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UNITED NATIONS INDUSTRIAL
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ESTABLISHMENT OF A MANUFACTURE OF GLAZED WALL AND FLOOR TILES

CYPRUS

IS/CYP/75/006

Feasibility study

Prepared for the Government of Cyprus by the
United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of Ludwig Braecher, expert
in glazed tiles manufacture

id. 76-4804

Explanatory notes

Reference to "tons" indicates metric tons, unless otherwise stated.

The monetary unit of Cyprus is the pound (£C). During the period of the project, the value of the Cyprus pound in relation to the United States dollar was $US 1 = £C 0.415. One thousand mils is one Cyprus pound.

ABSTRACT

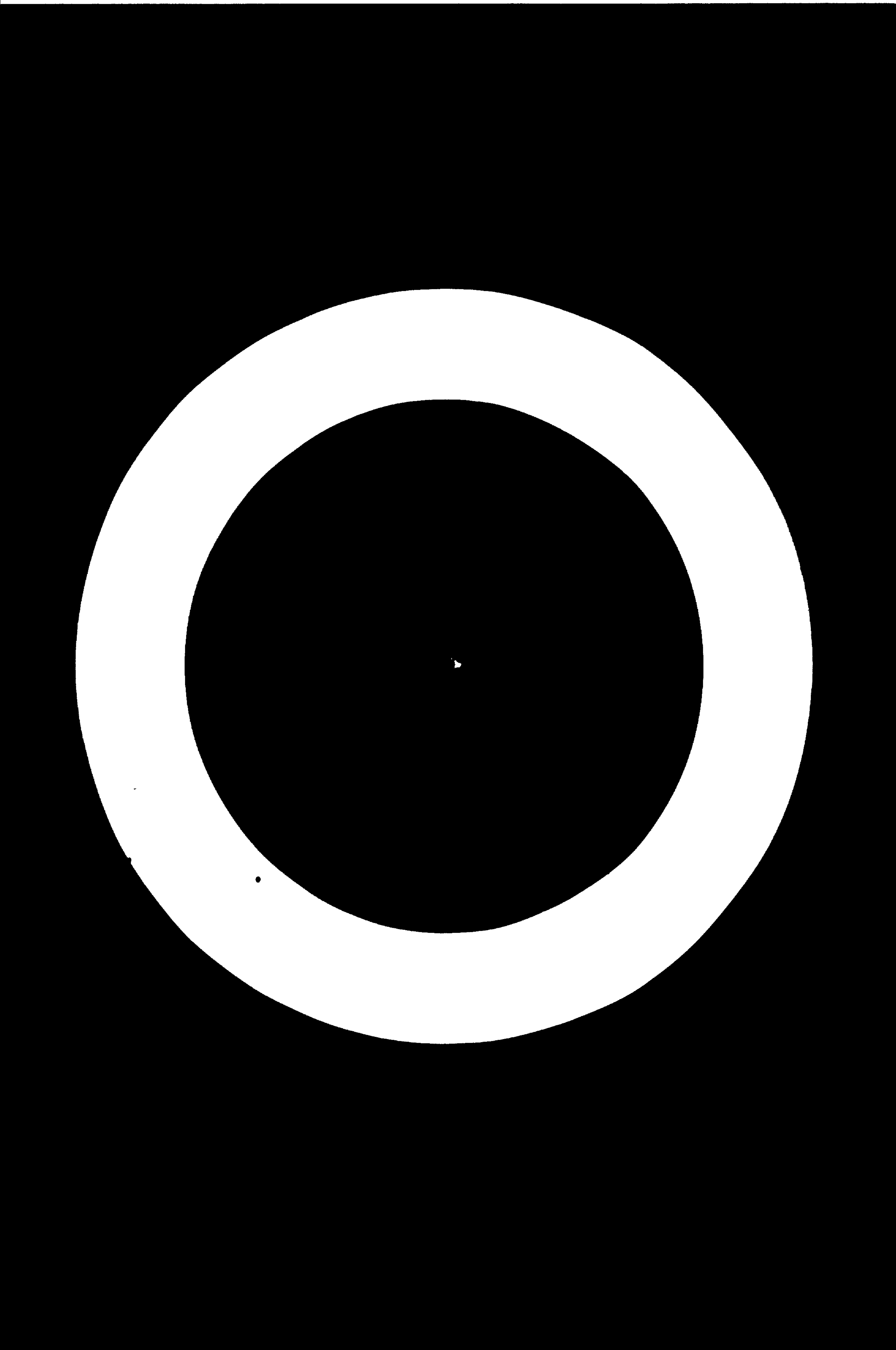
The local manufacture of clay-based products in Cyprus is at present limited to clay bricks (approximately 40 million per annum) and a limited amount of pottery and mosaic tiles.

At the request of the Government of Cyprus, a study was undertaken of the possibility of establishing a local tiles industry to supply the growing needs of domestic and export markets. The six-month project "Establishment of a Manufacture of Glazed Wall and Floor Tiles" (IS/CYP/75/003) of the United Nations Development Programme (UNDP) was carried out from December 1975 to May 1976 by an expert in the manufacture of glazed tiles. The United Nations Industrial Development Organization (UNIDO) was the executing agency and the UNDP contribution was $23,000.

The study indicates that the manufacture of a wide range of ceramic white-ware, including glazed wall and floor tiles, sanitary-ware and table-ware, is feasible and that the structural (clay bricks) sector could be greatly expanded. The Government decided to concentrate efforts, for the present, on the establishment of a plant for the manufacture of glazed wall and floor tiles. Although the domestic market is not large enough to support such a plant, a survey of the markets of neighbouring countries shows that part of the intended production could be exported.

The expert's tasks were to assist with the establishment of this plant and to prepare a long-range plan for the development of the ceramics and structural clay products industry.

He concluded that such a plant would be viable and recommended that further assistance be given by UNIDO in order that it may be established.



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INTRODUCTION

The local manufacture of clay-based products in Cyprus is at present limited to clay bricks (approximately 40 million per annum) and a limited amount of pottery and mosaic tiles.

At the request of the Government of Cyprus, a study was undertaken of the possibility of establishing a local tiles industry to supply the growing needs of domestic and export markets. The six-month project "Establishment of a Manufacture of Glazed and Floor Tiles"(IS/CYP/75/006) of the United Nations Development Programme (UNDP) was carried out from December 1975 to May 1976 by an expert in the manufacture of glazed tiles. The United Nations Industrial Development Organization (UNIDO) was the executing agency and the UNDP contribution was $23,000.

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The expert's task was to assist with the establishment of this plant. His main duties were:

1. To study available information on local ceramic raw materials and determine the need for further investigation of the quantity and quality of the deposits in order to determine the technical feasibility of a glazed tiles manufacture.

2. To plan and initiate the required raw-materials investigation to be carried out locally, as far as facilities permit, and abroad by a suitable laboratory.

3. To assess the market for glazed wall and floor tiles and determine a suitable size for the proposed production with a tentative description of the product selection.

4. To prepare a feasibility study for the proposed plant including descriptions of production technology, plant layout, equipment specifications, manpower and raw material requirements, cost and profitability analysis etc.

5. To draft the relevant tender documents, including terms and conditions of contract, to be used as the basis for an international call for tenders.

6. To advise on a long-range development plan for the ceramic and structural clay industry including, but not limited to, the proposed tile plant, and to assess the need for further UNIDO assistance.

I. FINDINGS

A. Raw materials

Availability

The expert's task was to plan and initiate investigations into ceramic raw materials to be carried out locally, as far as facilities permitted, and abroad by a suitable laboratory.

With the assistance of the Department of Geological Survey in Nicosia, the expert visited several extensive deposits and sites of bentonitic, halloysitic and illitic clays as well as granophyres, trondhjemites and colluvia.

The following samples were selected for testing:

AM 1	AM 2	PAR 1	PAR 2	PAR 3	DR 1
DR 2	MN 1	MN 2	MG 1	MG 2	PEN 1
PEN 2	MAR 1	KAN 1	KAN 2	KAN 3	KB 1
VL 1	VL 2	VL 3	VL 4	VL 5	
ZE 1	ZE 2	ZW	PEL		
TS 1	TS 2	TS 3	STV 1	STV 2	STV 3
STV 4	STV 5	PHN 1	PHN 2	PHN 3	PEN 4
KH 1	CHP 1	AYC E1	AYC E2	NAT 1	SOT 1
VAS 1					

Total 46 samples

Local facilities were available to carry out the following tests:

- Chemical analysis
- Determination of soluble salts (sulphates and chlorides)
- Linear shrinkage: wet-dry (105°C, 200°C), dry-fired (1,000°C, 1,100°C, 1,200°C)
- Moisture content at moulding stage
- Behaviour during drying
- Water adsorption at: 1,000°C, 1,100°C, 1,200°C
- Plastic limit and liquid limit
- Plasticity index

These tests, conducted in Nicosia (annexes I and II), did not provide sufficient information to support a conclusion on production technology, especially the suitability of the raw materials for use as body components of wall and floor tiles. It was therefore decided, that the following additional tests should be carried out abroad:

Dilatometric analysis - expansion coefficient 20°-1,000°C and the corresponding diagrams.

Differential thermal analysis results and corresponding diagrams.

X-ray examination -- results and films.

Deflocculation tests - (tripoli-phosphate, sodium carbonate, sodium silicate etc), to investigate the suitability of the raw materials and testing body compositions for the preparation of a dry pressing-powder through slurry preparation and spray drying.

pH-analysis

Bending strength - 105°C dry; fired to 1,000°C, 1,100°C and 1,200°C

Results of tests

Owing to budgetary difficulties, it proved impossible to get the results of the above-mentioned tests in time to complete the feasibility study urgently needed by the Government of Cyprus. Therefore, the expert was asked by UNIDO to base his views of the suitability of the raw materials, for the time being, only on the results of the local tests.

These views are that the following raw materials seem to be suitable for use as body components of wall and floor tiles:

Clays:	STV 1	STV 5	Rocks:	ZE 1
	PHN 1	PHN 4		ZE 2
	KR 1	AYC E2		ZW
	CHP 1	MAR 1		PEL
		KAN 3		

This selection of raw materials is provisional and will remain incomplete until the results of the additional tests, to be carried out abroad, are at hand. But even at this stage, it can be said that in all probability it will be possible to compose a ceramic body for wall and floor tiles using domestic raw materials only.

However, none of the investigated indigenous raw materials proved suitable for ceramic glazes, stains etc., mainly because of the relatively high iron content. This causes the material to turn a reddish-brown or yellowish-brown colour during firing and makes it unfit for use as a component of ceramic glazes, in particular, or of frits, stains etc. It will, therefore, be mandatory to import all material used for glazing and decorating wall and floor tiles.

B. Assessment of the market

Domestic

According to official statistics, the imports of wall and floor tiles into Cyprus are as shown in table 1.

Table 1. Estimated imports of wall and floor tiles

Year	Value (£C)	Quantity[a/] (m^2)
1970	222,620	85,620
1971	320,790	123,380
1972	439,920	168,850
1973	588,470	226,340
1974[b/]	502,110	193,120

a/ Average £C $2.6/m^2$.

b/ First six months only.

Discussions with leading importers of wall and floor tiles and sanitary-ware made it obvious that, in the absence of official statistics, the estimated post-1974 figures were not representative of the future requirements of the Cyprus market. In all probability, the future sales of wall and floor tiles will develop as shown in table 2.

