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# DEVELOPMENT AND RATIONALIZATION OF CEMENT FACTORIES AND RELATED INDUSTRIES IN THE PTA SUBREGION
DP/RAF/88/077/11-54

## Technical report: Technical assistance to the lime industry in the United Republic of Tanzania

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

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## Explanatory notes

The monetary unit in the United Republic of Tanzania is the Tanzanian shilling (TSh).

References to dollars ($) are to United States dollars.

References to tonnes are to metric tonnes.

The following symbols have been used in tables:

Two dots (..) indicate that data are not available or are not separately reported.

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

PTA Preferential Trade Area for Eastern and Southern African States
SIDO Small Industry Development Organization of the United Republic of Tanzania

The boundaries shown on the maps do not imply official endorsement or acceptance by the United Nations.

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## ABSTRACT

Within the context of the project "Development and rationalization of cement factories and related industries" (DP/RAF/88/077), for which the United Nations Industrial Development Organization is acting as the executing agency for the United Nations Development Programme, an expert was fielded in order to carry out a survey of the lime plants in the United Republic of Tanzania and to recommend measures for the improvement of lime production in that country. The visit took place between 23 October 1989 and 14 November 1989, at the request of the United Republic of Tanzania's Small Industry Development Organization (SIDO), through the Preferential Trade Area for Eastern and Southern African States (PTA), Lusaka. The following recommendations were made by the expert:

(a) The remuneration system of the lime plant workers should be based on output;

(b) The activities of SIDO could be improved in regard to supervision of the lime plants and solution of technical, organizational and financing problems;

(c) Initiatives of private owners should be supported;

(d) A pilot shaft kiln, coal-fired and continuously operating with nominal capacity of 6 tonnes per day, should be constructed;

(e) If results of this pilot kiln are positive, other such kilns should be erected in places located close to high-quality limestone deposits and fuel resources;

(f) Feasibility studies should be carried out for the production of pulverized limestone and writing-chalk in the United Republic of Tanzania;

(g) A new lime plant should be constructed with a nominal capacity of 40-50 tonnes per day. It should be heavy-oil fired, continuously operating, and located in a region of high lime demand, close to a limestone deposit and in an area with good communication facilities.

Implementation of the above proposals will cover the growing demand for lime in the United Republic of Tanzania and will open possibilities for profitable export of lime and its products.

## INTRODUCTION

Within the context of the project "Development and rationalization of cement factories and related industries" (DP/RAF/88/077) for which the United Nations Industrial Development Organization is acting as the executing agency for the United Nations Development Programme, an expert was fielded in order to carry out a survey of the lime plants in the United Republic of Tanzania and to recommend measures for the improvement of lime production in that country. The visit took place between 23 October 1989 and 14 November 1989.

The visit began at SIDO Headquarters, Dar es Salaam, where brief discussions were held with the Director of Extension Services and Training, D. Rulagora, and E. Ikomba, project manager for lime. The period from 28 October to 1 November 1989 was spent in the Mbeya and Iringa regions.

A field visit was made to Ihengeza village, where a lime production co-operative had been established several years ago. A sample of limestone was taken during the visit.

In the Mbeya region, the next field visit was made to the Songwe river, where traditional lime production is carried out on a small scale. There, also, a sample was taken.

The Mbeya cement plant limestone quarry is located on the opposite side of the hill. Two visits to the cement plant were made and discussions were held with the production manager and the chief chemist. Much information was obtained regarding the chemical analysis of limestone as well as of coal from the Kiwira coal mine. A sample of coal was taken.

During the return journey to Dar es Salaam, a visit was made to the Kilombero sugar plant. Information on lime consumption and present and future demand for lime was obtained from the managers of the Ruembe and Msolwa plants.

The second visit took place between 5 November and 7 November to the Tanga region. First, Tanga lime plant was visited. The plant, which is privately owned, belongs to Hamdan Salah. Unfortunately, owing to the absence of the commander, it was impossible to visit the SIDO shaft kiln located in the prison area. However, the expert could see from the distance that the kiln was not in operation.

The cement plant was the next target. The production manager, J. S. Bwegoge, explained the current production situation of the factory. In 1989 there would be a long stoppage of the rotary kiln, diameter 4.55 m. The lining of the calcining zone (approximately 23 m long) would be replaced.

