions, the general level of housekeeping in all factories is extremely poor. Tableware manufacturers are downgrading much ware because of glaze defects resulting from poor housekeeping in the biscuit storage areas and glazing departments. Similarly glaze defects in sanitary ware can be attributed to poor housekeeping and ineffective cleaning of the ware prior to glazing. To prevent needless losses of that type, management must ensure that all areas are cleaned thoroughly on a daily basis.

As in the refractory industry, the management of all factories, except those leasing their own mine, expressed serious concern about the quality of clays from Bijaipur which was stated to vary from one shipment to the next thus necessitating constant changes in body composition and causing production problems for the factories. Clay shipments were stated to be erratic and insufficient for the requirements of the industry, the shortfall having to be met by imported clays from India and Europe.

Testing of raw materials for the smaller factories appears to be a problem due to the lack of trained personnel both within the factories and at the government testing laboratories. While the larger factories have their own testing facilities they all expressed a desire for an improved consultancy service to be provided by the government laboratories to reduce their dependence on overseas laboratories.

Kiln insulation appears inadequate in all factories, including plants with new facilities. Insulation of kiln walls is particularly poor and this is one area where large fuel saving may be achieved. Other areas causing fuel inefficiency are in the use of imported saggers and in some cases of locally made saggers to support the ware in the kiln. The locally made saggers are particularly thick and heavy in order to achieve sufficient mechanical strength but this results in an extremely low weight ratio (product to kiln furniture) and hence a high fuel consumption per kilogramme of fired ware. With gas firing, using properly designed burners, profiled biscuit setters, either ring or solid type, manufactured to high-quality standards and with a much thinner cross-section, the fuel consumption in the kiln can be substantially reduced. The life of such setters is much longer than that of low-strength saggers and the large savings both in fuel and sagger replacement costs justify the initially higher purchase price for setters.

One company which had previously used furnace-oil burners converted to gas, but decided not to purchase new gas burners solely because of price considerations. Following the conversion losses of ware in the kiln increased because it was not possible to control the burners properly due to a deficiency of air. In addition, the complete lack of any instrumentation or thermocouples in the kiln caused difficulties in assessing the correct temperatures and this also led to inefficiencies in the utilization of fuel.

A similar situation exists in the sanitary-ware industry where locally constructed shuttle kilns are poorly insulated and no attempts are made to utilize waste heat from the kilns for drying purposes, which could substantially reduce fuel costs for relatively small amounts of capital expenditure. No temperature control exists for the mould dryers or the ware dryers and as no checks are carried out on the moisture content of ware entering the kiln, residual moisture could probably be one cause of the extremely high firing losses in that factory.

Since the body composition was changed some years ago, the output of first-quality ware has dropped from over 80 per cent to less than 10 per cent, and all efforts to correct the situation have failed.

The lack of well-trained personnel at the University and the Institute of Glass and Ceramics, and the inability of the factory to seek assistance from overseas due to financial constraints were stated to be the main factors in being totally unsuccessfull in solving these production problems.

Serious problems have also been encountered with the design of moulds for western-type water closets and with their production. All attempts to solve these problems have so far failed, again because of lack of expertise within the country.

Within the red-brick industry the quality of the product is generally poor and with very few exceptions the bricks are of varying sizes, are underfired and there is little or no attempt to establish some form of quality control. In most of the few Hoffmann-kiln plants existing in the country, control of the firing is very poor resulting in high top temperatures, low bottom temperatures, and in almost every chamber of some factories the ware collapses during the firing cycle. Very little or no instrumentation is used for the kilns, leading to serious inefficiencies in fuel consumption; but manufacturers generally appear complacent about these inefficiencies and are reluctant to invest in modern instrumentation, control and safety equipment.

Therefore, similarly to the refractory industry, the ceramic industry could also improve quality significantly by applying more technical controls to the production processes, by having suitably trained people at the factory and by having the facility of obtaining assistance from a reliable government laboratory when necessary.

IV. DOMESTIC MARKET POTENTIAL FOR THE REFRACTORY AND CERAMIC INDUSTRIES

A. Domestic market potential for refractory products

Together, the three main producers of refractories in Bangladesh have an installed capacity of approximately 10,000-12,000 t/year. When a significant proportion of the output is in the form of hollow-ware for the casting of steel, the tonnage becomes less relevant. The products are chiefly low-alumina firebricks produced from the local Bijaipur clay and bricks of higher alumina content made from imported clays or by local clays with added bauxite.

The import figures for refractories, as supplied by the Department of Industries, do not give a complete breakdown into the different qualities but only into broad groups. The figures were also found to fluctuate widely and, although the average imports taken over the last seven years amount to 20,000 t/year, the spread, during the same period, was considerable. This is in all probability due to the influence of capital projects which have been completed at different times. A more realistic figure for the imported refractories which are required solely for maintenance and day-by-day operation would be about half of this, i.e. 10,000 t/year.

Most of the imported refractories are high-alumina, basic or silica qualities which cannot be manufactured in Bangladesh at present because the necessary brick-making plant is not available. In addition to the above qualities, small tonnages of cements, castables and monolithic refractories, together with insulating bricks and specials such as crucibles and saggers, also have to be imported.

The following are the principal industries which use refractories.

Iron and steel industry

This industry is the largest user and as such will account for some 60-70 per cent of all refractories consumed. Chittagong Steel Mills Limited has over 95 per cent of the steel ingot capacity in Bangladesh and is therefore the largest single user of refractories in the country. The steelworks at Chittagong has a rated capacity of 250,000 ingot tonnes, but there would appear to be insufficient room in the casting bay to achieve that tonnage. In view of this, and taking into account actual furnace availability, a more realistic capacity seems to be 150,000 ingot tonnes.

Steelmaking facilities requiring refractories are:

(a) Open-hearth furnaces. There are four, each with a capacity of 60 t, cold charged and with oxygen assistance, with a tap-to-tap time of about 8 hours. The roof, side walls, end walls, uptakes and hearth are all made of basic refractories. The qualities vary, with magnesite for the hearth, metal clad internally, plated magnesite chrome for the side walls, metal-clad chrome magnesite for the roof and a chrome brick in the launders. The working hearth is of grain magnesite, fettled with dolomite which is calcined at the works. The top courses of the regenerators are of forsterite above medium/high alumina firebricks. A recent change to natural gas firing has caused increased wear on the ends and as a result the forsterite or high alumina in the regenerators will be extended for future campaigns;

(b) Electric-arc furnaces. In the foundry there is a small electric-arc furnace and a cupola. Four or five similar electric-arc furnaces are located elsewhere in the country. All require high-grade basic and high-alumina refractories for their operation. There was some mention of a sponge-iron plant being installed in which case steelmaking would probably be carried out in large electric-arc furnaces. This would increase the demand for basic and high-alumina refractories;

(c) Mill furnaces. These comprise: pusher-type triple-zone reheating furnaces, a billet reheating furnace, a sheet-bar reheating furnace and a normalizing furnace. Once installed, reheating furnaces should only require maintenance to be carried out annually apart from perhaps minor hearth repairs. The demand for refractories is not large and will include low-alumina, medium-alumina and high-alumina qualities. For the calcining of lime and dolomite there are three-shaft furnaces and a rotary kiln. All require high-grade refractories, although the quantity on an annual basis is small;

(d) Casting-pit refractories. At present this constitutes the main application for the local products, in the form of ladle lining and uphill casting ware. Ladle lives were said to be variable and for this application it is desirable to have dense, well-shaped uniformly fired bricks. The quality of the jointing cement is also very important. Without these properties the ladle performance is likely to be poor and there is some possible danger to the operators since breakouts become more frequent. A similar importance must be attached to the quality of stopper rod sleeves, stoppers, and the guides, trumpets and runners employed in uphill casting. With poor materials in these areas there is a possibility of non-metallic inclusions and consequently higher rejection of finished steel. Future development at Chittagong Steel Mills may include a changeover to continuous casting in order to relieve the load on the existing casting bay. Should this occur there will be a reduction in the demand for low-alumina refractories and a greater demand for high-alumina materials and special qualities for slide grates and nozzles. Steelmaking applications demand that the quality of the refractories of every type used must be accurately specified if the best conversion costs are to be obtained. Quality control of incoming materials is of paramount importance and it is recommended that materials are always purchased on the basis of technical merit rather than price. Apart from physical and chemical properties this includes that materials are well packed and protected against deterioration when stored.