Table 2. Estimated future imports of wall and floor tiles

Year	Value (£C)	Quantity[a/] (m^2)
1976	300,000	115,000
1977	400,000	155,000
1978	530,000	205,000
1979	670,000	260,000
1980	890,000	340,000

a/ Average £C $2.6/m^2$.

It can be assumed that a minimum of 50% of the total requirements of the Cyprus home market will be sold by the wall and floor tiles factory once it is established.

Export

The assessment of the potential export market is largely based on available statistics of the respective countries. However, as not all the figures are available in official statistics, some estimates had to be made.

Table 3. Potential export market for wall and floor tiles

Country	1972	1973	1974	1980
	(tons)			
Bahrain	3,000 a/	4,500 a/	5,992	
Iraq	3,500 a/	4,260	5,000 a/	
Kenya	1,455	1,505	1,265	
Kuwait	7,000 a/	9,599	11,229	
Libyan Arab Republic	25,349	31,069	35,000 a/	
Saudi Arabia	4,675	8,717	12,000 a/	
Syrian Arab Republic	5,657	5,500 a/	5,464	
Total	50,616	65,150	75,950	110,000 a/
	(in thousands of m^2)			
The ratio of wall to floor tiles is 60 to 40 (average 14 kg/m^2)	3,615	4,653	5,425	7,850

a/ Estimated figures.

If Cyprus had a 5% share of the export market, it could amount to approximately 392,000 m^2 per annum.

Conclusion

Estimated requirements of the domestic market in 1980	340,000 m^2
Estimated requirements of the export market in 1980	7,850,000 m^2
Estimated sales of the proposed tile factory	
Domestic market: 50% of 340,000 m^2	170,000 m^2
Export market: 5% of 7,850,000 m^2	392,000 m^2
Total	562,000 m^2

A proposed plant size for the production of about 500,000 m^2 per annum would therefore be completely justified.

Tentative product selection

Discussions with several importers resulted in the following production figures being proposed:

Wall tiles

70-60% comprising:	150 x 150 mm	90%
	108 x 108 mm	10%

Floor tiles

30-40% comprising:	200 x 200 mm	70%
	300 x 300 mm	15%
	200 x 100 mm	15%

The ratio of undecorated to decorated tiles would be approximately 15:85%.

TEXT

II. THE PROPOSED PLANT

The planned tile factory will be of an efficient but conventional type, using the most modern and tested technology, machinery and kilns.

Only indigenous raw materials will be used for the ceramic body whereas those for the glazes, screen-printing etc. will all be imported. As the ratio of body materials to glaze and printing materials is about 10 to 1 it is obvious that Cypriot raw materials will play an important rôle.

Location

The location of the proposed facilities is still under consideration but it has been suggested that it should be near to the raw materials, to the energy sources and, because of the importance of the export market, to the port facilities. Manpower is amply available and therefore less of a problem.

Production

The planned production capacity will be approximately 500,000 m^2 per annum, of glazed wall and floor tiles, decorated and undecorated. Specifications of the tiles produced will be according to German industrial standards (Deutsche Industrie-Norm (DIN)) 18 155 of January 1962 (ceramic walling and flooring tiles) or DIN 18 155 of January 1973 (ceramic earthenware tiles). Testing will take place according to the German standards indicated in DIN 18 155.

A. Technology

The determination of the required machinery and equipment and the technological sequence of operation is based on the proposed production capacity of 500,000 m^2 per annum salable production. This, in turn, had to be based on several assumptions as the complete results of the raw material investigations are still unknown.

One assumption is that approximately 60% of the raw materials can be ground in wet-grinding ball mills and the other 40% dissolved in blungers. The grinding period is between 16-18 h, while the dissolving would take a maximum of 4 h. The grinding fineness used aims at a residue of 3% on a screen with a clear width of 100-µm mesh.

The water content of the slip - the acqueous suspension of the complete raw-material mix or body composition - is approximately 40%; by the admixture of suitable liquefying agents, it should be possible to achieve a considerable reduction of this.

Raw materials store

A raw materials store is proposed to hold a three-months stock. This amount should be sufficient as raw materials in Cyprus are not subjected to much seasonal change of weather and can normally be delivered to the factory almost dry. Thus, the store's holding capacity will be 33 tons/day x 70 days = 2,310 tons.

Based on a bulk density of 1.5 tons/m^3 (loose heaping of clays and hard materials) and on an average heaping height of 3 m, the floor space required will be approximately 500 m^2.

The raw materials, delivered to the factory by motor trucks, are stored in boxes. A weight control of the trucks is possible on the weight-bridge provided for that purpose.

A stone-crusher roller mill is planned. For the pre-crushing of biscuit scraps or materials of a similar hardness, this machine has an output capacity of approximately 1.5 tons/h. If harder materials, such as feldspar and dolomite, with a hardness of 5°-6° according to the Mohs' scale of hardness, are processed, an output of about 1.0 ton/h can be expected. As only materials with a hardness of 6° can be disintegrated, quartz must be available in the form of sand.

The raw materials pre-crushed by the stone-crusher roller mill are conveyed by a steeply-inclined conveyor belt into the storing boxes from where they, like the other raw materials, are brought to the weighing plant by a shovel loader. At the weighing plant, the raw materials are taken out of the boxes by means of shovel loaders and charged into a box feeder. This is connected, by means of four pressure cells via corresponding base frames, to the foundation. According to the load on the pressure cells, they transmit electric tensions which, by means of a special electronic weighing control, are transformed into corresponding weight values.

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The body composition for the mills and blungers are weighed separately. The emptying of the box feeder and the transport of the raw materials to the mill or to the dissolving blunger are effected from the central control by a push-button. A clay shredder is set up beyond the box feeder for the purpose of pre-crushing the clays.

The time required for the composition of a batch depends on the distance to be covered by the shovel loader, its size and speed, the skill of the driver and the number of components in the batch. As a rule, it takes about 30 minutes for the filling of the box feeder. The discharge capacity of the box feeder, and the conveying capacity of the belt system, are chosen so that a 6.5 tons ball mill could be filled in about 20 minutes.

Preparation of slip

As previously mentioned, it is assumed that 60% of the raw materials will be ground in wet-grinding ball mills. The gross requirement of body composition is 28.8 tons/day. Consequently, the requirement would be: 28.8 tons/day x 0.6 = 17.3 tons/day. It is therefore proposed to use three ball mills each of a capacity of 6.5 tons.

Water is supplied by a pipe-line system with built-in fully automatic water-flow meter; the emptying of the mills takes place by using compressed air.

For plastic materials, the preparation, using the remaining 40% of the raw materials, would be: 28.8 tons/day x 0.4 = 11.5 tons/day. The quantity of slip, if the water content is 40%, would be calculated as follows: 11.5 tons of clay + 7.7 tons H_2O = 19.2 tons of slip. With this water content, the weight of the slip can be supposed to be approximately 1.6 kg/litre. The dissolving blungers should thus have a holding capacity of 12 m^3. Also, assuming that the material ground in the ball mills will be available in a slip with 40% water content, an additional holding capacity of the blungers equal to 18 m^3 will be required.

These blungers can be arranged in various ways but in this case it is proposed that the dissolving blungers also serve as recepients of the slip from the ball mills and thus function as combined dissolving and mixing blungers. For practical purposes three such blungers (one for each ball mill) will be installed. Consequently, each dissolving/mixing blunger has to accommodate 10 m^3 slip. The blungers, with pole-changing motors, can be used at two different speeds, i.e. high speed for dissolving and a power-saving lower speed for mixing or stirring.

The dissolving/mixing blungers are emptied by means of special pumps; two pumps will be provided equipped with variable-speed gearing so that the quantity of slip can be adapted exactly to the screening capacity.

The sieving of the slip takes place by two high-efficiency, vibrating sieves with permanent-magnetic filters. These sieves allow the screening of the total daily quantity of 30 m^3 of slip without difficulties in one to two shifts. The sieves are also equipped to automatically discharge the residuals.

The storage vats for slip are designed to hold a quantity sufficient for two days. Only by this measure can a continuous supply of granulate to the pressing plant be ensured. To be on the safe side, there will be two stirrers, both of these for a vat with a holding capacity of approximately 30 m^3.

The quantity of granulate to be prepared daily for the press will be 28.8 tons with a residual moisture content of 6%. For economic reasons, a 24-hours-a-day operation, is recommended, which corresponds to an output capacity of 1,200 kg/h. Assuming that the slip has a water content of 40%, a spray dryer with a water evaporation capacity of 680 kg/h would cover this requirement. The spray dryer in question would produce at least 1,400 kg granulate/h. This output capacity could be increased if the water content of the slip is reduced by adding adequate liquefying agents.

The spray dryer is arranged to atomize through nozzles on the fountain principle. All parts coming into contact with the slip or with the granulate are made of stainless steel. The spray dryer will be heated by means of light fuel oil. The slip is supplied to the spray dryer from the vats by a high-pressure diaphragm pump developed especially for this purpose. The spray dryer is fully automatic and can be operated by one person.

A vibrating sieve should be placed after the spray dryer to hold back any large-sized pieces.

The storage silos are filled via a belt system and a bucket elevator. The bulk weight of the spray-dried granulate is approximately 1 ton/m^3. A total holding capacity of 100 m^3 will be required for the granulate to ensure a sufficient quantity for about three days.

The filling silos arranged above each press have a holding capacity of 2 m^3 and are equipped with monitors, signalling the maximum and minimum filling level.

The pressing plant

In order to achieve a net output of 2,000 m^2 of tiles per day, a larger gross output has to be planned taking into account inevitable losses which are assumed to be:

Scraps from glost firing	3%
Scraps from biscuit firing	5%
Scraps from pressing	8%

As the subdivision of the assortment is still uncertain, it is tentatively based, in order to determine the size of the pressing plant, on a tile size of 150 x 150 x 6 mm. On the basis of 16 h/working day, the following gross output can be calculated: 2,000 m^2/day x 1.03 x 1.05 x 1.08 = 2,340 m^2/day.

A fully hydraulic high-efficiency tile press is planned, which can reach a maximum operating speed of 27 strokes/minute. In practice, it runs at speeds between 18-24 strokes/minute according to the size of tiles to be pressed and the properties of the granulate.

The calculated output per shift is based on a tile size of 150 x 150 x 6 mm, the use of a 4-fold die and an average operation speed of 20 strokes/minute.

Taking into account downtime for maintenance work, die exchange, repairs, punch cleaning, rests during work and cleaning of the machines the empirical factor to determine the practical output per shift will be 0.7; therefore, the theoretical output per shift will be multiplied by 0.7.

The number of presses required is deduced from the following calculation:

$$\frac{20 \text{ strokes/minute} \times 4 \times 60 \text{ minutes} \times 16 \text{ h}}{44 \text{ tiles/m}^2} \times 0.7 = 1{,}220 \text{ m}^2/16 \text{ h}$$

$$\text{Number of presses} = \frac{2{,}340 \text{ m}^2/\text{day}}{1{,}220 \text{ m}^2/16 \text{ h}} = 1.9 \text{ presses}$$

However, a third press would be required for producing different sized tiles.

It is planned to have automatic fettling and stacking machines. The stacks of tiles are then set manually on the kiln cars of the biscuit firing kiln.

For the extraction of dust from the body preparation department, the group of silos and the area of the presses, there should be a chamber filter dust exhausting plant.

There is a formation of dust in the following places:

Weighing plant, box feeder and crusher

Belt system between weighing plant and ball mills respectively and the dissolving blungers

Belt system between spray dryer and group of silos for the granulate

Group of silos for the granulate

Belt system to the presses

Pressing plant with fettling station

Glazing department

The total volume of dust laden air will be approximately 490 m^3/minute and the fully automatic filtering plant will be equipped with a cleaning system.