The last visit was to the Super Ambion lime plant, which, when it begins operation, will have a nominal capacity of 40-50 tonnes per day. The availability of a high-quality limestone quarry is a valuable asset for the owner.

After returning to Dar es Salaam, the expert visited the Ministry of Industries and Trade, the State Mining Corporation, the Bureau of Statistics and the Planning Commission. Important data which were obtained there are used in this report.

## RECOMMENDATIONS

1. In order to achieve significant quantitative and qualitative improvements in production, the following steps should be undertaken by SIDO immediately:

(a) Workers employed by lime plants should be paid on a piece-work basis and not a monthly wage as at present;

(b) The total costs of labour in primitive lime plants ought not to be less than 20-25 per cent of total production costs;

(c) Shortage of imported firebricks for lime shaft kiln linings could be at least partially covered by using selected refractories taken as waste materials from cement plants;

(d) All initiatives undertaken by private owners to establish new lime plants or modernize existing ones should be supported by SIDO in technical, organizational and financial aspects;

(e) In SIDO regional offices, especially in those regions where lime has already been produced, some technical officers should be responsible for the production and development of lime;

(f) Field visits to lime plants should be carried out to assist and support producers when problems arise. Financial problems, especially, should be addressed in good time;

(g) The SIDO Lime Project Manager should have all the up-to-date information concerning total lime production, demand for lime, cost trends etc. Adequate documentation should be provided at SIDO Headquarters.

2. There is clearly an urgent need to increase lime production in the United Republic of Tanzania. In order to fill the gap between the output of the existing plants and the demand for the product, some new installations should be established. Songwe valley near Mbeya is a preferable region for establishing the next shaft kiln.

3. In order to introduce some significant improvements into lime production, newly designed kilns should use coal for fuel and should be in continuous operation.

4. It is proposed to establish a new kiln in the Mbeya region, with a nominal capacity of 6,000 kg of burnt lime/24 h. Technical data of this kiln are given in annex II.

5. New investments should be undertaken in order to cover the growing demand for limestone and lime, and production of pulverized limestone ought to be started at once, as the United Republic of Tanzania does not yet have a chalk producer.

6. For the production of high-quality pulverized limestone (a) very good pure limestone should be prepared; and (b) a plant producing pulverized limestone should be constructed and equipped with modern high-technology machines and units.

7. Owing to transport problems and high costs, the sites for the new kilns or plants should be chosen close to fuel resources such as a coal mine or an oil refinery and in areas where there is a demand for high-quality limestone for agricultural or industrial purposes.

8. As the forecasted growth in lime demand is approximately 8,000 tonnes per year, kilns with a daily capacity of 25-30 tonnes burnt lime should be erected every year. These should be fired by coal or heavy oil only and operate continuously.

9. Feasibility studies should be carried out for the production of pulverized limestone and writing-chalk in the United Republic of Tanzania.

# I. THE LIME INDUSTRY IN THE UNITED REPUBLIC OF TANZANIA

## A. Natural resources of calcium minerals

The United Republic of Tanzania is rich in limestone deposits, with medium, high and very high $CaCO_3$ content (see figure I). The chemical analysis of limestone from several regions is presented in table 1. Very high-quality calcium stones appear in the Iringa, Mwanza, Shinyanga and Lindi regions. Tanga, Arusha, Rukwa and Dar-Lime possess a medium-quality limestone, while in Singinda and Musoma we find magnesium stone and in Kigoma, dolomitic stone. Analyses of samples taken during the visit are given in annex I.

Table 1. Chemical composition of limestone
(Percentage)