Cement industry

The annual production of cement in Bangladesh has varied between 157,000 and 345,000 t since 1945. A provisional figure for 1984 is 24,000 t of which more than half will be produced by grinding imported cement clinker. There are two rotary kilns presently operating at Chhatak, an F. L. Smidth kiln of 3.5 m diameter and one very old smaller Polysius kiln. Both are lined with high-alumina refractories in the burning zone and with lower-alumina grades in the transition, charging and discharge zones. A trial with castable is to be made shortly. Two new factories are proposed, located at Surma and Joypurhat, each having two kilns of an unknown diameter. An alternative and more common lining in the burning zone of rotary cement kilns is basic material. Uniform properties and accuracy of size are essential if economic lives are to be achieved.

Assuming that the new kilns will have a capacity of 100,000 t cement each, the total demand for refractories for this industry is estimated to be 750-800 t/year.

Glass industry

The glass industry requires a relatively small quantity of refractories, for under normal operating conditions repairs to the furnace are only needed every few years. The bulk of the refractories could be classed as specials of high quality. Silica bricks are used to build the roof, upper walls and arches. Fusion-cast refractories are used for the bath and melting channels and the regenerator filling may be high alumina or basic with low-alumina firebricks for the bottom courses. At Osmani Glass there are two tanks. Here too, following the changeover to natural gas firing, increased wear was occurring leading to an upgrading of materials in certain sections of the furnaces.

Power generation

Steam generating plants rely heavily upon castable and insulating refractories. However, the annual tonnage requirement is comparatively small since repairs need to be undertaken only every two or three years.

Chemical industries

These include sugar and fertilizer factories and papermills. Refractories are employed in comparatively small amounts but tend to be of a special nature in the form of castables, cements and individually shaped products. At the plants visited there was considerable scope for the application of insulating materials of all types.

Ceramic industries

Here refractories are required for the repair of kilns, and, where employed, of kiln cars and kiln furniture. The demand is low, but the qualities needed tend to be of a special type and high grades are necessary when temperatures exceed 1,200-1,300 °C. At all the works visited there was again scope for the wider use of insulation.

Capital projects

These are usually tied in with guarantees with respect to plant performance, especially when the plant comes from overseas. Therefore, until the commissioning period is over, all refractories have to be imported.

Demand forecast

The following forecast is made on the basis of information obtained during the assignment. It should be treated with reserve and with due regard to the accompanying text.

The estimate is based on an assumed steel output of 150,000 t.

	Possible annual demand (tonnes)
Low-alumina firebricks	10 000
Medium/high-alumina firebricks	3 000
High-alumina firebricks	2 500
Basic chrome-magnesite roof-quality bricks	1 200
Basic brick, other types including magnesite	2 400
Basic ramming material	300-400

With the exception of the magnesite and forsterite types which are burned, all the other basic bricks are metal clad, with metal inserts and chemically bonded.

Included in the figures for aluminosilicates there will be sufficient equivalent grade cement.

Other refractories for which a demand is expected, but of smaller amounts:

	Demand
Refractory castables	Steady
Low-temperature insulation	Increasing
High-temperature insulation	Increasing
Specials, crucibles, kiln furniture burner blocks etc.	Steady/increasing

A note on quality

It was found that many of the refractories were specified in terms of SK value (Seger cone) without reference to other properties. This can be most misleading and the need for a complete specification should be understood.

B. Domestic market potential for porcelain and ceramic tableware

Up to 1984 the demand for porcelain tableware in Bangladesh was met by three major producers, whose products catered to all sectors of the market except for the extremely high-quality products, which had to be imported. Their production capacity and output are shown in table 1.

The most recent production statistics supplied by the Department of Industries indicate that the demand is still increasing.

Table 1. Production capacity for and output of porcelain tableware (In tonnes)

Company	Annual rated capacity	Average annual production, 1980-1983	Actual production, 1983/84
Peoples Ceramic Industries Ltd.	2 850	1 862	2 890
Tajma Ceramic Industries Ltd.	1 200	520	530
National Ceramic Industries Ltd.	450	315	500
Total	4 500	2 697	3 920

In addition to the major companies, small quantities of low-grade porcelain ware, such as teacups, teapots, plates and salt jars are made by Imperial Pottery Works, Dacca Refractories and Bangladesh Pottery Industries Limited and earthenware such as curry cups, plates, teacups and teapots is manufactured by Bengal Ceramic Industries Limited. The relevant data are given in table 2.

Table 2. Production capacity for and output of low-grade porcelain ware and earthenware (In tonnes)

Company	Annual rated capacity	Average annual production, 1980-1983	Actual production, 1983/84
Imperial Pottery Works	600	27	28
Dacca Refractories	n.a.	n.a.	20
Bengal Ceramic Industries Ltd.	1 200	260	265
Total	1 800	287	313

Generally imports of porcelain tableware have declined substantially, as the quality of the local products has steadily improved, and high duties and import restrictions have protected the local industry. In 1981/82 the importation of 1,501 extremely high-quality and expensive dinner sets distorted the value of the imports in that particular year.

Year	Thousand taka
1979/80	762
1980/81	460
1981/82	1 349
1982/83	139
1983/84	13
1984/85 (July/May)	50

Early in 1985 a new porcelain tableware factory, operated by Monno Ceramic Industries Limited, with a rated capacity of 4,200 t was commissioned and is expected to produce approximately 2,500 t of high-quality ware during 1985, based solely on imported raw materials.

The importation of tableware into the country has now been banned except for small quantities of personal or diplomatic imports, and it is hoped that some exports of high-quality ware can be achieved during 1986.

Even with the added capacity of the new factory the general opinion of all manufacturers is that the demand for tableware, especially that for medium-quality ware, is far greater than the production capacity of the country and at least one other manufacturer is planning to double production during 1985/86.

In addition, a new stoneware factory built by Bengal Fine Ceramics Limited will be commissioned during early 1986.

A study carried out by BCIC estimated the demand for tableware to be in excess of 12,000 t basing their estimates on the following assumptions, which they believe to be realistic (see also table 3):

(a) Approximately 70 per cent of urban households use 25 pieces of porcelain and ceramic ware of different types weighing a total of 25 lb on average;

Table 3. Estimated local demand for tableware

Year	Number of households (in thousands)				Demand (tonnes)			
	Total		Using tableware					
	Urban	Rural	70% of urban	10% of rural	Urban	Rural	Others	Total
1980/81	1 411	14 038	988	1 404	6 616	3 761	1 038	11 415
1981/82	1 450	14 431	1 015	1 443	6 797	3 865	1 066	11 728
1982/83	1 491	14 835	1 044	1 484	6 991	3 975	1 077	12 063
1983/84	1 533	15 250	1 075	1 525	7 185	4 085	1 127	12 397
1984/85	1 576	15 677	1 103	1 568	7 386	4 200	1 159	12 445

(b) Approximately 10 per cent of the rural households use 12 pieces of porcelain and ceramic ware of different types weighing a total of 6 lb on average;

(c) Consumption by hotels and restaurants amounts to approximately 10 per cent of the total requirement of urban and rural households.

During 1984/85 the actual production within the country should increase to approximately 6,700 t and in 1985/86 to over 8,000 t, if there is no delay on planned expansions within the industry. The general opinion of manufacturers is that the BCIC estimates of the demand is overstated to some extent under present economic conditions, but that the tastes and habits of the people are changing, especially in the larger village areas, where a substantial increase in the use of porcelain is observed.

The current prices for one set of 12 cups and 12 saucers are indicated below.

Type of tableware	Price (Taka)	
Low-quality earthenware or porcelain	50	(no excise duty)
Medium-quality porcelain	159	(including 30% excise duty)
Medium- to high-quality porcelain	200	(including 30% excise duty)
Export-quality porcelain	200	upwards (including 30% excise duty)

C. Market potential for sanitary ware

No imports of sanitary ware such as wash basins and water closet pans have been allowed since 1979/80, and the total domestic market demand is met by two manufacturers, Bangladesh Insulator and Sanitaryware Factory (BISF) and Dacca Ceramics and Sanitaryware Limited, whose total installed capacity is far in excess of the current demand (see table 4).