Glaze preparation department

Approximately 1.0 kg of dry glaze is required for 1 m^2 of tiles and the quantity of glaze to be prepared daily is as follows: 2,000 m^2/day x 1.03 x 1.0 kg/m^2 = 2,060 kg/day. Given a grinding period of two days, the holding capacity of the mills amounts to: 2,060 kg/day x 2 days = 4,120 kg. Therefore, the following are required:

2 ball mills for a charge of 1,200 kg each	2,400 kg
2 ball mills for a charge of 550 kg each	1,100 kg
3 ball mills for a charge of 250 kg each	750 kg
Total holding capacity	4,250 kg

The equipment also consists of stirrers, sieves, water metering devices etc. of sufficient capacity.

Glazing and decoration

There will be two lines for the glazing of the approximate daily production of 2,060 m^2 tiles, with space reserved for a third line.

Apart from the usual standard equipment for decorating the tiles, there will be two high-efficiency automatic silk-screen printing machines on one of the two glazing lines. It will therefore be possible to decorate about 50% of the output. The practical working capacity of a glazing and decorating line is about 80-100 tiles/minute.

The collection of glazed and decorated tiles from the conveyor belt and the filling of the setting-racks in the kiln for firing will be manual operations. If desired, there can also be installed, according to the construction of the setting-racks (firm or movable), automatic transfer devices for the filling machines.

TEXT

Kiln plant

The proposed kiln plant (including dryer) consists of:

(a) 1 tunnel dryer;

(b) 1 biscuit-firing tunnel kiln;

(c) 1 glost-firing tunnel kiln.

(a) Tunnel dryer:

length	48 m
transit time	50 h
drying capacity	1,590 m^2 tiles per 24 hours

(b) Biscuit-firing tunnel kiln:

length	48 m
transit time	50 h
firing temperature maximum	1,150°C
firing capacity	1,590 m^2 tiles per 24 hours

(c) Glost-firing tunnel kiln:

length	48 m
transit time	18,4 h
firing temperature	1,050°C; maximum 1,150°C
firing capacity	1,520 m^2 tiles per 24 hours

The amount to be paid for the dryer and the kilns depends largely on which structural parts have to be imported and which could be procured in Cyprus. It is strongly recommended that these issues be clarified.

The heating of the kilns and the dryer will take place by means of oil-firing devices using a light fuel oil with a net calorific value of about 10,000 kcal/kg.

Sorting and packing

The tiles are taken manually out of the setting-racks, with the kiln cars standing close to the sorting plant, and are classified into the different qualities and shades by hand. Two sorting plants are planned. As the sorting belt is arranged to form a circuit, both sorting plants will allow classification of the tiles into qualities and colour shades while the speed of charging and sorting can be regulated exactly so that the operators are not under time pressure. In the case of automatic plants, such pressure often leads to faulty selection.

As soon as the carton is filled, it is loaded manually onto a conveyor belt that runs underneath the sorting belt towards the store for finished products. One person stands at the end of each conveyor belt, closes the cartons and stacks them onto pallets which are then transported into the store by a forklift truck.

It is planned to have sufficient floor space for the storage of about 100,000 m^2 salable wares.

B. Equipment specifications

The equipment required is listed below in sections corresponding to the sequence of operations.

Raw materials store, pre-crushing and composition of the batch

1 road vehicle balance for the weight control of body and glaze raw materials delivered to the plant

3 steeply-inclined conveyor belts: 1 for feeding the stone-crusher roller mill with uncrushed hard material and biscuit scraps; 1 for the transport of the pre-crushed hard materials and biscuit scraps to the storage boxes; 1 for the reception of the weighed raw materials and their transport onto the distributing belt

1 stone-crusher roller mill for pre-crushing mineral and ceramic raw materials, for instance, feldspar, dolomite etc., and for biscuit scraps

2 hydraulic shovel-loaders, diesel-driven for the transport of the raw materials from the boxes to the box feeder which serves for the composition of the batch

1 proportioning box feeder for the composition of the batch and for the proportioned charging onto a belt system

1 clay-shredder for the coarse crushing of soft to medium-hard clays and soft to medium-hard stones having cleavage faces

1 weighing unit with compression receiver for the box feeder, with an additional head-piece

1 electric weighing control with digital compensator, digital set value, actual value comparing unit in a cassette storage, as well as an electric large-figure indicator installed in the raw material stock

1 electrically movable and reversible trough-type conveyor belt for the distribution of the raw materials onto cross belts

2 reversible trough-type conveyor belts for the distribution of the raw materials into the wet-grinding ball mills or the dissolving blungers

3 proximity switches for the exact positioning of the wheeled group of conveyor belts and for feeding the ball mills and the dissolving blungers

1 switchboard for the control of the belt system from the box feeder to the ball mills and dissolving blungers

Preparation of slip

TEXT

3 wet-grinding ball mills for ceramic raw materials; charge of material to be ground, depending on the admixture of water and grinding media, will be about 6,500 kg, including the necessary slow-speed drives, complete switch cabinets, silex linings and flint pebbles

1 fully-automatic, 2-stage compressor plant, including the compressed air-line from the central compressor station to the ball mills in the slip preparation section, for the supply of compressed air inside the body and glaze preparation plant and on the glaze lines

1 automatic water meter NW 50 (including strainer) for the exact charging of the ball mills and dissolving blungers with the water necessary for the corresponding specific weight of slip

1 water supply line from the local water supply system to the ball mills and screw blungers inside the slip preparation section

1 compression line for slip from the ball mills to the screw blungers including all fittings and hose accessories

3 screw blungers with pole-changing motor as dissolver, agitator and stirrer for dissolving clays and kaolins, as well as for the subsequent mixing with slip coming from the ball mills

2 adjustable slip conveying pumps with variable speed gear for the conveyance of the mixed slip from the screw blungers to the final screening station. The pump capacity should be adjustable from 1.5-18 m^3/h of water under no pressure

1 stone catcher installed into the suction line in front of the slip conveying pumps for separating the coarse particles inside the slip

2 high-efficiency vibrating sieves with automatic discharge of the coarse residue for the final screening of the ready slip:

fine screen	0.10 mm
density of slip (assumed)	1.6 kg/litre
screening capacity	2 m^3/h

2 sets of permanent-magnetic filter inserts consisting of four permanent-magnetic lattice inserts and an aluminium funnel

2 body distributors attached to the vibrating sieves for the uniform distribution of slip over the total sieve width

1 suction line from the screw blungers to the slip conveyor pumps

1 pressure line for the conveyance of slip from the feed pumps to the final screening station

Potable and washing water and water lines inside the slip preparation section

Spray dryer, silos and other accessories

2 slow-running electric stirrers, each 30 m^3 in volume, for agitating the ready and screened slip

1 nozzle-type spray-drying plant specially designed for wall tile body:

Water evaporating capacity, 800 kg/h

Output capacity of dried material with a residual moisture content of 6%, 1,400 kg/h

Water content of the slip is assumed to be 40%

Residual moisture content of the dried material, adjustable up to 8%

Average consumption of light oil, 76 kg/h

Average consumption of electric power, 20 kW

Hot air temperature, depending on water content of slip and on desired residual moisture content, $400^{\circ} - 500^{\circ}C$

Waste air temperature, depending on residual moisture content, $70^{\circ}-110^{\circ}C$

All parts that come into contact with liquid and dried material are made of stainless steel, have nozzle atomization using the fountain principle and are equipped for counter-current flow, recovery of dust and direct heating by means of light oil

1 high-pressure diagphragm pump

1 supporting frame-work for the drying tower

Platforms, ladders, layers for grates, railings etc.

1 waste air chimney of special stainless steel

Refractory material for the horizontal combustion chamber

Oil pipe line from the day-container to the burner plant of the spray dryer

1 suction line from the slip storage tanks to the high-pressure diaphragm pumps

1 high-pressure diaphragm pump as reserve unit for the spray-dryer

1 change-over double filter to be installed into the slip suction line

Washing-water lines inside the spray-drying plant, including all fittings

1 high-efficiency vibrating sieve with automatic discharge of the residue, for dry ceramic bodies

1 stationary trough-type conveyor belt for the transport of spray-dried granulate into the bucket elevator

1 rubber-belt vertical bucket elevator for the transport of the spray-dried granulate onto a distribution belt

1 reversible trough-type conveyor belt for the transport of the spray-dried body granulate into the silo plant

1 group of silos for the storage of the spray-dried material

4 filling-level limit switches for the indication of the maximum and minimum filling level in the group of silos

2 flat-slide silo closures arranged under the outlets of the granulate storage silos as an emergency shut-off agent

2 manually actuated dosing closures flanged to the flat-slide silo closures for the dosed feeding of spray-dried material onto the subsequently arranged conveyor belt

1 reversible trough-type conveyor belt for the distribution of the spray-dried body granulate into the silos of the presses

4 filling-level proximity switches for the indication of the maximum and minimum filling level in the press silos

2 silos arranged above the filling silos of the hydraulic automatic presses

1 central switching cabinet for the control of the spray dryer and the belt system and the signal lamps of the filling level limit switches

<u>Pressing section and factory dedusting plant</u>

2 fully-hydraulic tile presses for the manufacture of ceramic wall and floor tiles and small and medium-size mosaic tiles of all usual sizes

2 complete 4-cavity dies for tiles of 150 x 150 mm

2 automatic fettling and stacking machines for ceramic tiles of all sizes

1 cooling plant for fully-hydraulic tile presses, with a cooling capacity of about 50,000 kcal/h, circulating cooling water at about 6 m^3/h, and including the necessary rotary pump, a corrosion-resistant water tank and all required fittings

1 central factory de-dusting plant for exhausting the dust in the slip and glaze preparation plant, the pressing plant and within the belt system and the granulate silos. The exhausting capacity is about 500 m^3/minute, however, without connecting lines from the exhausting places to the factory dust-exhausting plant; for this, detailed workshop drawings will be supplied by the supplier

Preparation of glaze

1 platform weighing machine for weighing the components of the glaze raw materials; maximum load: 1,000 kg; carrying capacity: 3,000 kg

1 platform weighing machine for weighing the smallest consitutents in the glaze preparation plant; maximum load: 100 kg; carrying capacity: 500 kg

2 wet-grinding ball mills, including silex linings and flint pebbles, for the wet grinding of the glaze raw materials. Charge of material to be ground, depending on admixture of water and grinding media, is about 1,200 kg

2 wet-grinding ball mills, including silex linings and flint pebbles, for the wet grinding of the glaze raw materials. Charge of material to be ground, depending on admixture of water and grinding media, is about 550-650 kg

3 wet-grinding ball mills, including silex linings and flint pebbles, for the wet grinding of the glaze raw materials. Charge of material to be ground, depending on admixture of water and grinding media, is about 250-300 kg

1 compressed-air line from the central compressor station arranged in the slip preparation plant to the wet-grinding ball mills in the glaze preparation section

1 automatic water meter NW 32, for the proportioned filling of the glaze wet-grinding ball mills with the water required for each specific weight of slip

1 scraper NW 32 installed in front of the automatic water meter

1 water supply line from the local water supply system to the glaze mills inside the glaze preparation plant

1 slip pressure line from the ball mills to the glaze storage tanks, including all fittings and hose fittings

2 slow-running electric stirrers for the storage of the ready glaze slip, suitable for useful tank volumes of up to approximately 4 m^3