| Region | Insolubles | $R_2O_3$ | CaO | MgO | LOI | Total | Remarks |
|---|---|---|---|---|---|---|---|
| Tanga | 9.31 | 0.67 | 48.53 | 0.23 | 38.65 | 97.39 | |
| Dodoma | .. | .. | .. | .. | .. | .. | |
| Iringa | 4.16 | 0.96 | 52.37 | 1.00 | 42.11 | 100.60 | |
| Kigoma | 0.55 | 0.58 | 32.64 | 19.84 | 45.84 | 99.45 | |
| Mwanza | 3.55 | 0.98 | 52.95 | 0.82 | 42.09 | 100.37 | |
| Musoma | 13.41 | 1.87 | 38.89 | 7.58 | 38.48 | 100.23 | |
| Mbeya | 2.71 | 2.14 | 53.09 | 0.55 | 41.16 | 99.65 | High quality limestone from cement plant quarry |
| Lindi | 0.30 | 0.17 | 56.03 | 0.20 | 43.16 | 99.86 | |
| Arusha | 8.00 | 6.00 | 47.60 | 0.50 | 37.90 | 100.00 | |
| Rukwa | 8.33 | 1.13 | 50.78 | 0.23 | 39.96 | 100.43 | |
| Dar es Salaam | 7.07 | .. | 51.07 | .. | 41.87 | 100.01 | Average from 3 selected samples |
| Singida | 5.19 | 1.93 | 40.85 | 9.82 | 42.76 | 100.55 | |
| Shinyanga | 4.41 | 0.56 | 51.97 | 0.32 | 42.57 | 99.84 | |

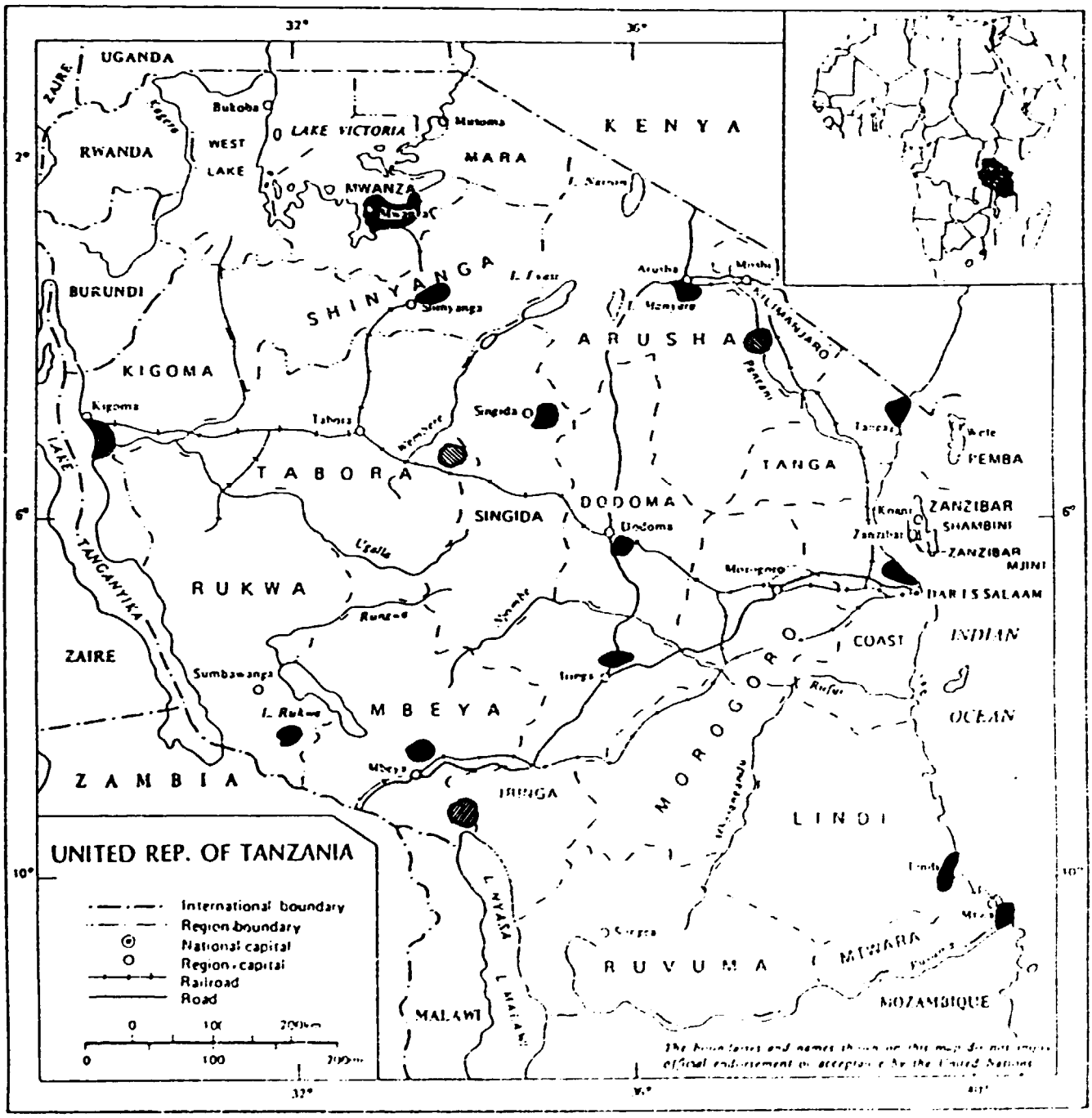
Taking into consideration the figures presented in table 1, we can state that the United Republic of Tanzania is in a good position, as far as its located deposits are concerned, to produce large quantities of high-quality lime-stone, chalk and both burnt and slaked lime.