Table 4. Production capacity for and output of sanitary ware
(In tonnes)

Company	Installed capacity	Actual production, 1983/84	Estimated production, 1985
BISF	4 000	1 317	1 400
Dacca Ceramics and Sanitaryware Ltd.	1 800	341	500
Total	5 800	1 658	1 900

At the current levels of output it is becoming increasingly difficult to sell all of the production, as most of the distributors in the city areas appear to be fully stocked and the factory stocks are almost filled. The expectation is that production may have to be reduced slightly in the near future. The manufacturers believe that, unless there is substantial additional investment in new housing construction and institutional buildings, the demand for sanitary ware will remain at a level of approximately 1,500-1,900 t/year, despite the rising population. Sanitary ware in the rural areas is still quite rare due to its relatively high cost and the low rate of permanent buildings in these areas. Early market studies carried out before the construction of the BISF plant estimated the annual demand to be in excess of 5,000 t/year by 1980, but these estimates proved to be too optimistic as planned building was frequently delayed or reduced due to changing economic conditions.

In the urban areas there is a strong demand for western closets of various colours, while in the smaller communities the eastern type pan is still prevalent and is expected to remain in use. Because of this stronger demand for western-style closets Dacca Ceramics and Sanitaryware Limited is planning to diversify its product range to include these items.

D. Market potential for insulators

At present only a small number of special high-tension insulators are being imported, the latest available statistics being:

Year	Weight (Kg)	Value (Thousand taka)
1979/80	1 521	119 728
1980/81	nil	-
1981/82	12 137	846 590

The total requirements of the country for both, high- and low-tension insulators, are otherwise met by BISF, apart from a very small quantity of low-tension insulators produced by Imperial Pottery Works. For details see table 5.

Table 5. Production capacity for and output of insulators
(In tonnes)

Company	Installed capacity	Actual production, 1983/84	Estimated production, 1985
BISF	2 400	341	950
Imperial Pottery Works	10	9	9
Total	2 410	350	959

The demand is currently limited by the production of transformers within the country and expectations are that the demand will not exceed the current 950 t/year for some considerable time.

E. Market potential for building bricks

Numerous small brick-fields throughout the country supply low-quality hand-made bricks for general building purposes and also as a major base material for aggregate production.

In and around Dacca city there are approximately 400 brick-fields and a further 800 elsewhere in the country. The production capacity of a single unit varies from approximately 160,000 up to 60,000 bricks per season, in some cases equating to a total brick production in these Bull's trench-type kilns of a minimum 192 million bricks per year.

Four extruded-brick factories utilizing Hoffmann-type kilns produce a further 50 million bricks per year, therefore the total annual production of the country is a minimum of 240 million bricks.

As there is no production reporting procedure for the brick-fields, obtaining accurate production statistics is virtually impossible. Production varies tremendously dependent on local demand and prevailing weather conditions.

Natural gas is currently supplied to 104 brick-fields located in the Dacca area and, although the Government is discouraging the use of wood for firing bricks because of the serious problem of deforestation in recent years, it is still commonly used in the Chittagong area and many rural areas. Imported coal is still used in some areas, although the high price of $US 80 per tonne tends to discourage its utilization.

Only one factory in the entire country is manufacturing products of a quality high enough to be acceptable to be used as a facing brick in structural brick buildings, i.e. buildings in which the bricks are employed as load-bearing materials, not merely as an in-fill material between reinforced concrete frames. If more bricks of that standard could be produced in the country, specifically for load-bearing construction, the cost of housing could be reduced by eliminating much of the concrete and steel reinforcing necessary in framed structures, and would also reduce the amount of cement presently imported into the country, thus saving valuable foreign exchange.

Brick-built structures are aesthetically more pleasing in the environment, and require far less maintenance than concrete structures. By utilizing more of the cheaper indigenous red clays, which are abundant in this country, the production of such bricks would aid the economy of Bangladesh and improve the quality of the urban environment.

Current prices of field-burnt bricks are approximately 1.5-1.6 taka per piece, while prices of good-quality facing bricks can yield 1.9-2.6 taka per piece, depending on the standard required. This price difference would indicate that, close to urban centres, investment in new machines and better quality control would be justified.

V. OTHER INDUSTRIAL APPLICATIONS FOR THE INCREASED UTILIZATION OF RAW MATERIAL RESOURCES AVAILABLE IN THE COUNTRY

A. Aggregates

Throughout the country there is an extreme shortage of suitable materials for the production of aggregates which are used for road building and reinforced concrete in most construction work.

Stone, washed down from India into Sylhet during each annual monsoon period, is collected from the river courses and transported to all major towns, where it is broken by hand into blocks of various sizes. This material is very expensive; in Dacca, 100 ft^3 of hard stone cost 7,500 to 8,000 taka, and soft stone approximately 6,000 taka.

By far the most common aggregate is broken brick chips and a high proportion of the field-burnt bricks is converted into aggregate by hand breaking. As the majority of bricks are underfired with high porosity and low strength, this type of aggregate, although much cheaper than stone (1,400 taka for 100 ft^3), gives inferior concrete and roads built with that material quickly collapse and require constant repair.

However, a review of existing geological information shows that the country has virtually no alternative material with few reserves of stone formations from which hard aggregates could be obtained. All major accessible rock structures are found in India, close to the Bangladesh border. However, five holes drilled by the Geological Survey in the Modhyapara area of Dinajpur proved the existence of inexhaustible reserves of hard igneous rock at about 500 feet below the surface. The rocks are of excellent quality for all construction purposes.

The principal source of gravel in the country is Bholagana in Sylhet. Other smaller sources are Telulia in Dinajpur and Patysam of Rangpur. The reserves have been estimated at 180 million ft^3 with replenishment by floods. In 1976, the United States Department of the Interior Geological Survey produced a report entitled "Lightweight aggregate production from claystone and shale in Bangladesh", which suggests that the production of lightweight aggregate is feasible since bloating clays have been found near Dacca. However, further studies and a pilot plant would be necessary to evaluate the scheme fully. The market for such aggregates is presently very small, as alternative lightweight walling blocks or flooring systems are already manufactured locally by Mirpur Ceramic Works Limited, which meet all current requirements.

B. Floor tiles

No floor tiles are presently manufactured in Bangladesh although the Bangladesh Insulator and Sanitaryware Factory intends to recommence trial production of both floor and wall tiles in 1986. However, these tiles are not intended for highly frequented pedestrian areas such as shopping areas, airports, bus stations etc. The second-grade Bijaipur clay would be a suitable material as the major constituent for a floor tile, produced either as a split tile or as an extruded punched tile. Depending on the body composition split tiles could be salt-glazed, spray-glazed or produced as an unglazed quarry tile. Punched tiles could be produced unglazed or spray-glazed.

It should be noted that the market for floor tiles is very small in Bangladesh and any proposed production facility should be carefully designed to operate economically at low levels of output.

C. Field drainage tiles

Although large areas of high-quality agricultural land are water-logged for a considerable proportion of each year, no manufacturer has yet commenced to produce field drainage tiles. Such tiles are easy to produce with inexpensive low-technology equipment, and the abundant deltaic alluvium is an ideal material for such a product. The installation of properly designed drainage systems in high-quality agricultural or grazing land increases yields by lengthening the growing season and maintaining aerated soil conditions. As ceramic field drainage tiles are a low-cost product, adequate draining can be achieved economically with very short pay-back periods. Such tiles are also superior in all respects to competing plastic-pipe systems, achieving higher water flow rates for equivalent sized pipes and having a much longer life due to their resistance to deformation and higher strength characteristics.

The facilities already exist within government organizations to produce sufficient quantities of these tiles to enable the Ministry of Agriculture to carry out tests with drainage systems on good-quality land, which is subject to water logging for lengthy periods and to measure the effect of drainage on crop yields.

D. Refractories

Apart from the deposits of white clay the only other mineral resources suitable for the manufacture of refractories would appear to be:

(a) Rice husk ash. This could be used for the manufacture of insulating products. It may be possible to manufacture an intermediate-duty insulating brick which can be used up to a temperature of 1,200-1,250 °C, which would form a back-up insulation for kilns and furnaces or be used as a hot-face material in low-temperature kilns. It is also possible to manufacture an insulating brick from the Bijaipur clay by adding combustible material. Such bricks would not have the insulating properties of a brick made from rice husk ash, but they would be much stronger;

(b) Minerals from the beach sands of Cox's Bazaar:

- (i) Zircon may be used in ladle bricks, for the production of zircon bricks and zircon nozzles;
- (ii) Kyanite for high-alumina refractories;
- (iii) Rutile for special applications;

(c) The Bijaipur clay may also be used, together with imported graphite, to manufacture plumbago crucibles;

(d) Some of the clay bearing sands might be suitable as an alternative ladle lining material.