2 slow-running electric stirrers for the storage of the ready glaze slip, suitable for useful tank volumes of up to approximately 1.8 m^3

3 slow-running electric stirrers for the storage of the ready glase slip, suitable for useful tank volumes of up to a maximum of 0.5 m^3

7 rust-proof outlet cocks, flanged to the corresponding glaze storage tank

3 high-efficiency vibrating sieves (fine sieve, 0.1 mm) for liquid ceramic bodies and glazes, screening capacity at approximately 1 m^3/h (specific weight of slip: approximately 1.6-1.8 kg/litre)

3 sets of permanent-magnetic filter inserts consisting of two permanent-magnetic lattice inserts and an aluminium funnel

3 body distributors attached to the vibrating sieves for the uniform distribution of the slip over the entire screening area

4 wheeled glaze tubs for the transport of the ready glaze slip from the storage tanks to the corresponding glaze lines, including the necessary rotary pump; useful volume of tank: about 300 litres

1 wet-grinding ball mill for the preparation of the pastes for silk-screen printing, charge of material to be ground, depending on admixture of water and grinding media, is approximately 100 kg, including the necessary steatite lining and steatite grinding balls

1 wet-grinding ball mill for the preparation of the silk-screen pastes, charge of material to be ground, depending on admixture of water and grinding media, is approximately 40 kg, including the necessary steatite lining and the steatite grinding balls

Potable and washing water and water lines from the local water supply system inside the entire glaze preparation plant

Glazing and decoration

2 automatic glazing lines for the automatic glazing and decorating of wall and floor tiles according to sizes still to be determined. Capacity. with tiles of 150 x150 mm, 100-130 tiles/minute. The capacity of the glazing lines depends on the thickness and characteristics of the glaze, the porosity of the biscuit-fired product, and on the silk-screen decoration. Overall length of one line is approximately 75 m

2 automatic silk-screen printing machines for the decoration of wall tiles of sizes still to be determined. Capacity, with tiles of 150 x 150 mm, 100-130 tiles/minute. The decorating machines are incorporated into one of the two automatic glazing lines and include a screening cloth, and a control for the fully-automatic sequence of the programme

1 conveyor belt for the automatic transport of the biscuit scraps from the glazing lines into collection bins

1 compressed-air line from the central compressor station, placed in the slip preparation plant, to the silk-screen printing machines installed in the automatic glazing lines

Kiln plant

1 tunnel drier for drying the raw-pressed wall tiles. Specfications are:

length of drier	48 m
kiln car dimensions:	
length	1,970 mm
width of charge	750 mm
height of charge	1,000 mm
volume of charge	1.48 m^3
width of track	400 mm
transit time	50 h
drying capacity	1,590 m^2 wall tiles per 24 hours

Insulating material of diatomite; an oil-hydraulic push-in machine with accessories; air circulation ventilators with motors and adjustable vanes; and devices to measure the temperature and residual moisture content.

1 biscuit-firing tunnel kiln for the biscuit-firing of the dried wall tiles. Specifications are:

overall length of kiln	48 m
kiln car dimensions:	
length	1,970 mm
width of charge	750 mm
height of charge	1,000 mm
volume of charge	1.48 m^3
width of track	400 mm
transit time	50 h
fuel required	light oil
net calorific value	10,000 kcal/kg
firing temperature	1,150°C maximum
firing capacity	1,590 m^2 wall tiles per 24 hours

Refractory material consisting of burner tips, normal and profiled bricks of sillimanite, silica and diverse qualities of chamotte; light-weight refractory bricks; diatomite insulating material; tracks for the kiln; a burner plant consisting of 18 oil burners with delivery pumps, and all necessary fittings; an oil-hydraulic push-in machine; ventilators and motors; and a complete measuring and regulating plant, including the temperature supervision plant.

1 glost-firing tunnel kiln for the glost-firing of the biscuit-fired wall tiles. Specifications are:

overall length of kiln	48 m
kiln car dimensions:	
length	1,970 mm
width of charge	750 mm
height of charge	1,000 mm
volume of charge	1.48 m^3
width of track	400 mm
transit time	18.4 h
fuel required	light oil
net calorific value	10,000 kcal/kg
firing temperature (approximately)	1,050°C
(maximum)	1,150°C
firing capacity	1,520 m^2 wall tiles per 24 hours

Refractory material consisting of burner tips, normal and profiled bricks of sillimanite, silica and diverse qualities of chamotte, light-weight refractory bricks; diatomite insulating material; tracks for the kiln; a burner plant consisting of 18 oil burners with delivery pumps and circulation pumps, and all necessary fittings; an oil-hydraulic push-in machine; ventilators and motors; a complete measuring and regulating plant including the temperature supervision plant.

Structural parts for 150 kiln cars for the entire kiln plant consisting of:

300 wheel sets for 150 kiln-car frames including ball bearings;
150 kiln-car linings consisting of a refractory tamping compound, light-weight refractory bricks and insulating bricks.

Sorting and packing

2 lines for the manual sorting and packing of tiles by means of a rotary-belt system complete with all conveyor belts including a control panel

2 gas-powered forklift trucks for the transport of the packed tiles from the packing machines into the store for finished ware, as well as for the delivery department and repairs within the factory

Spare parts and wearing parts (for an operating period of from one to two years)

Recommendations for spare and wearing parts, which have not yet been specified, will be made according to experience.

C. Requirements for raw materials etc.

Raw materials

According to their suitability, indigenous raw materials (bentonitic, halloysitic and kaolinitic clays, granophyres, trondhjemites, quartz) will be used for the composition of the body whereas the raw materials (china clay, ball clay, frits, stains etc.) for the composition of the glazes will be imported because they do not occur in Cyprus.

The printing colours, printing media and other materials used in screen printing to decorate the tiles will also have to be imported.

The approximate consumption of raw materials for the planned production of 500,000 m^2/annum will be:

Preparation of the body	33 tons/day
Preparation of the glazes	3 tons/day
Decoration of the tiles	0.1 tons/day

Fuel

For the heating of the spray dryer, the tunnel dryer and the two kilns, a light fuel oil of approximately 10,000 kcal/kg net calorific value will be employed. The required quantity will be approximately 5,000 kg/day.

Power

The electric-power consumption of alternating current or three-phase current will be about 6,500 kWh/working day.

Water consumption

The water consumption will be approximately 30 m^3/day.

Transportation requirements

The raw materials for body, glaze and decoration as well as the fuel oil will be delivered to the factory by truck from the mines, airports, ports or refineries. It can be assumed that these vehicles will be owned by the mines, forwarding agencies and refineries. Therefore, the purchase of vehicles for the delivery of tiles to the customers should be taken into consideration.

D. Plant layout, bids, orders and schedule of construction

Plant layout

The building area would be 192 m long and 44 m wide and would be approximately subdivided as follows:

Manufacturing plant	5,850 m^2
Raw material store	1,500 m^2
Storage of finished products	1,150 m^2
Total covered space	8,500 m^2

Therefore, the size of the site should be a minimum of 25,000 m^2, and should be 40,000 m^2 in case production doubles.

Bids

Taking into consideration the data given in this feasibility study, it would appear reasonable to expect tender documents to be prepared and bids to be made within four months.

Orders

The terms and conditions of the contract should comprise:

Ordering and conditions of delivery
Price and conditions of payment
Reservation of rights of ownership

Dates of delivery
Dispatch and transfer of risk
Erection of the plant
Responsibility for defects in delivery
Withdrawal of the customer from the contract
Withdrawal of the supplier from the contract
Competent court
Any other arrangements to be agreed upon

The time limit to carry out the placing of the order (including the evaluation of bids received and the confirmation of the order by the supplier) should not exceed four months.

Schedule of construction

An approximate schedule of construction for the plant could be as follows (time in months):

Drafting of the construction drawings	3
Erection of buildings; construction of roads; installation of water and power connections; erection of oil storage tanks	12
Installation of machinery and equipment, erection of kilns etc.	6
Commissioning of the plant	3
Total	24

Because the erection of the buildings and the installation of machinery, equipment, kilns etc. can, to a certain extent, take place simultaneously, the schedule can be shortened by from four to six months.

E. Management and labour

Prospective owners

It is expected that the Cyprus Development Bank in Nicosia will sponsor this project on behalf of the Cyprus Government with the participation of the major importers of tiles.

Staff

The staff requirements are as follows:

[illegible]	Number of persons	[illegible] £C/annum	[illegible] £C/annum
1. Management and technical staff			
General manager	1	5,000	5,000
Production manager	1	3,000	3,000
Sales manager	1	3,000	3,000
Salesmen	2	1,500	3,000
Accountant	1	2,500	2,500
Book-keeper	1	1,500	1,500
Designer	1	1,500	1,500
Laboratory technicians	2	1,500	3,000
Clerk/typists	4	600	2,400
Subtotal	14		24,900

	Number of persons	£C/annum	£C/annum
2. Labour			
Supervisors	4	2,000	8,000
Skilled workers, male	78	1,000	78,000
Skilled workers, female	24	830	19,920
Semi-skilled workers, male	3	830	2,490
Unskilled workers, male	17	630	10,710
Maintenance workers	4	1,000	4,000
Guards	4	600	2,400
Subtotal	134		125,520
Management and technical staff	14		24,900
Labour	134		125,520
Total staff requirements (salaries and wages)	148		150,420

F. Cost estimates

Land and buildings

The requirements for buildings are 10,000 m^2 broken down as follows:

Production hall	5,850	
Raw materials store	1,500	
Finished goods store	1,150	8,500
Offices	500	
Workshop and laboratory	500	
Canteen etc.	500	1,500
Total covered area		10,000 m^2

The cost per square metre of covered area for factory buildings is £C 18.00; thus the cost of the buildings is estimated at 10,000 m^2 x £C 18 = £C 180,000. For these buildings the required land area is 25,000 m^2, or approximately 19.3 donums. Allowing for future expansion, about 30 donums (38,800 m^2) of land are required. This area is to be rented as an industrial estate; the land necessary for the extractions of raw material is estimated at about £C 20,000.

Plant and equipment

The approximate cost of machinery and equipment is broken down as follows:

	£C	
Machinery and equipment specified in section B above	803,500	
Equipment for laboratory and workshop	50,000	
Shovel loaders and forklift trucks	25,000	
		878,500

Seaworthy packing	64,600	
Freight	64,600	
		129,200
Metallic constructions, platforms, silos etc. (150,000 kg at £C 0.200)		30,000
		1,037,000
Installation expenses, electricity and telephone connexions etc. (approximately 10%)		103,770
Cost of plant and equipment		1,141,470
Plus a contingency fund		58,530
Estimated total cost of plant and equipment		1,200,000

G. Financial plan

Total cost of the project

The fixed assets amount to £C 1,400,000 of which £C 1,200,000 represents the total cost of plant and equipment and £C 200,000, the total cost of land and buildings.

Table 4 gives the working capital required annually for the third through the twelfth production year.

Table 4. Working capital calculations

Year	3	4	5	6	7	8–12 (per annum)
Production (m^2)	250,000	300,000	350,000	400,000	450,000	500,000
			£C			
Salaries and wages (2 months)	25,000	25,000	25,000	25,000	25,000	25,000
Glazes and stains (4 months)	27,000	32,000	37,000	42,000	47,000	53,000
Fuel (3 weeks)	3,600	3,700	3,800	3,900	4,000	4,100
Packing (3 months)	6,250	7,500	8,750	10,000	11,250	12,500
Administration and sales	6,000	7,200	8,400	9,600	10,800	12,000
Stock of finished goods (about 2.5 months)	82,150	89,600	97,050	104,500	111,950	118,400
Total working capital	150,000	165,000	180,000	195,000	210,000	225,000

F

Funding

Funding will consist of an equity of approximately 40% of the fixed assets and working capital given above, with the remaining 60% in loans.