## B. Description of the lime plants

Limestone is available throughout Tanzania but burned lime is produced only on a very small scale. The existing plants are primitive, operating only periodically and using mostly wood as fuel. Figure II shows the location of existing lime plants in the United Republic of Tanzania. These plants are described in table 2.

On the way to Iringa, the expert visited Ihengeza village, about 30 km north of Iringa. According to the information provided by SIDO, two lime kilns established by SIDO lime specialists should have been in operation. After checking, it was observed that both vertical lime kilns of 3 tonnes per day capacity each were badly cracked and had been out of operation since 1980.

Figure I. Deposits of limestone, coal and gypsum

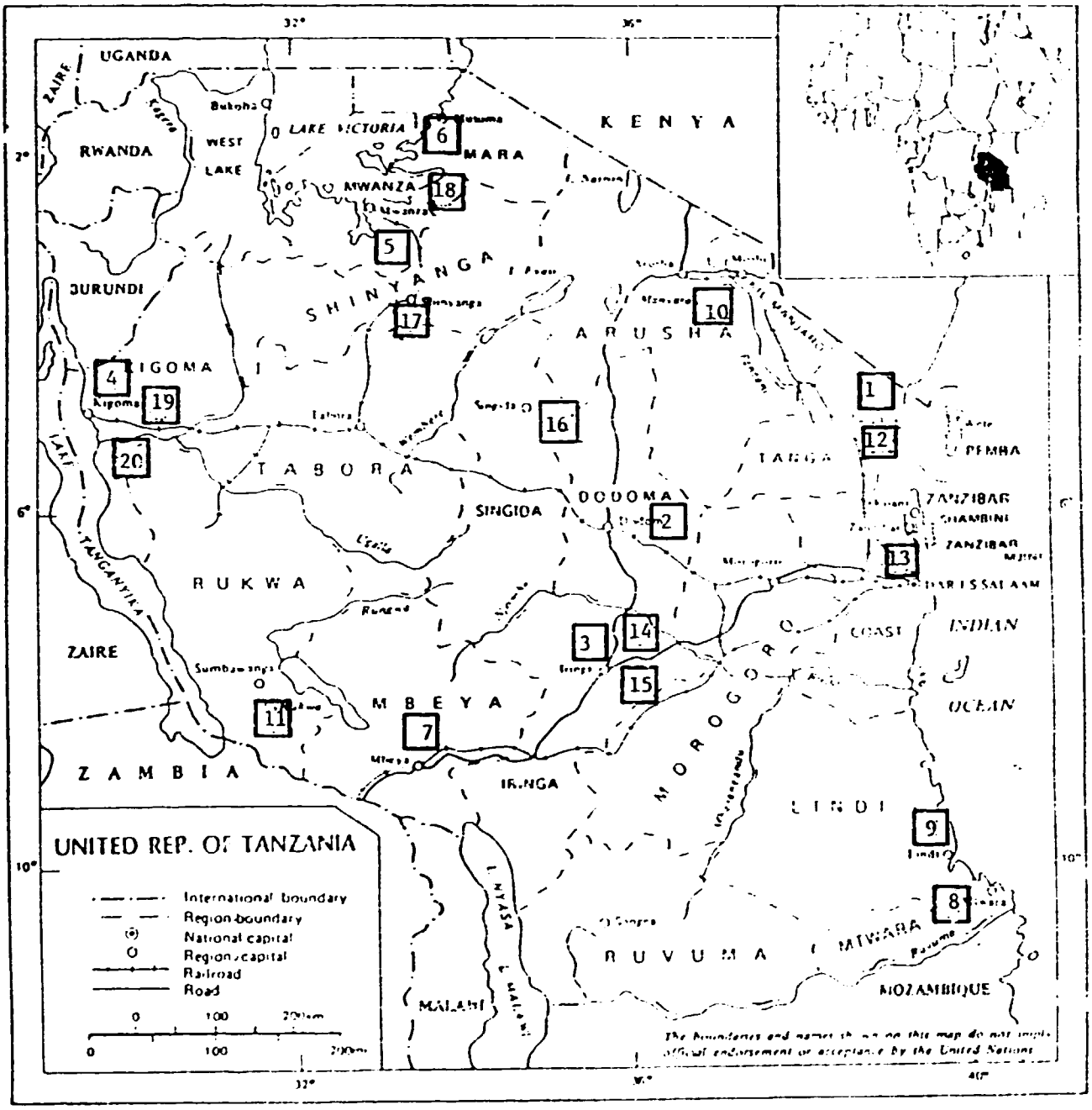



Key: Limestone

Coal

Gypsum

Figure II. Lime plants in the United Republic of Tanzania




| | | | |
|---|---|---|---|
| Key: | 1 Tanga | 11 Rukwa |
| | 2 Dodoma | 12 Maweni |
| | 3 Iringa | 13 Dar-Lime |
| | 4 Kigoma | 14 Ihengeza |
| | 5 Mwanza | 15 Vitono |
| | 6 Musoma | 16 Singida |
| | 7 Mbeya | 17 Shinyanga |
| | 8 Mtwara | 18 Magu |
| | 9 Lindi | 19 Makere |
| | 10 Arusha | 20 Bulombora |

Note: Numbers 1 to 10 are financed by SIDO but owned by the local communities, and numbers 11 to 20 are privately owned.

Table 2. Description of the lime plants plotted in figure II

| Plant | Number of shaft kilns | Capacity of the kiln (tonnes) | Kind of fuel | Kind of kiln operation | Estimated total annual capacity of kiln (in tonnes) | Remarks |
|---|---|---|---|---|---|---|
| Tanga | 1 | 10 | Wood | Periodically | 3 000 | |
| Dodoma | 1 | 10 | Wood | Periodically | 3 000 | |