VI. MANPOWER REQUIREMENTS OF THE REFRACTORY AND CERAMIC INDUSTRIES

The manufacture of modern ceramics and refractories is an applied science which demands from its practitioners the possession of a wide range of disciplines. To work in these industries, a senior technologist needs to have a sound basic knowledge of mathematics, physics and chemistry, together with some specialist subject such as mechanical engineering, chemical engineering or physical chemistry. For higher management positions, in addition to the studies in physical science, training in business and general management is also desirable.

A. Staff requirements of the refractory industry

The refractory industry in Bangladesh is comparatively small, for there is only one works having a capacity in the region of 10,000 t/year. Judged by international standards this would be considered a small plant, further emphasized by the fact that the products are of a quality which, in comparison to basic- and high-alumina refractories, are of low value. There is at present a small but steady demand for refractories of a higher grade and of a type which cannot be manufactured locally. As other industries are being developed within Bangladesh this demand will increase and should create a market situation which would favour the installation of plant for the manufacture of a far wider range of refractories.

At the moment there would appear to be nobody in Bangladesh with any experience of manufacturing a full range of refractories and what practical knowledge is available is confined solely to the production of aluminosilicate materials. Higher management at all the works visited were well aware of the situation and realized that any future plans for extending the product range could be placed in jeopardy by the shortage of suitably qualified staff. The laboratory facilities existing at each works varied enormously, although it was perhaps significant that the restriction to their greater use was being caused by the lack of trained personnel rather than for want of equipment. Limited testing was being carried out but manufacturers had come to rely upon overseas laboratories for any experimental work and the testing required to satisfy customers' specifications.

In addition to possessing or having available staff with the necessary knowledge of making good-quality refractories, the manufacturer needs also to have an understanding of the service conditions likely to be encountered by his products. Such knowledge is not readily obtained unless some time can be spent working in the industry concerned, and this is seldom possible. Very large European producers do have members on their staff who are professionally qualified and considered to be expert in a particular branch of operation within the major industries. The alternative is to develop a close working relationship with personnel of other industries so that their requirements and problems arising from the use of refractories are better understood. Any personnel allotted this task need to acquire special skills and have had an extremely sound technical education.

Refractories technology should not be confined to the manufacturing industry alone, for refractories constitute an essential material in every industry where heat is being used as a means of production. Operators within the different industries should preferably have some idea of the importance of the properties of refractories together with the principles of refractories engineering. An in-depth knowledge is not necessary, just sufficient understanding to judge performance and appreciate the various property differences between different products.

It is suggested that the refractories industry in Bangladesh has openings, now and in the near future, for the following classes of personnel:

Professional	-	Graduate with higher degree
Senior technician	-	Diploma or graduate
Junior technician	-	Matriculation plus extra studies
Supervisory grades	-	Relevant craft training

B. Staff requirements of the ceramic industry

Although the majority of companies have been established for many years and a number of their personnel have received some training in overseas countries in various aspects of ceramic production technology, their needs are very similar to the refractories industries. Most companies stated that a lack of expertise was an important factor in not solving the many production problems faced by the industry. Some of the industries' requirements for junior technicians are being met by the existing diploma course students, but there is a definite need, recognized by the management of the companies within the ceramic industry, to improve the standard of that course. The industry would like to see those graduates enter the industry more able and qualified to solve normal production problems based on a sound technical knowledge of the industry during the course of their studies.

Some special needs, particularly for mould-makers and hand-painting artisans, were also identified but there are presently no trained teachers for such crafts in Bangladesh.

In both, the refractories and ceramic industries, combustion engineering is an area of technology which would be of significant benefit to these industries provided that suitably trained personnel were available.

To ensure that a major and lasting improvement is made in the training of personnel for the refractories and ceramic industries, it is recommended that a team of fully experienced expatriate personnel be employed to carry out a series of seminars and workshops in their respective specialized fields.

This will give the added support required to improve the standard of existing educational courses and will be an opportunity to concentrate on the major areas of weakness within the refractory and ceramic industries to generally improve the quality of production, reduce fuel consumption and improve the level of technical knowledge of the industries' technicians and management.

VII. ENERGY CONSERVATION

During this project visits were made to all the firms connected with the manufacture of ceramics and refractories and also to other major industrial units producing a wide range of commodities. It would seem that, with the exception of the very large concerns, no attempts were being made to monitor energy usage. Even at the larger factories, although the staff were aware of the need to save energy, they were not sure how to tackle the job and there was an apparent lack of both, the necessary knowledge as well as equipment with which to carry out monitoring on a regular basis. At every plant visited there was seen to be scope for energy saving by the application of suitable insulating materials. We were told that a major energy conservation programme for Bangladesh is being formulated by a committee made up from the Engineering Department of Dacca University, the Ministry of Minerals and Energy, together with representatives from the major industries. The refractories works and ceramic plants, bing comparatively small users, were not represented.

It is suggested that there are three main areas which could profitably be examined by both the ceramic and refractories manufacturers in regard to energy conservation. A similar approach would be of benefit to all other industries.

(a) Combustion engineering principles need to be understood, especially with respect to burner design and the efficient and safe firing of kilns and furnaces. Furnace and kiln design, insulation and the utilization of waste heat are all subjects which deserve study;

(b) Provided that the necessary instrumentation is available with which to measure energy consumption, the findings should be used to compile regular energy audits, the purpose being:

(i) To pinpoint regions of high energy consumption or loss;

(ii) To compare performance against targets;

(c) All process operations should be frequently reviewed to determine whether or not a change of practice or replacement of old or obsolete equipment could be justified by the saving of energy as a result of such changes.

Staff and workers at all levels must be made aware of the need to conserve energy. This could be implemented by means of posters, short lectures and more involvement of personnel in energy saving schemes. At each large factory one staff member should be installed as energy manager, with this as his sole responsibility. At a smaller factory this could be made an extra duty for one of the staff.

There is an obvious need for specialized workers in that area, and this suggests that a national training programme could be justified.

VIII. SUMMARY OF CONCLUSIONS

This project has clearly identified a number of factors, which are contributing significantly to restrict the development of and also reduce the efficiency of the refractory and ceramic industries in Bangladesh, these being:

(a) A basic lack of detailed knowledge of the clay deposits and a lack of trained mining engineers has resulted in the present clay mining operations being inefficient and disorganized, producing clays of varying qualities and in quantities insufficient for the present demand of the country. This inevitably results in production problems for the user companies and an increased level of clay imports;

(b) Despite the fact that a number of organizations within the country possess the facilities for raw-material and product testing, a lack of well-trained personnel in these laboratories has resulted in the fact that there is no laboratory within the country, which has the full confidence of the refractory and ceramic industries to produce reliable and meaningful test results. Therefore, all important testing is still carried out by overseas laboratories;

(c) Within the refractory and ceramic industries and the educational establishments associated with these industries, there is a serious lack of well-trained technical managers and technicians, which is seriously affecting the standard of teaching, the quality of the industries' production and also restricting the development of new or improved products;

(d) Throughout all industries in Bangladesh, including the refractory and ceramic industries, there is very little awareness of the importance of conserving energy. Few attempts are made to monitor energy usage, and management is generally unaware of energy costs and the potential for savings and increased profits by the correct use of insulation, instrumentation and attention to burner design and control.

Annex I

TERMS OF REFERENCE OF CONSULTANTS UNDER THE SUBCONTRACT

The work will be carried out by two consultants to be assigned to the project for a period of seven weeks each. The consultants will stay in Bangladesh for a maximum of six weeks and before leaving Bangladesh a draft project document will be submitted to UNDP/UNIDO.

The consultants will be attached to the Ministry of Industry and will carry out the following activities, to formulate a technical assistance project document:

(a) Review of all relevant data and information made available by the Geological Survey of Bangladesh;

(b) Evaluate existing laboratory facilities at the Bangladesh Institute of Glass and Ceramics, the Geological Department of Dacca University and BCSIR and recommend any additional equipment needed to perform tests required by the industry;

(c) Visit all manufacturers of refractories and ceramic products, and identify their requirements to improve production methods and product quality, and make recommendations to improve existing operational conditions with special emphasis to energy and raw material problems;

(d) Assess the domestic market potential for refractory and ceramic products;

(e) Evaluate the possibility of other industrial applications for the increased utilization of raw material resources available in the country, e.g. the production of aggregates;

(f) Identify the skilled manpower requirement of the relevant industries and recommend appropriate measures for training, to ensure continuity of activities after the completion of UNDP-supported project;

(g) Examine the possibility of introducing an energy-conservation programme within the project document to be formulated;

(h) Formulate a technical assistance project document based on the fact-finding activities described above.