TEXT

H. Operational forecasts (profitability)

Calculations are based on figures derived from experience. Estimates of cost factors are generally on the high side, whereas those for sales prices are on the low side. Therefore, it can be assumed that the figures given in the tables and calculations will not be too far from reality. Altogether, it can be said that the planned venture will be viable and profitable.

A sensitivity analysis follows the tables.

Table 5. Operating costs

Year[a]	3	4	5	6	7	8-12
Production (m^2)	250,000	300,000	350,000	400,000	450,000	500,000
				£C		
Rent on land	3,000	3,000	3,000	3,000	3,000	3,000
Clays etc.[b]	1,300	1,500	1,800	2,000	2,300	2,500
Salaries and wages	150,000	150,000	150,000	150,000	150,000	150,000
Electricity	20,000	22,500	25,000	27,500	30,000	32,500
Fuel	63,000	64,700	66,400	68,100	69,900	71,600
Glazes and stains	80,000	96,000	112,000	128,000	144,000	160,000
Water	1,200	1,200	1,200	1,200	1,200	1,200
Spare parts	25,000	25,000	25,000	25,000	25,000	25,000
Packing	25,000	30,000	35,000	40,000	45,000	50,000
Administration expenses [c]	7,400	7,900	8,400	8,900	9,400	9,900
Selling costs[d]	18,400	19,700	21,000	22,200	23,500	24,800
Total expenditure	394,300	421,500	448,800	475,900	503,300	530,500
Revenue	500,000	600,000	700,000	800,000	900,000	1,000,000

a/ First two years of operation are non-productive.

b/ 300 mils/ton (assumed consumption 17 kg/m^2 of tile).

c/ 2% on total of other costs before interest and depreciation.

d/ 5% on total of other costs before interest and depreciation.

Table 6. Debt service

Year		Loan	Outstanding loan	Interest	Loan repayment	Interest paid during the year
		£C				
1		-	-	-	-	-
2	End of 1st half	780,000	-	-	-	-
	End of 2nd half	185,100	965,100	35,100	-	35,100
3	End of 1st half	965,100	965,100	43,430	-	86,860
	End of 2nd half	[illegible]	965,100	43,430	-	
4	End of 1st half		965,100	43,430	-	86,860
	End of 2nd half		965,100	43,430	-	
5	End of 1st half		965,100	43,430	48,250	84,690
	End of 2nd half		916,850	41,620	48,250	
6	End of 1st half		868,600	39,100	48,250	76,020
	End of 2nd half		820,350	36,920	48,250	
7	End of 1st half		772,100	34,740	48,250	67,320
	End of 2nd half		723,850	32,580	48,250	
8	End of 1st half		675,600	30,400	48,250	58,630
	End of 2nd half		627,350	28,230	48,250	
9	End of 1st half		579,100	26,060	48,250	49,950
	End of 2nd half		530,850	23,890	48,250	
10	End of 1st half		482,600	21,720	48,250	41,270
	End of 2nd half		434,350	19,550	48,250	
11	End of 1st half		386,100	17,370	48,250	32,570
	End of 2nd half		337,850	15,200	48,250	
12	End of 1st half		289,600	13,030	48,250	23,890
	End of 2nd half		241,350	10,860	48,250	
13	End of 1st half		193,100	8,690	48,250	15,210
	End of 2nd half		144,850	6,520	48,250	
14	End of 1st half		96,600	4,350	48,250	6,530
	End of 2nd half		48,350	2,180	48,350	

Table 7. Physical depreciation

	Original value (£C)	Depreciation rate (%)	Annual depreciation Production year 1-5	6	Residual value in 10 years
			£C		
Machinery (group A)	116,350	20	23,270	-	-
Machinery (group B)	464,300	10	46,430	46,430	-
Machinery (group C)	115,950	6.67	7,730	7,730	38,650
Machinery (group D)	444,400	5	22,220	22,220	222,200
Land	20,000	-	-	-	20,000
Buildings	180,000	4	7,200	7,200	108,000
Preliminaries	59,000	20	11,800	-	-
Total	1,400,000		118,650	83,580	388,850

Figure. Break-even chart

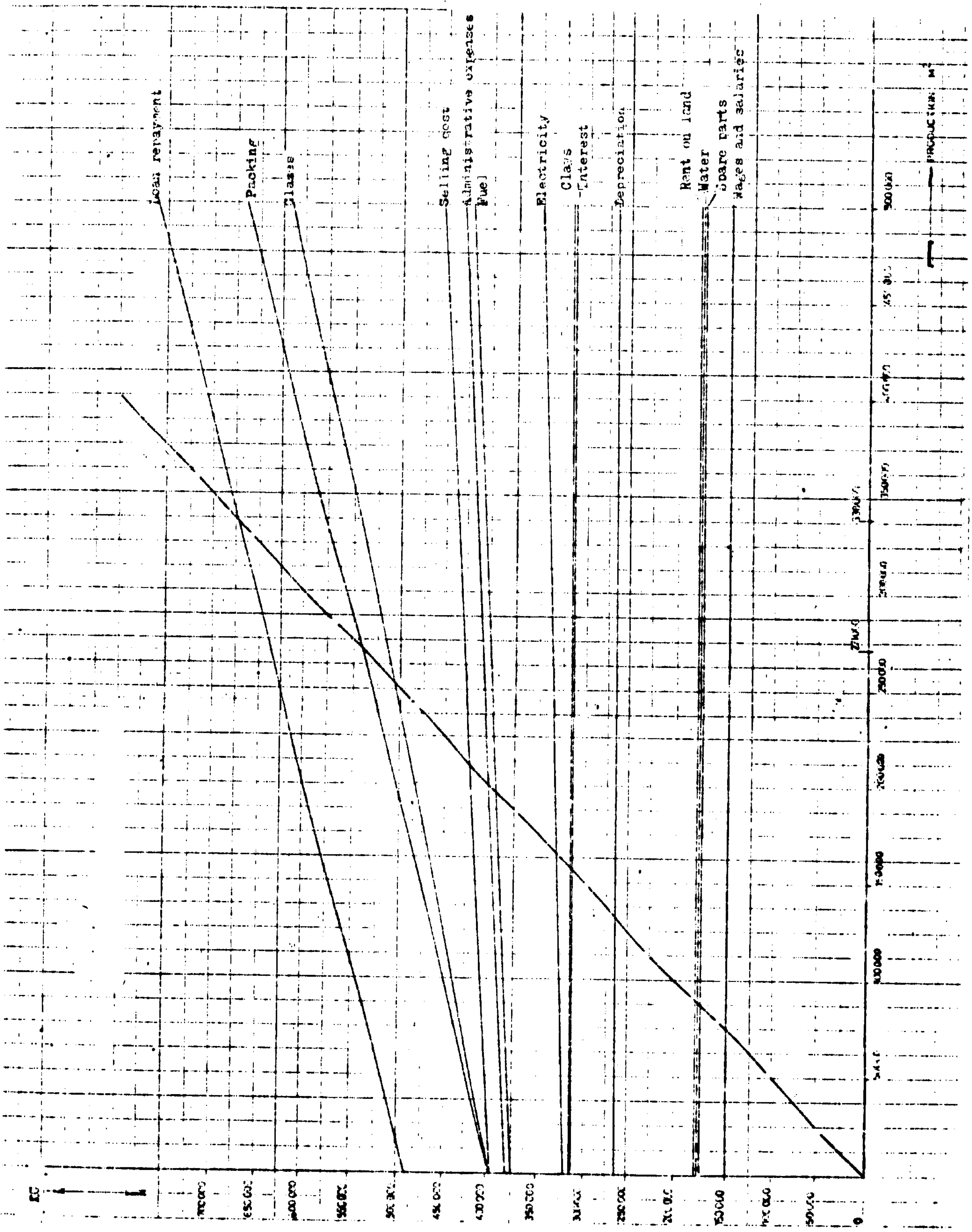


Table 8. Computation of income tax
(£C)

Year	1	2	3	4	5	6	7	8	9	10	11	12
Loss brought forward	-	-	(35,100)	(1,774,560)	(1,682,920)	(1,516,410)	(1,268,330)	(938,950)	(679,380)	(259,830)	-	-
Sales revenue	-	-	500,000	600,000	700,000	800,000	900,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Operating cost	-	-	394,300	421,500	448,800	475,900	503,300	530,500	530,500	530,500	530,500	530,500
Depreciation on buildings and preliminaries	-	-	275,000									
Depreciation on machinery	-	-	1,483,300					151,300				
Interest	-	35,100	86,860	86,850	84,690	76,020	67,320	58,630	49,950	41,270	32,570	23,890
Taxable profit (or loss) carried forward		(35,100)	(1,774,560)	(1,682,920)	(1,516,410)	(1,268,320)	(938,950)	(679,380)	(259,830)	168,400	436,930	445,610
Tax (25% on profit)	-	-	-	-	-	-	-	-	-	42,100	109,200	111,402

Notes: 1. The figures in parenthesis represent losses.

2. Tax is paid the year following that in which it is incurred.

Table 9. Cash flow
(£C)

Year	1	2	3	4	5	6	7	8	9	10	11	12
A. CASH INFLOW	500,000	1,085,100	500,000	600,000	700,000	800,000	900,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
Equity	500,000	120,000										
Loan		965,100										
Sales revenue (£C 2,000/m^2)			500,000	600,000	700,000	800,000	900,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
B. CASH OUTFLOW	500,000	1,085,100	496,160	523,360	644,990	663,420	798,470	685,630	676,950	668,270	701,170	759,590
Fixed capital expenditure:	500,000	900,000					116,350					
Land	20,000											
Buildings	144,000	36,000										
Machinery and equipment	311,000	726,000					116,350					
Installation of machinery		104,000										
Pre-investment and start-up expenses	25,000	34,000										
Working capital		150,000	15,000	15,000	15,000	15,000	15,000					
Production expenditure			394,300	421,500	448,800	475,900	503,300	530,500	530,500	530,500	530,000	530,000
Debt Service		35,100	36,860	86,860	181,190	172,520	163,820	155,130	146,450	137,770	129,070	120,390
Interest on loan		35,100	36,860	86,860	84,690	76,020	67,320	58,630	49,950	41,270	32,570	23,890
Loan repayment					96,500	96,500	96,500	96,500	96,500	96,500	96,500	96,500
Taxes											42,100	109,200
C. SURPLUS (A-B)	-	-	3,840	76,640	55,010	136,580	101,530	314,370	323,050	331,730	298,830	240,410
D. DEPRECIATION RESERVE	-	-	3,840	30,140	8,510	43,580	8,530	221,370	199,050	207,730	143,830	85,410
E. SURPLUS FOR DIVIDEND (C-D)	-	-	-	46,500	46,500	93,000	93,000	93,000	124,000	124,000	155,000	155,000
or percentage of equity	-	-	-	7.5	7.5	15.0	15.0	15.0	20.0	20.0	25.0	25.0

Sensitivity analysis

The various elements that constitute the cash flow (table 9) are as follows:

- Q = Quantity of production
- S = Selling price per m^2
- CE = Capital expenditure
- I = Interest on loan
- LR = Loan repayment
- D = Depreciation
- E = Electricity costs
- F = Fuel costs
- G = Glazes and stains
- P = Packing costs
- CL = Clays etc.
- R = Rent on land
- W = Wages and salaries
- WA = Water
- SP = Spare parts
- AD = Administration expenses
- SC = Selling costs

Thus, the surplus (line C of table 9) is given by:

$$\text{Surplus} = S \times Q - (E+F+G+P+CL+R+W+WA+SP+AD+SC) - I - LR$$

Market

If the expected level of production and sales changes by an amount dQ then the surplus will change by an amount equal to

$$\begin{aligned} d\,(\text{surplus}) &= SdQ - (dE+dF+dG+dP+dCL+dAD+dSC)dQ \\ &= SdQ - 0.59\,dQ \\ &= 2dQ - 0.59dQ \\ &= 1.41\,dQ \end{aligned}$$

where the selling price S = £C $2/m^2$ and the factor £C 0.59 per m^2 is derived from the break-even chart (figure). Thus, if there is a change of production/sales of 10% for expected production of 300,000, 400,000 and 500,000 m^2, dQ becomes 30,000, 40,000 and 50,000 m^2, and the corresponding changes of surplus will be £C 42,300, £C 56,400 and £C 70,500. This change of surplus, expressed as a percentage of the original surplus, will be 55%, 41% and 22%.