| Iringa | 3 | 10 | Wood | Periodically | 3 000 | Only one kiln in operation |
| Kigoma | 3 | 10 | Wood | Periodically | 9 000 | |
| Mwanza | 1 | 10 | Wood | Periodically | 3 000 | |
| Musoma | 2 | 5 | Wood | Periodically | 3 000 | |
| Mbeya | 1 | 10 | Wood | Periodically | 3 000 | Only one field kiln in operation |
| Mtwara | 1 | 10 | Wood | Periodically | 3 000 | |
| Lindi | 1 | 10 | Wood | Periodically | 3 000 | |
| Arusha | 1 | 10 | Wood | Periodically | 3 000 | |
| Rukwa | 1 | 5 | Wood | Periodically | 1 500 | |
| Maweni | 1 | 50 | Oil | Periodically | 15 000 | Real annual production approximately 5,000 t |
| Dar-Lime | 2 | 60 | Oil | Continuously | 30 000 | Not in operation. New kiln under construction |
| Ihengeza | 2 | 3 | Wood | Periodically | 1 800 | Not in operation since 1980 |
| Vitono | 1 | 10 | Wood | Periodically | 3 000 | |
| Singida | 1 | 5 | Wood | Periodically | 1 500 | |
| Shinyanga | 1 | 5 | Wood | Periodically | 1 500 | |
| Magu | 1 | 6 | Wood | Periodically | 1 800 | |
| Makere | 1 | 17 | Wood | Periodically | 5 100 | |
| Bulombora | 1 | 5 | Wood | Periodically | 1 500 | |

The kilns were 3.3 m high, the internal diameter was 1.35 m and the total thickness of the wall was 0.9 m (two layers of red bricks with an insulation layer on the inside).

The internal volume of the kilns was therefore 4.7 $m^3$, which is hardly consistent with the rated capacity of 3 tonnes per day. In fact it is unlikely that the kilns could have produced more than 1 tonne per day on average. The ratio of height to diameter is only 2.44, which is extremely low and means that fuel would have been used very inefficiently. It was impossible to obtain good figures on this.