Annex II

COMPANIES AND ORGANIZATIONS VISITED

1. Dacca Refractories Ltd.
2. Mirpur Ceramic Works Ltd.
3. Calcutta Tile and Refractories Industries Ltd.
4. Savar Refractories Ltd.
5. Conforce Ltd.
6. Master Industrial Corporation Ltd.
7. Chittagong Steel Mills
8. Chittagong Cement Clinker
9. Bengal Steel Works
10. T.S.P. Complex
11. Peoples Ceramic Industries Ltd.
12. Monno Ceramic Industries Ltd.
13. National Ceramic Industries Ltd.
14. Bengal Fine Ceramics Ltd.
15. Dacca Ceramics and Sanitary Wares Ltd.
16. Bangladesh Insulator and Sanitaryware Factory
17. Bengal Glass Works Ltd.
18. Shams Glass Works Ltd.
19. Ali Glass Works Ltd.
20. Usmania Glass Sheet Factory Ltd.
21. Jazmina Glass Works Ltd.
22. Geological Survey of Bangladesh
23. Petrobangla
24. Dacca University
25. Bangladesh Institute of Glass and Ceramics
26. Bangladesh Council for Scientific and Industrial Research
27. Housing and Building Research Institute
28. Bangladesh Oil, Gas and Minerals Corporation
29. Ministry of Industries
30. Bijaipur clay mines of:

    (a) Bangladesh Chemical Industries Corporation
    (b) Oxydental Ltd.
    (c) Tajma Ceramic Industries Ltd.
    (d) Calcutta Tiles and Refractories Ltd.
    (e) Peoples Ceramic Industries Ltd.
    (f) Dacca Refractories Ltd.

Annex III

DRAFT PROJECT DOCUMENT

Title: Analysis of raw materials for non-metallic mineral based industries

Number: Duration:

Primary function: Direct support

Sector: (Govt. class.) Industry (UNDP class. and code) ________

Government implementing agency:

Executing agency: United Nations Industrial Development Organization (UNIDO)

Estimated starting date:

Government inputs: ____________ (in kind) (local currency) UNDP inputs: 571,500 (US dollars)

Signed: ______________________________ Date: ____________________
On behalf of the Government

______________________________ Date: ____________________
On behalf of the executing agency

______________________________ Date: ____________________
On behalf of the United Nations Development Programme

PART I. LEGAL CONTEXT

This Project Document shall be the instrument (therein referred to as a Plan of Operation) envisaged in article 1, paragraph 2, of the agreement between the Government of the People's Republic of Bangladesh and the United Nations Development Programme (UNDP) concerning technical assistance under the Special Fund sector of UNDP, signed by the parties on 12 and 31 July 1972.

PART II. THE PROJECT

A. Development objective

To assist the Government of Bangladesh in developing and expanding the ceramic and refractory industries by upgrading the technical knowledge within these industries, promoting better utilization of indigenous non-metallic raw materials and improving the efficiency of the present production.

B. Immediate objectives

(a) To improve the present clay-mining operations of the Bijaipur region, thereby increasing the utilization of the existing raw-material deposits;

(b) To improve the capability of testing raw materials and products of the refractory and ceramics industries at existing laboratories within government organizations;

(c) To investigate the potential of other raw-material resources such as rice husk ash, zircon and kyanite, with a view to manufacturing new products;

(d) To implement an energy-conservation programme at a national level and develop efficient energy application within the refractory and ceramic industries;

(e) To improve the general knowledge in refractory and ceramic technology among both, the students of these fields and the technicians and supervisors of the industries concerned.

C. Special considerations

None.

D. Background and justification

Background

In a meeting held early in 1984 between the Department of Industries, UNIDO and manufacturers of refractories, the possibility of developing the refractory industries was discussed. Three firms, namely Dacca Refractories Limited, Mirpur Ceramics and Calcutta Tiles, involved in the manufacture of refractories, were represented in that meeting and indicated that they are the only ones producing refractories. These representatives stated that at present a large percentage of the country's requirement for refractories is being imported from abroad. They explained that one of the operational problems continuously encountered is the inability to predict the type, grade, quality and composition of the raw material which they buy from the clay deposit operated by the Government. The reason for this is that the area is not geologically classified, and that the raw materials are taken from the same area which is currently bein_ ned to fill orders for all types of users, such as brick manufacturers, refractory manufacturers and ceramics manufacturers.

It was, therefore, agreed that the Department of Industries, in collaboration with the Ministry of Minerals and Energy, should undertake a geological survey and laboratory tests of the clay deposits in order to classify them, to assess their suitability for the manufacture of refractories, and to recommend better methods for the mining and beneficiation of raw materials, if the latter is necessary. The possibility of establishing a laboratory within the Government to service the requirements of the manufacturers for testing their raw materials and products was also discussed.

The Department of Industries would then request UNDP/UNIDO to send a preparatory assistance mission for a period of three months to undertake the two tasks identified above, and also to visit the three manufacturing plants for refractories and submit specific recommendations on how their operations could be improved. This would enable the formulation of a proposal for technical assistance to develop the refractory industry. Finally an analysis would have to be made to estimate the potential market for refractories.

While reviewing this proposal, in order to optimize the benefit from such a mission, UNIDO suggested that while undertaking the geological survey and laboratory tests of the clay deposit, the possibility of utilizing these raw materials for other industrial applications such as production of aggregates should also be evaluated. It is already known that the demand for aggregates is increasing and the supply is coming from only one area, Sylhet.

The other important area which would be examined by the mission is energy conservation. Plant visits to major energy users such as cement, fertilizer, ceramics and steel factories, would be conducted to identify specific activities where energy savings could be achieved.

That preparatory assistance mission was carried out by a team of two experts under the project DP/BGD/85/006, in October-December 1985.

Justification

The terminal report of the project "Analysis of raw materials for non-metallic mineral based industries" (DP/BGD/85/006) should be considered as a basis of this project document. The following summary of the findings constitute the justification for the project.

Within Bangladesh only four main types of clay are known to occur, three of which are important only for the red-brick industry, namely the flood plain alluvium north of the Ganges, the deltaic alluvium which extends over the complete area south of the Ganges to the Bay of Bengal, and the Madhupur clay which forms the low hillocks in many parts of the country.

The only other type of clay found in the country are the deposits of white kaolinitic clays, the major and most important deposits being located in the Bijaipur area of the Mymensigh district, close to the Indian border. Smaller deposits are known to exist in various localities in Sylhet and the Chittagong Hill Tracts, and a number of private companies are attempting to exploit them, albeit on a small scale.

By far the most important deposit, suitable for the requirements of the refractory and ceramic industries, however, is that of Bijaipur, which is presently being mined in an unco-ordinated manner in several locations by both the Government and a number of private companies, who lease sections of land from the Government. In all cases the mines are being developed, where the white clay is exposed in the hillocks, by fox-hole type cuttings.

Two grades of clay are generally extracted. The higher grade, having a lower iron-oxide content, is used in the manufacture of porcelain tableware, sanitary ware and insulators, and the lower grade is utilized by the refractory industry. All of these industries suffer from serious quality problems in their production caused directly by the inability of any of the mines to supply a consistent product of known properties.

The hand-digging methods presently employed, the complex structure of the deposit with high angles of dip in the clay strata, coupled with no precise geological information on the mine areas and the lack of any trained and experienced mine manager are not only adversely affecting the quality of the clays extracted, but have already resulted in a serious shortfall in the quantity of clay mined for the industry, resulting in an increasing volume of clay imports from overseas. Planned expansion within both, the refractory and ceramic industries, some of which is already at the construction stage, will result in a substantial increase in demand, which can only be met by an increased level of imports if no improvement in the present mining operations and transportation systems is made. It is estimated that the current level of output of approximately 4,100 tonnes per year must be increased to a level of 8,000-10,000 tonnes to cope with that demand.

Much work has already been carried out in order to improve the quality of the clay, but for the relatively small quantities involved beneficiation is uneconomic and, in any case, much of the silica-sand contamination is very fine and has a grain size similar to that of clay particles so that it cannot easily be separated by simple washing. In addition, most of the products presently being manufactured by the refractory and ceramic industries in Bangladesh do not require such treatment, the factories already possessing the equipment to remove much of the iron-oxide contamination. A far better and more cost-effective method of improving the quality of all products would be to supply a more consistent material from the mines by observing recognized clay-mining and clay-stockpiling practices.