Selling price

For a variation of selling price by an amount dS the surplus will change by an amount equal to $d(\text{surplus}) = QdS$.

If the selling price changes by 10%, dS = £C 0.2/m^2 and for levels of production of 300,000, 400,000 and 500,000 m^2 the change in surplus will be £C 60,000, £C 80,000 and £C 100,000, i.e. 78%, 56% and 32% of the original surplus.

Cost of materials

Glazes and stains. If there is a change dG in the cost of glazes and stains the change in surplus will be given by d(surplus) = -dG -(0.32 Q). If the cost of glazes changes by 10%, dG = 0.032Q, and for levels of production 300,000, 400,000 and 500,000 m^2, this change will represent £C 9,600, £C 12,800 and £C 16,000 or 13%, 9% and 5% of the original surplus.

Electricity cost. If the electricity cost rises by 10%, the rise of the annual electricity bill will be by 750 + 0.005Q and the lowering of surplus for the three levels of production will be £C 2,250, £C 2,750 and £C 3,250 or 3%, 2% and 1% respectively.

Fuel cost. If the fuel costs rise by 10%, the rise of the annual fuel cost will be 5,440 + 0.00344Q and the lowering of surplus for the three levels of production will be £C 6,472, £C 6,816 and £C 7,160 or 8%, 5% and 2.3% respectively.

Capital expenditure

For a change d(CE) of plant cost the change in surplus will be

$$\begin{aligned} d(\text{surplus}) &= d(LR) + d(I) \\ &= d(0.60CE \times 0.1) + d(0.60CE \times 0.09 \times 0.5) \\ &= 0.06d(CE) + 0.027d(CE) \\ &= 0.087\, d(CE) \end{aligned}$$

If the capital expenditure changes by 10%, d(CE) = £C 140,000 and the change in surplus will be £C 12,180 or 15.9%, 8.9% and 3.9% for levels of production of 300,000, 400,000 and 500,000 m^2 per year respectively.

TEXT

Table 10. Internal rate of return (= 17.2%)

Year	Share capital £C	Surplus £C	Factor	Share capital resultant £C	Net inflows, resultant £C
1	500,000	-	1.000000	500,000	-
2	120,000	-	0.853242	102,389	-
3		3,840	0.728022		2,796
4		76,640	0.621179		47,607
5		55,010	0.530016		29,156
6		136,580	0.452232		61,766
7		101,530	0.385863		39,177
8		314,370	0.329235		103,502
9		323,050	0.280917		90,750
10		331,730	0.239690		79,512
11		298,830	0.204514		61,115
12		240,410	0.174500		41,952
12		388,850 a/	0.174500		67,854
12		225,000 b/	0.174500		39,263
12		-241,350 c/	0.174500		-42,116
13		-111,402 d/	0.148891		-16,587
				602,389	605,747

$$\frac{\text{Present value of return}}{\text{Present value of share capital}} = \frac{605.747}{602.389} \approx 1.00$$

a/ Residual value of assets at end of 12-year period

b/ Working capital in hand

c/ Loan outstanding

d/ Taxes payable

Table 11. Net present value					
Production year	Share capital	Surplus	Factor	Present value of share capital[a]	Present value of cash inflow[a]
	£C	£C		£C	£C
1	500,000		1.000	500,000	
2	120,000		0.917	110,040	
3		3,840	0.842		3,233
4		76,640	0.772		59,166
5		55,010	0.708		39,497
6		136,580	0.650		88,777
7		101,530	0.596		60,877
8		314,370	0.547		171,960
9		323,050	0.502		162,171
10		331,730	0.460		152,596
11		298,830	0.422		126,106
12		240,410	0.388		93,279
12		388,850[b]	0.388		150,874
12		225,000[c]	0.388		87,300
12		-241,350[d]	0.388		-93,644
13		-111,402[e]	0.355		-39,548
				610,040	1,062,644

	£C
Present value of return	1,062,644
Present value of share capital	-610,040
Net present value	452,604

a/ Discounted at 9%.

b/ Residual value of assets at the end of 12-year period.

c/ Working capital in hand.

d/ Loan outstanding.

e/ Taxes payable.

TEXT

J. Economic benefits

Foreign exchange

Up till now, quality wall and floor tiles have not been produced in Cyprus and still have to be imported, therefore, the foreign exchange factor is of great importance. Even a low production, during the first few years, will achieve considerable savings of foreign exchange. With full-scale production (500,000 m^2/annum) the figures (in £C) will be as follows:

Revenue		1,000,000
Less		
Glazes and stains	160,000	
Fuel	71,600	
Electricity (50% of total cost)	16,250	
Spare parts	25,000	
Depreciation on machinery	78,650	351,500
Annual foreign exchange savings (£C)		648,500

Employment, trade increase etc.

The planned factory will employ about 150 employees, technicians, and workers (of which about 30 will be female) which will also have considerable impact on related professionals, and also stimulate artisan and trade businesses thereby increasing government revenues.

A further contribution, if and when full scale production is achieved and loan interest and repayment are made, will be an anticipated annual tax of about £C 100,000.

III. RECOMMENDATIONS

If the Government of Cyprus decides to go ahead with the proposed wall and floor tiles project, the following UNIDO/UNDP assistance is recommended.

1. Testing abroad of the raw material samples (batches I and II) according to the agreement reached with UNIDO.

2. A second mission of an approximate duration of four months during which the expert's duties would be:

(a) To evaluate the results of the raw materials tests carried out abroad;

(b) To prepare an engineering report for the tiles plant;

(c) To draft the final formulation of the tender documents;

(d) To select local technical staff for the tiles plant who would later be trained partly by the expert and partly abroad;

(e) To advise the Government on a long-range development plan for the ceramic and structural clay industry.

3. Long-term follow-up mission of a total duration of 14 to 18 months during which the expert's duties would be as follows:

Part 1 (2 months)

(a) To evaluate the tenders received;

(b) To assist with the ordering of machinery and equipment from local and international firms.

Part 2 (12 to 16 months)

(a) To train local staff in ceramic technology, testing and laboratory methods, and identification, diversification and development of products;

(b) To provide technical knowledge in the production of wall and floor tiles, for example:

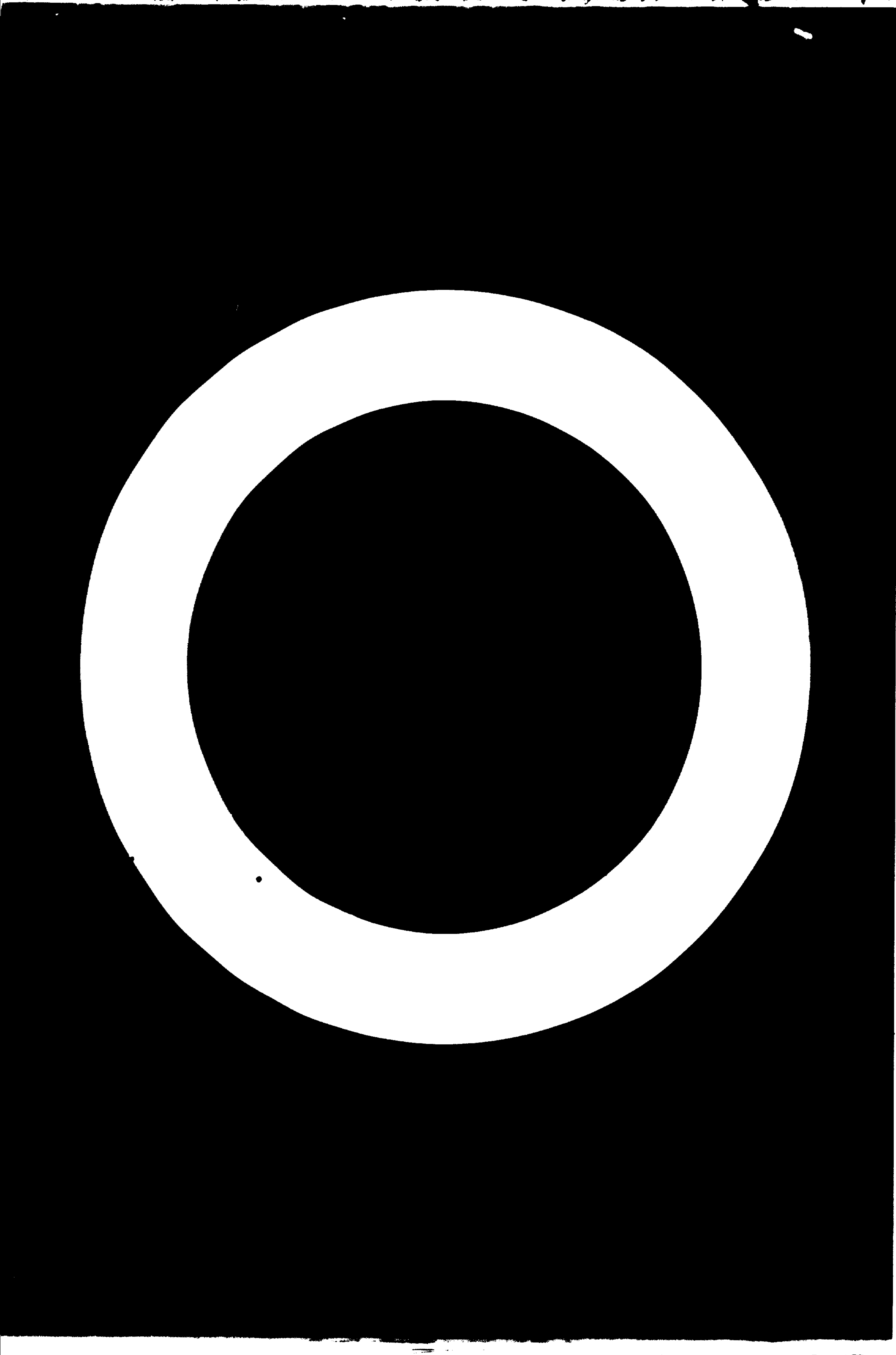
(i) To compose and test suitable ceramic bodies for use in the manufacture of wall and floor tiles made of selected local raw materials;

(ii) To compose and test, as far as facilities allow, ceramic glazes etc. for wall and floor tiles made of imported raw materials;

(c) To assist during the erection of the tiles plant and the installation of machinery and equipment in order to achieve a suitable production line;

(d) Procurement of suitable laboratory equipment;

(e) Fellowship training.