The kilns were not equipped with regularly spaced metal hoops. However, the location of the kilns was very unfortunate, lying at a distance of about 50 m from the limestone deposit and about 70 m from the Ruaha river.

The kilns were free-standing, with an unstable ladder as the only means of access to the top. It would reduce labour considerably if the kilns had been built into or adjacent to a bank so that stones and firewood could be prepared at the level of the kiln and not have to be laboriously lifted in small quantities.

Later, the supervisor of the plant presented the three existing and still operating field kilns located on the sloped bank of the river, about 30 m from the limestone deposit. Two kilns have the dimensions 6 x 10 x 2.5 m and the third measures 10 x 16 x 3.5 m. Between the kilns is arranged a platform used for slaking, sieving and bagging of lime.

The average monthly wage of each worker is TSh 2,000. The supervisor's wage is TSh 6,000. The total number of employees is 21 (including the supervisor). They are employed permanently, except for the rainy season, for cutting trees, transporting wood to the plant (using their own donkeys), quarrying limestone, loading the kiln with wood and stones, burning, extracting, slaking, sieving, bagging and loading onto buyers' vehicles.

According to the supervisor's explanation, the average monthly production reaches 50 tonnes of slaked lime in polyester bags. The current price of one bag containing 25 kg slaked lime is TSh 250 from the lime plant. It means that the total value of monthly production is:

$$\frac{250 \times 50{,}000}{25} = \text{TSh } 500{,}000$$

The expenses for the lime production include the polyester bags, which cost TSh 70 each, plus the labourers' wages. Total production costs are as follows:

$$2{,}000 + 6{,}000 + 50 \times 40 \times 70 = \text{TSh } 186{,}000/\text{month}$$

Monthly profit: 500,000 - 186,000 = TSh 314,000

The village community receives only TSh 5,000/month as a special bonus. Nobody could account for the missing TSh 309,000. The low efficiency of the existing lime plants is mainly due to the low wages, which are calculated on a monthly basis. The workers are completely uninterested in increasing production. Should they be paid on the basis of their output, they would doubtlessly work more efficiently. It is interesting to note that wages only account for 9.2 per cent of the total income, whereas profit accounts for 61.8 per cent!

The second field visit was made to Songwe valley, about 25 km west of Mbeya. Small-scale production of lime is carried out in one kiln which is 3 m high and has an internal diameter of 2.5 m. The kiln was built on a limestone hill and has only one layer of red-brick lining. The average production is 2.5 tonnes per day of slaked lime, or 100 bags. Because of the proximity of a military area, soldiers are employed as workers, thus the problem of low wages does not exist.

In the same valley, located close to the slope of the hill, there is also a battery of three vertical shaft kilns. These kilns, which are privately owned, were not in operation, and two of them showed serious deterioration. They measured 9 m in height and had an internal diameter of 4 m. The 0.20 m thick exterior shell was made of reinforced concrete, the red-brick inside lining was 0.36 m thick and the insulating layer measured 0.07 m. There is no information available on the capacity of these kilns.

The Songwe valley area is well suited to the industrial production of lime for the following reasons: the vicinity of the Kiwira coal mine, located approximately 110 km away, the Tazara railway station and the railway siding to the Mbeya cement plant; the very good quality of the limestone; and the fact that a small river flows along the valley. Lime production has already been carried out here on a small scale for several years. In the Mbeya region, demand for lime will be high, especially for road construction for soil stabilization. The kiln to be built in the Mbeya region is described in annex II. Annex III contains several diagrams of the type of kiln proposed. The Kilombero sugar plant will also increase its capacity and, therefore, its lime consumption.

In the Tanga region, the situation of the lime industry is much better. The Tanga lime plant produces approximately 40 tonnes per day of slaked lime. According to information obtained from the Bureau of Statistics, production was as follows:

| Year | Tonnes of slaked lime |
|---|---|
| 1985 | 3,385.3 |
| 1986 | 4,645.8 |
| 1987 | 4,976.5 |
| 1988 | 4,583.3 |
| 1989 | 5,000.0 (estimate only) |

The factory employs a total of 80 workers:

| | |
|---|---|
| Quarry staff (drilling, blasting, excavating, loading) | 17 |
| Transport from the quarry to the plant (2 dump trucks with 7 t capacity each) | 4 |
| Burning plant (3 shifts) | 18 |
| Lime-slaking plant | 14 |
| Lime-bagging plant | 13 |
| Foremen | 3 |
| Watchmen, yard workers etc. | 10 |
| Plant manager | 1 |