Accessibility to the Bijaipur clay deposits is extremely difficult. The deposits can be reached from the Jaria-Jhanjail rail terminus only in the dry season, partly by four-wheel drive vehicles, and the last few miles by bullock carts, small motorcycles or by foot through rice fields. During the rainy season lasting from June to October, large country boats can travel to Bijaipur along the Someswari River to within a few miles of the mine sites and the mines must take advantage of this circumstance to move as much clay as possible to the railhead. During the dry season only small country boats can travel to Bijaipur and these are sometimes used to transport clay to Jaria, although this is considerably more expensive.

To ensure maximum production during the dry season and maximum deliveries during the wet season, therefore, requires not only good mine management in regard to clay extraction, clay stockpiling, pumping operations and maintenance of equipment, but also calls for good planning of clay transport and delivery schedules to meet the requirements of customers. Any shortfall in output or deliveries has to be met by an increased level of imports into the country.

In order to achieve the objectives of improving the consistency of the quality of the clays and of increasing the output from the mines, this project provides for a properly organized drilling programme to be undertaken by the

Geological Survey of Bangladesh, who have all the required machines and personnel for that work. This drilling programme will be carried out in conjunction with a fully experienced expatriate clay-mining engineer, who will be provided under this project. In addition to advising the Geological Survey, the expert will re-organize the present mining operations to increase the efficiency of all mines in the area. He will formulate a detailed mining plan, based on the information from the drilling survey to enable the mines to increase their recovery of good-quality clays for the refractory and ceramic industries. Part of this plan will include an assessment of both the practicality and economic benefit of utilizing a low-cost light-weight overhead cableway system to transport clay from the mine stockpiles to the river to overcome the serious transportation difficulties in that region.

Throughout all of the refractory and ceramic industries it has been clearly identified that there are serious deficiencies in the testing of the raw materials and finished products, despite the fact that laboratory facilities relating to refractory and ceramic product industries exist within government organizations at the Bangladesh Institute of Glass and Ceramics, at the Geological Department of Dacca University, at the Bangladesh Council for Scientific and Industrial Research (BCSIR) and at the Bangladesh Insulator and Sanitaryware Factory.

The laboratory at Dacca University which has full facilities and trained staff to carry out the chemical analysis of raw materials, works closely with the Geological Survey of Bangladesh in the evaluation of these materials, although in recent years the amount of work specifically related to the refractory and ceramic industries has been rather limited.

At BCSIR the work is primarily of a research nature, and while it has all the facilities to carry out the chemical testing of raw materials and occasionally carries out these tests, the policy of the Council is not to become too involved with the specific production problems of the refractory and ceramic industries.

The most important facilities exist at the Bangladesh Institute of Glass and Ceramics, but these are currently not being fully utilized due to a lack of trained personnel and qualified teachers and a general reluctance of the refractory and ceramics industries to properly support the Institute.

It is because of this marked lack of confidence in these laboratories to supply reliable results within a reasonable timespan, that manufacturers of refractories, tableware, sanitary ware and heavy-clay products still rely on overseas testing laboratories for most of their raw materials testing.

The laboratories of these organizations have complete facilities for the chemical and physical testing of refractories as well as for the testing and development of ceramics, including all necessary equipment for the production of porcelain and earthenware bodies, casting slips and glazes. In addition, a complete pilot plant for the production of refractories and ceramics exists, with all necessary grinding equipment, mixers, extruders, presses, pottery machinery, dryers and kilns.

The deficiencies in the testing of raw materials and products in the industries are therefore not due to any lack of equipment but are solely due to the lack of adequately trained personnel in the laboratories. This project therefore provides for well-experienced expatriate laboratory and technical personnel to offer their advice in seminars and practical workshops to upgrade the knowledge and skills of local personnel in all kinds of chemical and physical testing of refractory and ceramic raw materials and products.

The testing laboratories are not the only weak points found within the refractory and ceramics industries. Without exception, all companies expressed a concern about the low level of technical expertise within the industries and a desire for better training of their technicians and managerial staff by improving the overall standard of the three-year diploma course in ceramics at the Institute of Glass and Ceramics. Again, because of an acute shortage of trained professional staff, this course has to be taught by junior instructors of diploma level, who have had virtually no experience in industry. Graduating students are therefore felt to be of limited value to companies in trying to sclve their production problems and improving the quality of the production.

At present there is no reliable consultancy service in the government sector which can adequately help the refractory and ceramic industries to solve their production problems and aid in the development of new products. To add to the quality of existing refractory and ceramic technology courses, therefore, and to improve the consultancy service which can be offered by the University and other establishments, this project provides for short-term courses of an intensive nature which will be given by expatriate advisors, expert in their particular field of refractories, ceramics and clay mining.

Various potential new products for the refractory and ceramic industries have been identified, some of which could be produced within a fairly short time, provided that sufficient expertise is available for the initial development work.

The vast reserves of alluvial clays are underutilized and could be used to produce good-quality load-bearing facing bricks and field drainage tiles. Load-bearing bricks can reduce the cost of housing by eliminating much of the concrete and steel reinforcing necessary in framed structures, and would reduce the amount of cement at present imported into the country. However, better production facilities and up-to-date technical knowledge are required to produce such high-quality bricks. The means to improve the technical standard within the brick-making industry is provided for within this project document.

Brick-built structures are aesthetically more pleasing in the environment and require far less maintenance than concrete structures. By utilizing more of the cheaper indigenous red clays, which are abundant in the country, the production of such bricks would aid the economy of Bangladesh and at the same time improve the quality of the urban environment.

As the quality of aggregates made from field-burnt bricks is very poor and the cost of stone aggregate from the distant Sylhet region is extremely high, the possibility of utilizing other materials for aggregate production was considered. However, no suitable mineral deposits for hard aggregates are available in the country, and while bloating shales in the Dacca area have been evaluated for light-weight aggregate production and found to be suitable, there is at present no market for such aggregate and, therefore, should be considered as a long-term and not an immediate possibility.

The low-grade white clay, which is used only for refractories, would appear to be a suitable major constituent for floor tiles, produced either as split tiles or punched tiles, and the possibilities of salt glazing to reduce the requirement for very expensive imported glaze constituents will be investigated under this project.

Although large areas of high-quality agricultural land are water-logged for much of the year, no manufacturer has yet commenced to produce field-drainage tiles. Such tiles are easy to produce with inexpensive low-technology equipment and the abundant deltaic alluvium is an ideal material for such a product. The installation of properly designed drainage systems using these tiles in high-quality agricultural or grazing land increases yields by lengthening the growing season and maintaining aerated soil conditions. Such tiles are superior to competing plastic pipes. This project will provide for the manufacture of a sufficient quantity of tiles to enable the Ministry of Agriculture to carry out drainage tests on agricultural land subject to water logging, to measure the effect of improved drainage on crop yields.

Apart from the white-clay deposits there would seem to be only two other sources of minerals with industrial potential as refractories:

(a) Rice husk ash to be employed to manufacture insulating products;

(b) Minerals from the beach sands of Cox's Bazaar, namely zircon, kyanite and rutile.

This project will provide for samples to be produced for evaluation by the industry.

Within the refractories and ceramics industries, in common with most other energy users producing a wide range of commodities, it would seem that, with the exception of the very large concerns, no attempts are being made to monitor energy usage. Even at the larger factories, although the staff are aware of the need to save energy, they are not sure how to achieve it, and there is an apparent lack of the necessary knowledge and equipment with which to carry out monitoring on a regular basis.

At all plants there would seem to be scope for substantial energy savings by the application of suitable insulating materials.

Combustion engineering principles need to be understood, especially with respect to burner design and the efficient and safe firing of kilns and furnaces. Furnace and kiln design, insulation and the utilization of waste heat are all subjects which deserve study.

Energy audits are required in all factories to pinpoint regions of high energy consumption or loss and to compare performance against target. It is only by involving personnel at all levels and making them more aware of the need to conserve energy that consistent savings can be made. For this reason this project provides for an expatriate combustion engineer who will carry out seminars and workshops in the educational establishments and provide training and practical help in the factories for specific energy-related problems.

E. Outputs

1. A well-designed plan to improve the mining operations of white clays in the mines of the Bijaipur region, including:

(a) Detailed methods of winning, stockpiling and transportation of the clays;

(b) A training programme for three mine technicians;

(c) An increase in output from the mines by an estimated 50 per cent;

(d) An improvement in the consistency of the quality of the different grades of clays.