Annex I

Table 12. Chemical analyses of clays, granophyres and trondhjemite
(Calculated on dry basis)

Serial No.	Sample No.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O^+	TiO_2	P_2O_5	MnO	CO_2	S	Total	Total Fe as Fe_2O_3	Soluble sulphates as SO_4 in ppm	Soluble sulphates as S in %	Soluble chlorides	Loss on ignition unground	Loss on ignition ground
1	KAS 1	62.66	15.18	5.86	0.29	1.97	4.25	1.12	0.99	5.10	0.60	0.09	0.17	1.64	tr	99.92	6.17	tr	tr	100	4.3	4.3
2	KAS 2	59.03	13.47	7.05	0.29	3.11	4.15	0.60	1.42	7.58	0.56	0.12	0.27	3.43	tr	101.08	7.37	320	0.011	50	6.9	6.9
3	KAS 3	68.91	12.92	5.15	1.22	1.41	1.31	0.26	0.97	5.75	0.68	0.05	0.12	1.76	tr	100.54	6.51	330	0.011	50	5.5	4.9
4	KE 1	59.23	9.21	4.11	0.96	1.77	7.54	0.99	0.64	7.39	0.36	0.21	0.13	6.14	n.d.	98.68	5.17	330	0.011	150	9.8	10.7
5	MT 1	56.36	11.98	4.88	0.50	2.55	7.29	0.80	1.19	6.60	0.68	0.18	0.13	5.73	0.23	100.01	5.39	6 600	0.219	250	[illegible]	9.8
6	ML 2	57.25	12.07	5.90	0.67	2.67	5.98	0.80	1.39	7.09	0.36	0.26	0.14	5.07	0.36	100.01	6.64	9 970	0.332	225	6.6	9.1
7	KAR 1	65.59	11.92	5.99	0.34	2.63	2.58	0.49	1.02	7.18	0.56	0.13	0.16	2.39	tr	100.98	6.37	tr	tr	50	6.5	6.0
8	PEN 1	58.59	16.30	6.27	1.31	2.59	1.12	1.04	1.16	7.83	1.01	0.10	0.16	2.49	0.19	100.16	7.72	4,770	0.159	900	7.5	6.4
9	PEN 2	58.35	17.91	6.20	1.15	2.28	0.95	0.80	1.19	8.08	0.95	0.11	0.18	2.24	0.16	100.56	7.47	4,500	0.150	1,050	7.6	6.9
10	KS 1	63.84	13.83	5.71	0.33	2.62	1.72	0.44	1.22	7.48	0.64	0.24	0.33	1.75	0.10	100.25	6.20	2,650	0.083	250	6.8	6.5
11	KH 2	61.52	14.26	6.25	0.43	2.44	3.07	0.81	1.21	5.96	1.03	0.17	0.13	2.06	0.21	100.35	6.74	1,250	0.042	100	5.5	6.2
12	AN 1	63.23	11.95	5.92	n.d.	2.46	1.37	0.71	1.02	5.60	0.56	0.24	0.27	1.62	0.05	100.00	5.92	1,400	0.046	1,150	[illegible]	4.3
13	AN 2	67.23	11.12	6.01	n.d.	2.60	1.17	0.71	1.22	5.70	0.62	0.26	0.65	1.63	0.10	99.07	6.01	1,610	0.053	775	5.2	4.9
14	PAR 1	71.48	10.90	4.76	0.35	2.21	1.05	0.67	0.99	5.13	0.54	0.27	0.05	1.33	0.14	99.91	5.18	1,170	0.039	250	4.3	4.2
15	PAR 2	68.37	10.61	4.93	0.25	2.56	2.51	0.73	0.99	5.18	0.54	0.31	0.16	2.56	0.07	100.03	5.20	470	0.016	200	4.9	5.4
16	PAR 3	68.57	11.36	5.52	0.29	2.68	1.43	0.93	1.07	5.34	0.56	0.39	0.15	1.46	0.13	99.96	5.94	2,165	0.072	2,050	4.9	4.7
17	DR 1	74.07	9.15	3.73	0.14	2.02	1.92	0.27	0.80	6.18	0.47	0.21	0.05	1.85	0.13	100.99	3.99	155	0.005	70	5.2	4.4
18	DR 2	62.35	14.17	5.08	0.49	3.49	1.45	0.71	1.42	7.51	0.70	0.20	0.06	1.80	0.12	100.56	6.63	465	0.015	150	6.8	5.5
	ZG 1	73.33	12.98	2.02	1.00	0.50	2.60	4.47	0.20	1.16	0.28	0.07	0.06	0.84	n.d.	99.51	3.13					0.5
	TS	74.64	12.30	2.27	1.12	0.35	2.25	3.76	0.20	1.06	0.26	0.03	0.09	0.81	n.d.	99.15	3.52					0.5
	TA	75.20	10.52	3.69	0.58	0.27	2.27	3.92	0.20	1.04	0.21	0.07	0.05	0.53	n.d.	95.60	4.35					0.6
	PSA	71.73	12.44	1.37	1.09	0.50	2.41	5.43	tr.	1.14	0.34	0.09	0.04	0.70	n.d.	100.33	5.57					0.5

Notes: tr. = traces
n.d. = not detected

Table 13. Physical tests

Part A

Serial No.	Name of sample	Linear shrinkage: 140 mm compared with length at 105°C	1000°C	1100°C	1200°C (%)	Length at 105°C compared with length at 1000°C	1100°C	1200°C	Remarks	Moisture content at time of moulding: As percentage of dry soil weight	As percentage of dry soil weight
1	AN 1	19	26.5	29.5	27.5	9	12	10	-	58	50
2	AN 2	17±1	25.5	27±1	26	10	12	10.5	-	93	43
3	PAR 1	15	21	23	22	6.5	9.5	8	-	81	45
4	PAR 2	16	20.5	23	23	6	8	9	-	88	47
5	PAR 3	15	22.5	23.5	-	8.5	9.5	-	Sample fused at 1200°C	71	41
6	DR 1	14	17.5	18.5	-	4.5	6	-	" " " "	70	41
7	BR 2	20±1	22	22.5	-	2±1	3.5	-	" " " "	90	47
8	MN 1	14	17.5	15.5	-	3.5	1.5	-	" " " "	92	48
9	MN 2	18	21.5	22	21±1	4	5.5	3.5	-	81	44
10	MG 1	18	18	18.5	-	1	0.5	-	Sample fused at 1200°C	73	42
11	KG 2	18	-	-	21	-	-	4	Above 105°C only one rod survived, the rest were fractured and disintegrated	73	42
12	PEN 1	16.5	19	17	-	2.5	1	-	Sample fused at 1200°C	65	46
13	PEN 2	9	9	10	-	1	1.5	-	" " " "	43	30
14	MAR 1	16	21	21	23	6	7	9±1	-	68	40
15	KAN 1	-	-	-	-	-	-	-	Properties not determined because sample was not mouldable	-	-
16	KAN 2	18	24.5	24	-	7.5	6.5	-	Sample fused at 1200°C	80	44
17	KAN 3	9	9	10	10	1	2	1.5	-	30	23
18	KB 1	14	19	22.5	-	6	9	-	Sample fused at 1200°C	70	41
19	VL 1	18	25.5	26	25	9.5	10	8	One of the 2 rods fired at 1200°C fused	94	43
20	VL 2	17	24	24	23.5	9	8.5	7.5	-	79	44
21	VL 3	16	23	26	23	8	10	8	-	81	45
22	VL 4	15	19.5	23.5	23.5	6	10	10	-	76	43
23	VL 5	22±1	25	24.5	-	3.5	4	-	Sample fused at 1200°C	93	45

Table (continued) Part B.

Serial no.	Name of sample	Behaviour during drying (sample weights and loss of moisture): Weight (wt.) % moisture content (M.C.)	Moulded	Room dry	40°C	60°C	80°	100°C	200°C	Plastic limit account to B.S.: On dry weight	On wet weight	Water absorption (apparent porosity) (%): 1000°C	[illegible]°C	[illegible]°C
1	AN 1	wt.* M.C.	40.1		36.6 91	25.8 97		25.4 99	25.3 100	54	35	4	0	i.P.
2	AN 2	wt.** M.C.	51.4	29.5 88	27.5 96	27.0 96	26.8 98	26.6 99	26.4 100	52	34	1	0	i.P.
3	PAR 1	wt.* M.C.	54.5		31.4 94	30.5 98		30.2 99	30.0 100	49	32	2	0	i.P.
4	PAR 2	wt.* M.C.	54.5		30.1 95	29.3 98		29.0 99	28.8 100	48	32	1	0	i.P.
5	PAR 3	wt.* M.C.	54.7		33.3 93	32.4 97		31.9 99	31.7 100	48	32	1	i.P.	-
6	[illegible] 1	wt.* M.C.	55.8		34.3 92	33.5 96		32.8 99	32.5 100	47	33	15	13	-
7	[illegible] 2	wt.** M.C.	53.0	31.1 86	29.1 94	28.5 96	28.2 98	27.9 99	27.6 100	44	30	6	i.P.	-
8	[illegible] 1	wt.** M.C.	61.9	35.4 88	33.4 95	32.7 97	32.4 98	32.1 99	31.8 100	33	27	5	i.P.	-
9	[illegible] 2	wt.** M.C.	52.1	31.7 85	29.8 93	29.2 96	28.9 97	28.7 98	28.2 100	46	31	2	3	i.P.
10	[illegible] 1	wt.* M.C.	57.1		34.5 92	33.6 96		33.0 99	32.7 100	27	29	10	i.P.	-
11	[illegible] 2	wt.* M.C.	58.9		35.7		34.6	33.9		37	27	-	-	9
12	[illegible] 1	wt.* M.C.	55.8					30.2 99	30.0 100	33	28	12	i.P.	-
13	[illegible] 2	wt.** M.C.	53.5	44.1 80	42.3 90	41.4 95	41.1 97	40.8 98	40.5 100	35	26	6	i.P.	i.P.
14	MAR 1	wt.** M.C.	53.5	35.3 82	33.0 92	32.4 95	32.0 97	31.7 98	31.3 100	41	29	12	10	3
15	KAN 1	wt. M.C.	-	-	-	-	-	-	-	-	-	-	-	-
16	KAN 2	wt.** M.C.	52.6	32.4 85	30.5 93	29.6 96	29.6 97	29.3 93	28.9 100	47	37	3	i.P.	-
17	KAN 3	wt.* M.C.	61.2		48.2 90	47.6 94		47.0 98	46.7 100	19	16	14	9	6
18	[illegible] 1	wt.* M.C.	53.2		32.5 94	31.8 97		31.4 99	31.1 100	38	28	5	1	-
19	VL 1	wt.* M.C.	56.1		30.1 95	29.3 93		28.9 99	28.7 100	46	32	2	0	i.P.
20	VL 2	wt.** M.C.	51.3	31.4 87	29.4 96	28.9 98	28.7 99	28.5 100	28.4 100	45	31	0	i.P.	i.P.
21	VL 3	wt.** M.C.	52.1	31.6 87	29.6 96	29.1 98	28.9 99	28.8 99	28.6 100	50	32	3	0	i.P.
22	VL 4	wt.** M.C.	52.1	32.5 88	30. 96	30.1 98	29.9 99	29.9 99	29.7 100	42	28	11	0	i.P.
23	VL 5	wt.** M.C.	49.5	28.9 85	26.8 94	26.1 97	25.9 98	25.7 99	25.4 100	47	32	8	i.P.	-