Wages are calculated on a monthly basis but include bonuses for both output and overtime. The owner was not prepared to define how total production costs were calculated. Only the following data could be obtained:

| | |
|---|---|
| Present price of one 25 kg bag of slaked lime from the plant | TSh 250 |
| One litre of heavy fuel oil for the plant | TSh 27.52 |
| Paper bags (manufactured by Kibo Paper Industries - Dar es Salaam) - per piece | TSh 40.0 |

Fuel consumption is approximately 0.15 l/kg of burnt lime. Limestone size 80-120 mm is delivered from the quarry by a dump truck and dumped onto the hopper. Under the bin, there is a bucket-lift with a capacity of approximately 1.5 $m^3$. Every four hours, the kiln is loaded with limestone. The shaft of the kiln is rectangular. Eight oil burners are installed under the burning zone, four for each side of the shaft.

Heavy oil delivered by tank trucks is stored in four underground tanks with a total capacity of approximately 200 $m^3$. One tank installed over the platform of the burner is equipped with four electric heaters. A high pressure pump supplies hot fuel to burner nozzles and there is a pocket hole under each burner opening. Burned lime is extracted from under the kiln shaft by means of movable plates with motorized drive.

Slaking facilities are very primitive, consisting of a roofing area watered by a rubber pipe. Slaked lime is delivered by wheelbarrows to the mill, and from under the mill to a packing machine by a bucket-elevator. Only one small-size bag filter is installed and dedusting is very poor.

The owner informed the expert about maintenance troubles. There is a serious shortage of imported goods such as explosives, refractories, mortars and spare parts.

Among the main consumers of Tanga Lime products are: the sugar factories, Williamson Diamond Company, building contractors, the Railway Company and the Tanseed Corporation. In the plant area, there is a second shaft kiln, but it has been out of operation for several years owing to serious deterioration.

Tanga Lime is the only factory in the United Republic of Tanzania which produces lime continuously, mostly for industrial buyers. The plant is equipped with very primitive machines and units, especially those used for transport and dedusting. Even a primitive slaker is lacking. The factory will be able to produce between 15 and 20 per cent more good quality lime if production is modernized and improved. A small crusher for burnt lime and lime slaker and two spot bagging machines with scales have to be installed.

As far as environmental protection is concerned, heavy-oil leakages and excessive dusting must be restricted. The estimated cost of the above-mentioned modernization is between TSh 3 and 4 million.

The Super Ambion lime plant, which was under construction at the time of the visit, was due to start normal production at the beginning of 1990. The shaft of the kiln is rectangular and has the internal dimensions 5.3 x 4.0 m. Its working height is 15 m. Heavy oil will be used for fuel. Its designed

capacity of 40-50 tonnes per day ought to cover the demand for burnt and slaked lime in the Tanga region and enable the plant to begin exporting its products. However, the owner, Mohamed Marshed, has been having serious financial problems as a result of importing some machines and units. The availability of a high-quality limestone quarry is a major asset for the plant.

SIDO, being the main organizer of lime production in the United Republic of Tanzania, should support him by solving the above-mentioned problems. It was somewhat unfortunate that no shaft kiln constructed by SIDO could be observed and tested in operation.

The information available on lime shaft kilns located in other regions of the United Republic of Tanzania is insufficient to form a basis for up-to-date calculations of the total national lime production.

Since the expert's stay in the United Republic of Tanzania was very short, it was impossible to organize visits to Arusha and the Lindi region, where, according to information obtained from SIDO, other lime shaft kilns are located.

The estimated total production of slaked lime for 1989 was 23,000 tonnes: the SIDO-financed plants 12,000 tonnes and the privately owned plants 11,000 tonnes.

### C. Production of lime-pozzolana binders

In May 1980, R.J.S. Spence, a SIDO consultant, visited several places in the United Republic of Tanzania and drew up a detailed report concerning the production of pozzolime as an alternative cementing material to expensive Portland cement.

The report described a programme for the development of pozzolime production in several regions of the United Republic of Tanzania. The programme also dealt with budget and funding for the implementation of pozzolime production. Unfortunately, the necessary financing has not yet been made available.