2. To establish a workshop and seminar centre at the Dacca University for the refractory and ceramics industries, orientated towards those industries, for the training of personnel, improvement of existing products and development of new products by means of the following fully operational units:

(a) A chemical testing laboratory, as an efficient and reliable laboratory, capable of testing all raw materials used in the refractory and ceramics industry, and also their finished products;

(b) A physical testing laboratory and pilot plant, as an efficient and reliable laboratory capable of testing all of the physical properties of the raw materials and the finished products of the refractory and ceramics industries;

(c) A training unit for conducting workshops and seminars for the refractory and ceramic industries;

(d) Improved library facilities for the staff and students of the centre;

(e) A consulting unit for providing practical immediate help to the refractory and ceramic industries in regard to all problems related to raw material and production encountered by the industries.

3. A programme of testing to examine the possibility of utilizing rice-husk ash for the manufacture of refractory insulating bricks and rice-husk ash cement.

4. A programme of testing to examine the possibility of utilizing the zircon and kyanite fractions of the sands at Cox's Bazaar beach for the manufacture of refractories.

5. A programme of testing to examine the possibility of utilizing the lower-grade white clay from Bijaipur for salt-glazed floor tile.

6. A consultancy service and advisory centre for combustion engineering, embracing kiln and furnace design, burner design, combustion of fuel, kiln, furnace and dryer efficiency, energy audits and advice on the safe application of fuel and power.

7. Syllabi for the planned short-term specialized courses, which are designed for the needs of the industries, encompassing theoretical and practical training.

8. Provision of well-trained expatriate personnel, capable of operating the facilities of the centre and training technical staff for the benefit of the country's refractory and ceramics industries:

(a) One clay mining engineer;

(b) One refractories technologist;

(c) One ceramic technologist;

(d) One combustion engineer;

(e) One research laboratory supervisor;

(f) Three technologists/engineers for short-term workshops in:

(i) Ceramic raw-material testing;

(ii) Refractories;

(iii) Combustion engineering.

F. Activities

Activity	Planned implementation
1. Train the counterpart staff and technologists in the use of all chemical and physical testing equipment in the existing laboratories.	Throughout the entire duration of the project
2. Train the counterpart staff and technologists in the use of all ceramic production machinery and kilns in the existing small ceramic factory located at the Institute.	Throughout the entire duration of the project
3. Offer consultancy services and direct technical assistance to all refractory and ceramic manufacturers in the public and private sectors, to solve specific raw material and production-related problems, to develop new products, and to improve process and quality control.	Throughout the entire duration of the project
4. Prepare syllabi for short courses to be held for the staff of the refractory and ceramic industries. All courses to be tailored to the requirements of the local industries.	During first three months of the project
5. Organize a programme of the specialized courses for the individuals selected by UNIDO in accordance with the requirements of the industry.	During first three months of the project
6. Carry out the programme of the specialized short courses for the refractory and ceramic industries.	Starting at the beginning of fourth month of the project
7. Carry out a survey of all companies in the refractory and ceramic industries and all other major industrial users of fuel, to offer detailed advice on kiln, furnace and dryer design, burner design, combustion engineering, energy audits and inspection of safety procedures in respect to fuel and power.	Throughout the entire duration of the project

Activity	Planned implementation
8. Carry out a detailed survey of the current mining operations at Bijaipur, utilizing new information to be obtained from the drilling programme to be undertaken by the Geological Survey, and design the most efficient method of mining for each mine area in order to recover the maximum quantities of good-quality clays from the deposits.	Throughout the entire duration of the project
9. Production of a range of insulating brick samples utilizing rice-husk ash, for evaluation by industry.	Starting at the beginning of the seventh month of the project
10. Production of a range of zircon and kyanite refractory samples utilizing the zircon and kyanite fraction of the Cox's Bazaar sands for evaluation by industry.	Starting at the beginning of the tenth month of the project
11. Production of a range of salt-glazed clay samples utilizing compositions based on the lower grade white clays of Bijaipur for evaluation by industry in respect to salt-glazed floor tile.	Starting at the beginning of the seventh month of the project
12. Production of a range of field drainage tile for assessment by the Ministry of Agriculture in improving the yields of agricultural land. Sizes to be produced initially to be: (a) 4 in. diameter x 12 in. long (b) 6 in. diameter x 12 in. long	Starting at the beginning of the seventh month of the project
13. Provision of up-to-date technical reference books and journals in the English language for the refractories, ceramics and heavy clay industries.	Starting at the beginning of the third month of the project

G. Inputs

1. Government inputs

(a) Personnel for the duration of the project

3 Senior laboratory technicians
3 Junior laboratory technicians
1 Senior geologist
3 Trainee mining engineers
2 Trainee combustion engineers

(b) Transportation costs and subsistence costs

All costs of the counterpart personnel will be met by the Government or corporation.

(c) Equipment and supplies

(i) Sufficient amounts of deltaic alluvium clay from the Dacca area, white kaolinitic clay from the Bijaipur area, rice husks and the refractory fractions of the Cox's Bazaar sands, to carry out all required tests and pilot production of new products foreseen under this project;

(ii) Sufficient materials and chemicals for the operation of the laboratories and the pilot plant.

(d) Premises

(i) Furnished and suitably equipped office accommodation for the international team will be provided by the Government at Dacca University in accordance with the actual needs of the project;

(ii) Suitably furnished living accommodation for the expatriate mining engineer and the counterpart local personnel will be provided by the Government in the neighbourhood of the Bijaipur mine site at the rest house operated by the Bangladesh Insulator and Sanitaryware Factory.

2. UNDP inputs

(a) Personnel

Post number		Man-months
11-01	Refractory technologist/team leader	12
11-02	Clay mining engineer	12
11-03	Ceramic technologist	10
11-04	Combustion engineer	10
11-05	Research laboratory supervisor	12
11-50	Short-term consultants in refractory and ceramic technology, energy conservation and raw-material testing	6
	Total	62

Post 11-01: Refractory technologist/team leader

The expert should be well qualified in a materials science discipline of at least degree standard. He should have a minimum experience of ten years in the manufacture and application of refractories of all types, preferably with some experience in developing countries.

The expert must be able to explain the theoretical and practical aspects of refractories technology in both the lecture theatre and in the factory. A sound knowledge of testing methods and some experience of developing new products is also required.

Post 11-02: Clay mining engineer

The expert should be a well-qualified mining engineer of at least degree standard, with a minimum of ten years experience in the mining and quarrying of clays, with special emphasis on the development of new quarries or mines.

His theoretical and practical knowledge should include all aspects of core drilling, including the complete evaluation of the core samples obtained. Previous experience in a developing country would be desirable.

The expert will be based at Dacca University and is to be initially attached to the Geological Survey drilling team as an adviser to help the Geological Survey to evaluate the results.

The expert will, on the basis of the results from the drilling programme, develop a comprehensive mining plan to:

(i) Optimize the utilization of all clay deposits in the area;

(ii) Improve the clay-stockpiling and testing techniques to achieve consistent quality of the various grades of clays;

(iii) Improve the method of transportation of the clay from the mine to the customer, special emphasis being given to alternative methods of transport from the mine sites to the loading station at the river.

Post 11-03: Ceramic technologist

The expert should be a well-qualified technologist or engineer of at least degree standard, with a minimum of ten years experience in the ceramic industry, preferably with detailed knowledge of the tableware, sanitary-ware and heavy-clay industries.

The technologist will be based at Dacca University, Geological Department, where he will be expected to carry out a series of lectures and practical workshops in the chemical and physical testing of ceramic raw materials and products and utilizing the facilities of other government organizations where appropriate.

These lectures and workshops will include staff and students of all government organizations involved in the refractory and ceramic industries, and also technicians, supervisors and management staff of private industries.

The technologist will also be expected to visit all ceramic industries to act in a consultative role, helping to solve production problems and to improve the quality of the products.

The third area of work for which this technologist will be responsible will be to aid in the development of new products for the industry.

Post 11-04: Combustion engineer

This expert should be well qualified in fuel engineering technology to at least degree standard, with a minimum of ten years experience in the application of combustion science. He must be able to demonstrate the theoretical and practical aspects of all kinds of energy usage, with particular emphasis placed on energy conservation in industry.

The expert will be based at Dacca University from where he will be expected to carry out a series of lectures in his subject.

The expert will also be expected to visit all refractory and ceramic industries and all other major users of energy and to act in a consultative role by helping these industries to become more aware of the need to conserve energy, advising them on all practical aspects such as energy audits, burner design and operation, kiln and furnace design and all safety aspects of fuel combustion.