Annex II

Table 14. Chemical analyses of clays and colluvium from various parts of Cyprus

Serial no.	Sample no.	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O^+	TiO_2	P_2O_5	MnO	CO_2	S	Total	Total Fe_2O_3	Soluble sulphates as SO_4 in ppm	Soluble sulphates as S in %	Soluble chlorides in ppm	Loss on ignition (unground)	Loss on ignition (ground)
1-2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	TS 3	47.15	13.35	6.64	1.76	4.55	10.35	2.35	0.93	5.33	0.83	0.08	0.10	7.24	0.07	100.73	8.61	1,650	0.05	650	10.7	10.4
4	STV 1	55.97	15.69	9.29	0.97	3.78	3.26	2.22	0.31	6.33	0.58	0.04	0.21	0.03	n.d.	98.69	10.37	n.d.	n.d.	80	4.8	4.4
5	STV 2	55.54	16.36	10.48	0.66	3.42	3.14	2.38	0.16	6.94	0.61	0.02	0.15	0.20	tr	100.09	11.21	12220	0.094	70	5.1	5.3
6	STV 3	56.20	17.00	9.93	1.68	2.70	2.07	2.36	0.62	7.27	0.71	0.04	0.20	0.03	n.d.	100.81	11.80	n.d.	n.d.	75	5.9	5.6
7	STV 4	56.20	16.31	9.45	1.12	3.84	2.59	1.69	0.46	7.54	0.62	0.04	0.20	0.06	tr	100.32	10.70	n.d.	n.d.	65	6.0	5.9
8	STV 5	57.06	15.73	9.25	0.67	5.82	1.06	1.71	0.16	8.11	0.48	0.04	0.17	0.03	tr	100.29	10.00	n.d.	n.d.	65	5.	6.1
9	PEK 1	49.04	17.70	3.54	2.69	9.94	8.55	0.60	0.22	7.16	0.24	0.01	0.10	0.03	tr	100.22	6.94	n.d.	n.d.	75	4.0	5.6
10	PEK 2	54.19	18.48	9.57	0.32	4.91	1.75	0.40	0.07	10.19	0.49	0.03	0.10	0.03	tr	100.53	9.94	n.d.	n.d.	65	7.3	7.3
11	PEK 3	49.97	15.76	6.89	4.43	4.94	3.62	1.55	0.15	7.90	0.76	0.03	0.15	0.03	n.d.	99.18	11.76	n.d.	n.d.	100	5.8	5.3
12	PEK 4	52.20	18.25	10.02	2.33	2.70	3.27	1.44	0.46	7.91	1.25	0.04	0.10	0.03	n.d.	100.00	12.62	n.d.	n.d.	60	6.1	6.2
13	KR 1	56.43	15.81	10.59	0.51	3.84	1.77	3.36	0.62	5.56	0.83	0.04	0.20	0.06	n.d.	99.67	11.17	n.d.	n.d.	100	4.0	4.5
14	CHP 1	79.44	8.58	3.48	0.22	1.09	0.72	0.46	0.93	4.51	0.48	0.09	0.21	0.24	n.d.	100.55	3.75	n.d.	n.d.	75	5.0	3.3
15	ATCE 1	55.40	15.28	6.08	3.27	5.65	4.15	4.03	0.15	4.76	0.81	0.06	0.15	0.02	n.d.	99.81	8.63	n.d.	n.d.	60	3.0	3.7
16	ATCE 2	64.29	15.07	6.10	1.39	2.21	2.41	2.85	0.36	5.23	0.58	0.10	0.10	0.02	tr	100.73	7.66	n.d.	n.d.	75	3.8	3.8
17	KAT 1	59.63	17.76	7.12	1.03	2.63	0.69	1.00	1.25	7.25	0.99	0.10	0.16	0.37	0.05	100.08	8.27	925	0.03	250	6.7	6.4
18	MCT 1	59.19	12.90	5.0[illegible]	0.42	3.11	5.10	2.09	1.44	5.46	0.73	0.21	0.37	3.54	0.07	100.24	6.10	1,475	0.05	9,400	8.0	5.3
19	TAS 1	57.77	19.36	4.20	5.60	2.05	0.15	1.30	3.49	5.55	0.94	0.13	0.05	0.10	0.34	100.47	10.43	2,770	0.09	150	-	4.6

Notes: tr = traces

n.d. = not detected

Analysis calculated on dry basis at 105°C

Table 15. Physical tests

Part A.

No.	Sample no.	Linear shrinkage: Original length compared with 105°C	1000°C	1100°C	1200°C	Length at 105° compared with 1000°C	1100°C	1200°C	Remarks
		(%)							
a	b	c	d	e	f	g	h	i	
1	TS 1	9	10	12	-	1	2	-	Rods fused at 1200°C
2	TS 2	11	11	11	14	1	1	4	-
3	TS 3	9	11	10	-	1	1	-	Rods fused at 1200°C
4	STV 1	6	7	8	12	1	2	6	-
5	STV 2	9	10	11	-	2	2	-	Rods fused at 1200°C
6	STV 3	10	12	14	16	2	4	7	-
7	STV 4	9	10	11	19	1	3	3	-
8	STV 5	14	16	18	9	11	4	4	-
9	PHN 1	6	-	6	7	-	1	2	Rods to be fired at 1000°C were broken and not available
10	PHN 2	10	12	13	13	3	4	3	-
11	PHN 3	9	11	11	16	2	2	8	-
12	PHN 4	11	14	14	15	3	4	4	-
13	KP 1	8	8	11	14	1	3	7	-
14	CHP 1	7	7	7	8	0	0	0	-
15	AYCE 1	12	6	6	-	1	1	-	Rods fused at 1200°C
16	AYCE 2	10	11	12	12	0	1	2	-
17	KAP 1	14	17	21	20	4	8	7	-
18	SOT 1	20	26	25	-	0	7	-	-
19	VAS 1	6	9	11	9	4	5	3	-

Table 15 (continued) Part B.

No.	Sample no.	Moisture content at time of moulding		Plastic limit (Pl)		Liquid limit (Ll)		Plasticity index
		Calculated on dry wt.	Calculated on wet wt.	Calculated on dry wt.	Calculated on wet wt.	Calculated on dry wt.	Calculated on wet wt.	Established by subtracting Pl from Ll both calculated on dry wt.
1	TS 1	36	26	25.5	20.5	33	25	7.5
2	TS 2	34	26	23.5	19.0	33	25	9.5
3	TS 3	33	25	23.0	19.0	31	23	8.0
4	STV 1	29	23	can not be determined		28	22	–
5	STV 2	34	25	23.0	19.0	32	24	9.0
6	STV 3	31	25	21.0	17.5	34	25	13.0
7	STV 4	32	24	22.5	18.5	34	25	11.5
8	STV 5	50	33	27.0	21.5	46	31	19.0
9	PHN 1	31	23	can not be determined		29	23	–
10	PHN 2	41	29	can not be determined		43	30	–
11	PHN 3	38	27	25	20	37	27	12.0
12	PHN 4	40	29	23	18.5	37	27	14.0
13	KR 1	37	27	25.5	20.0	32	24	6.5
14	CHP 1	32	24	23.5	19.0	30	23	4.5
15	AYCE 1	32	24	can not be determined		30	23	–
16	AYCE 2	33	25	19	16	32	24	13.0
17	MAT 1	57	36	29	23	43	30	14.0
18	SOT 1	37	46	49.5	31.0	89	47	40.0
19	VAS 1	22	18	14.0	12.5	–	–	–

Table 16. Moisture loss

No.	Sample/no.		Moulded	Room temp.	40°	60°	80°	108°	200°
1	TS 1	wt. M.C.%	64.3 0	50.3 83	49.0 90	48.1 95	47.8 97	47.5 98	47.2 100
2	TS 2	wt. M.C.%	64.8 0	50.8 82	49.4 90	48.7 95	48.4 96	48.1 98	47.8 100
3	TS 3	wt. M.C.%	66.2 0	52.9 82	51.6 90	50.8 95	50.5 96	50.3 98	50.0 100
4	STV 1	wt. M.C.%	69.22 0	54.46 84	53.7 88	52.9 93	52.5 95	52.2 97	51.7 100
5	STV 2	wt. M.C.%	65.5 0	52.8 77	51.35 86	50.32 92	50.0 94	49.5 97	49.0 100
6	STV 3	wt. M.C.%	64.1 0	50.7 80	49.5 86	48.8 91	48.3 94	48.0 95	47.2 100
7	STV 4	wt. M.C.%	65.7 0	52.7 78	51.5 86	50.5 92	50.2 92	49.8 95	49.1 100
8	STV 5	wt. M.C.%	59.0 0	42.2 81	40.6 88	39.6 93	39.2 95	38.8 97	38.2 100
9	FHW 1	wt. M.C.%	71.3 0	56.3 86	55.4 91	54.8 95	54.5 97	54.3 98	53.9 100
10	PMN 2	wt. M.C.%	62.1 0	46.8 80	45.6 86	44.5 92	44.0 94	43.5 97	42.9 100
11	PMN 3	wt. M.C.%	64.1 0	49.6 84	48.6 89	47.9 93	47.6 95	47.3 97	46.8 100
12	PMN 4	wt. M.C.%	62.0 0	47.0 83	45.8 89	45.1 93	44.8 95	44.5 97	44.0 100
13	KR:1	wt. M.C.%	66.4 0	50.4 85	49.7 89	48.86 93	48.5 95	[illegible].2 97	47.6 100
14	CMP:1	wt. M.C.%	63.4 0	49.7 85	48.7 91	48.1 95	47.8 96	47.5 98	47.2 100
15	AYCE 1	wt. M.C.%	65.4 0	52.12 83	51.4 88	50.6 93	50.4 94	50.0 97	49.4 100
16	AYCE 2	wt. M.C.%	63.9 0	49.9 84	49.00 90	48.3 94	48.0 96	47.7 97	47.2 100
17	MAT 1	wt. M.C.%	55.7 0	37.5 88	36.70 92	35.9 96	35.6 97	35.5 97	35.3 100
18	SOT 1	wt. M.C.%	50.1 0	29.7 87	28.30 93	27.4 97	27.1 98	27.0 99	26.7 100
19	VAS 1	wt. M.C.%	72.9 0	60.8 92	60.4 95	60.1 97	60.0 98	59.9 99	59.8 100

Note: Moisture loss, as given in table 1 was calculated on the basis agreed upon with the expert. The method used was based on the assumption that the moisture lost from the moulding stage to the rod being oven dried at 200°C represents 100%. All samples were dried at room temperature for eight days. After commencing the drying procedure with the use of the oven at various temperatures, e.g. 40°C, 60°C etc. drying was carried out every 24 hours for each of those temperatures.

Table 17. Porosity of samples

No.	Sample no.	Firing temperatures		
		1000°C	1100°C	1200°C
1	TS 1	21	18	-
2	TS 2	22	21	5
3	TS 3	21	21	-
4	STV 1	24	20	12
5	STV 2	17	15	-
6	STV 3	16	13	0
7	STV 4	17	15	1
8	STV 5	9	7	6
9	PKN 1	-	23	20
10	PKN 2	23	21	20
11	PKN 3	18	16	0
12	PKA 4	14	13	11
13	KF 1	24	17	13
14	CHP 1	20	18	18
15	AYCE 1	23	22	-
16	AYCE 2	17	17	-
17	MAT 1	9	1	2
18	SOT 1	5	3	6
19	VAS 1	6	1	5

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