Post 11-05: Research laboratory supervisor

This expert should be well qualified in materials science, such as refractories technology and ceramic technology to at least degree standard, with a minimum of ten years experience in the management of both research laboratories and production-control laboratories within the refractory and ceramics industries. The expert will be expected to demonstrate a full range of tests, physical and chemical, which are required to control the production processes in the refractory and ceramics industries. A knowledge of the relevant international standards is essential.

The expert will also be expected to aid in the development of new products within these industries and to train the national counterpart personnel.

Post 11-50: Short-term consultants

A number of consultants in the fields of raw material testing, refractories and ceramic technology, and energy conservation will be employed for short periods, depending on specific needs of the industry which will be identified during the course of this project.

(b) Administrative support personnel (post No. 13-00)

Two drivers will be required for the duration of the project.

(c) United Nations volunteers (post No. 14-01)

A laboratory technician will be supplied under this project to assist the research laboratory supervisor in his duties.

(d) Fellowship training

No fellowship training is planned under this project.

(e) Equipment

Expendable equipment (41-00)	Estimated cost ($US)
Three sets of replacement elements for the 38-kW kiln (type HT16, serial No. 02626), manufactured by Kilns and Furnaces Limited, United Kingdom	1 500
Three sets of replacement kiln furniture for the above kiln, manufactured by J. Hewitt and Son, United Kingdom	3,000
One full set of spares to refurbish the Rawdon 3-inch horizontal de-airing extruder manufactured by Edwards and Jones Limited, United Kingdom	1 500
Total	6 000

Non-expendable equipment (42-00)	Estimated cost ($US)
Four-wheel drive Landrover	50 000
Station wagon for the transportation of project personnel	20 000
Portable Orsat flue gas analyzer, type GAS-210-N (BS1756, part 2), for the determination of carbon monoxide, carbon dioxide and oxygen in flue gases, with one complete set of spare parts, manufactured by A. Gallenkamp and Co. Ltd., United Kingdom	500
Pipe dies (100 mm and 150 mm) for Boulton extruder	5 000
Text books on ceramic and refractories technology	5 000
Total	80 500

(f) Miscellaneous

Reporting costs (51-00)	1 500

H. Preparation of work plan

A detailed work plan for the implementation of the project will be prepared by the leader of the international staff assigned to the project, in consultation with the team leader of the national staff. This will be done at the start of the project and be brought forward periodically. The agreed-upon work plan will be attached to the project document as annex I and will be considered as part of that document.

I. Framework for effective participation of national and international staff in the project

The activities necessary to produce the indicated outputs and achieve the project's immediate objectives will be carried out jointly by the national and international staff assigned to it. The respective roles of the national and international staff will be determined by their leaders by mutual discussion and agreement at the beginning of the project and set out in a "Framework for effective participation of national and international staff in the project". The Framework which will be attached to the project document as an annex, will be reviewed from time to time. The respective roles of the national and international staff shall be in accordance with the established concept and specific purposes of technical co-operation.

J. Development support communication

Appropriate and effective communication and understanding between all of the agencies responsible for promoting the refractory and ceramic industries in Bangladesh have to be established to successfully achieve the objectives of the project. The key relationships have to be developed between:

Preliminary work plan

	First year									Second year					
	April	May	June	July	August	September	October	November	December	January	February	March	April	May	June
1. Prior obligation (a) satisfied	—	—	—												
2. Prior obligation (b) satisfied	—	—	—												
3. Prior obligation (c) satisfied	—	—	—												
4. Prior obligation (d) satisfied	—	—	—												
5. Contract period of clay mining engineer				—	—	—	—	—	—	—	—	—	—	—	—
6. Contract period of refractories technologist				—	—	—	—	—	—	—	—	—	—	—	—
7. Contract period of ceramic technologist						—	—	—	—	—	—	—	—	—	—
8. Contract period of combustion engineer						—	—	—	—	—	—	—	—	—	—
9. Contract period of research laboratory supervisor				—	—	—	—	—	—	—	—	—	—	—	—
10. Activity 1				—	—	—	—	—	—	—	—	—	—	—	—
11. Activity 2				—	—	—	—	—	—	—	—	—	—	—	—
12. Activity 3				—	—	—	—	—	—	—	—	—	—	—	—
13. Activity 4				—	—	—									
14. Activity 5				—	—	—									
15. Activity 6							—	—	—	—	—	—	—	—	—
16. Activity 7				—	—	—	—	—	—	—	—	—	—	—	—
17. Activity 8				—	—	—	—	—	—	—	—	—	—	—	—
18. Activity 9										—	—	—	—	—	—
19. Activity 10												—	—	—	—
20. Activity 11										—	—	—	—	—	—
21. Activity 12										—	—	—	—	—	—
22. Activity 13						—	—	—	—	—	—	—	—	—	—

(a) The national and international staff involved in the project; the Ministry of Education, Dacca University, Geological Department; the Bangladesh Institute of Glass and Ceramics; and the Geological Survey of Bangladesh;

(b) The project staff and students at the University of Dacca and the Institute of Glass and Ceramics, and the technicians and managerial staff at the private refractory and ceramic industries.

K. Institutional framework

The government counterpart organization for this project is Dacca University, Geological Department, which operates under the Ministry of Education. The wide-ranging scope of this project involving geological evaluation of raw materials, clay mining, refractory and ceramic technology and energy conservation, demands that a number of other ministries and public organizations will be involved in part of this project to varying degrees.

Apart from the Geological Department of Dacca University, these will include:

(a) The Geological Survey of Bangladesh with respect to the inputs in the clay mining operations and the development of other refractory products;

(b) The Institute of Glass and Ceramics regarding some of the refractory and ceramic technology inputs;

(c) The Ministry of Energy with respect to energy conservation inputs;

(d) The Ministry of Industries, who will establish the necessary contacts with private refractory and ceramic industries;

(e) The Bangladesh Chemical Industries Corporation which is responsible for the only clay mine operated by the Government under the management of the Bangladesh Insulator and Sanitaryware Factory.

The necessary co-ordination between those ministries and other government organizations will be the responsibility of the Dacca University.

L. Prior obligations and prerequisites

Obligations

(a) The Dacca University will ensure that it has the required staff, either at the University itself or at other government organizations, to fulfill the needs of the project;

(b) The Dacca University will also ensure, prior to the approval of the project, that all premises required for the project, whether at the University or elsewhere, are in a satisfactory condition with all facilities such as water, electricity and gas connected, and that all existing equipment is clean and in good working order;

(c) The Geological Survey of Bangladesh will arrange a comprehensive drilling programme in the region of the Bijaipur clay mines, to which the mining engineer of this project will be attached. All arrangements for that drilling programme must be completed, and all necessary machines, equipment and personnel available at the site of the clay mine before the mining engineer is fielded;

(d) Prior to the commencement of the project, the Dacca University must confirm its ability to co-ordinate this project effectively. The project document will be signed by the resident representative on behalf of UNDP, and UNDP assistance to the project will be provided only if the prior obligations stipulated above have been met to the satisfaction of UNDP.

Prerequisites

Not applicable.

M. Future UNDP assistance

It is anticipated that the current project will provide the groundwork for an improvement in clay mining technqiues, an improvement in the knowledge of refractory and ceramic technology and also an increase of the awareness within all industries for energy conservation.

However, due to the present low standard of technical training and the lack of any well-qualified personnel within the refractory and ceramic industries, it would be advisable to continue a similar programme of training and development after the current project is complete, with the necessary amendments, once the present project has been fully evaluated.

A period of three to five years is considered necessary to achieve a lasting impact on the quality of students and technicians within these industries.

PART III. SCHEDULES OF MONITORING, EVALUATION AND REPORTING

A. Tripartite monitoring reviews; technical reviews

The project will be subject to periodic review in accordance with the policies and procedures established by UNDP for monitoring projects and programme implementation.

B. Evaluation

The project will be subject to evaluation in accordance with the policies and procedures established for this purpose by UNDP. The organization, terms of reference and timing of the evaluation will be decided in consultation between the Government, UNDP and the executing agency concerned.

It is recommended that this evaluation take place during the final month of the project, to determine what, if any, future assistance will be required.

C. Progress and terminal reports

All advisers will prepare bi-monthly progress reports for assessment by the UNDP resident representative and, in addition, the refractory technologist, as chief technical adviser, will prepare the terminal report for the project at the end of the project.

PART IV. PROJECT BUDGET

The project budget covering the UNDP inputs is attached.

The project budget covering the government counterpart contribution in kind will be determined by the UNDP resident representative in his discussions with the Government.