The need for electric power supply and the purchase of some imported machines and units such as conveyors or ball mills is a handicap in starting the production of pozzolime. Meanwhile, most of the existing lime plants are located in small villages not supplied with electricity.

According to information obtained in Mbeya, in 1990 the cement plant will be able to produce pozzolana cement with the following composition: clinker 75-80 per cent; pozzolana 15-20 per cent; and gypsum 5 per cent. The experience of the cement plant and the presence of lime production in the vicinity will be a sound basis on which to start pozzolime production in the region in future.

## II. DEMAND FOR LIMESTONE

### A. Current demand

According to information obtained from the Bureau of Statistics, the quantities of limestone, lime and chalk shown in table 3 were imported into the United Republic of Tanzania in 1988. The fact that imports were low should not be taken to mean that all needs for limestone and lime were covered by domestic production.

Table 3. Imports in 1988

| Product | Amount (tonnes) | Value (TSh) |
|---|---|---|
| Limestone | 51.00 | 71 000 |
| Lime | 0.31 | 13 000 |
| Writing chalk | 3 000.00 (approximately) (=279 445 boxes) | 63 107 052 |
| Total | 3 051.31 | 63 191 052 |

According to an estimated calculation, the current demand for limestone and lime is as follows (in tonnes per year):

| | |
|---|---|
| Sugar industry | 6,000 |
| Paper industry | 3,500 of high quality limestone are used in paper processing<br>1,000 of lime for bleaching and softening of process water |
| Leather industry | 600 of lime for tanning |
| Other industries (glass, rubber, paint etc.) | 200 of lime and/or pulverized limestone |
| Agriculture | 15,000 |
| Road construction | 2,000 (for soil stabilization) |
| Building purposes | 6,200 |
| Miscellaneous purposes (sewage and trade wastes treatment, water softening etc.) | 500 |
| Chalk (pulverized limestone) | 3,500 (up to the present, only imported) |

| | | |
|---|---|---|
| Total | 31,300 | lime (mostly slaked) |
| | 3,500 | limestone |
| | 3,700 | pulverized limestone |
| Grand total | 38,500 | |

The gap between demand and production is calculated by the expert as follows: 38,500 - (2,300 + 3,500 + 3,700) = 8,300 tonnes per year.

## B. Demand forecast for the period 1990-1993

Table 4 is based on data contained in the report "Planning Development of Tanzania", drawn up by the Planning Commission and printed in Swahili. Figure III shows the location of the main limestone and lime consumers.

Table 4. Estimated limestone and lime demand for industrial uses
(Thousands of tonnes)

| Industry | 1988/89 | 1989/90 | 1990/91 | 1991/92 | 1992/93 |
|---|---|---|---|---|---|
| Sugar | 115 | 140 | 158 | 166 | 174 |
| Paper | 32 | 35 | 36 | 38 | 40 |
| Cement | 540 | 620 | 730 | 850 | 972 |
| Gypsum | 30 | 33 | 37 | 43 | 50 |

For the period 1988-1991, roads were expected to be rehabilitated at the rate of 5,000 km per year and for 1991-1993, at an annual rate of 4,000 km. Growth in the agricultural sector for this period was expected to remain stable at 5.5 per cent per year.

The total estimated requirements are given in table 5.

Table 5. Estimated requirements 1988-1993
(Thousands of tonnes)

| Product | 1988/89 | 1989/90 | 1990/91 | 1991/92 | 1992/93 |
|---|---|---|---|---|---|
| Limestone | 3 500 | 3 650 | 3 800 | 3 900 | 4 000 |
| Pulverized limestone | 3 700 | 4 000 | 4 500 | 5 000 | 5 500 |
| Lime | 31 300 | 41 150 | 48 800 | 55 050 | 62 300 |
| Total | 38 500 | 48 800 | 57 100 | 63 950 | 71 800 |

If the new lime shaft kiln being constructed in Tanga produces 8,000 tonnes per year and other kilns maintain the present production level, the gap between demand and the capacity of the existing plant will be as shown in table 6.

Table 6. Gap between production and demand 1988-1993
(Thousands of tonnes)

| Product | 1988/89 | 1989/90 | 1990/91 | 1991/92 | 1992/93 |
|---|---|---|---|---|---|
| Limestone | .. | .. | .. | .. | .. a/ |
| Pulverized limestone | 3 700 | 4 000 | 4 500 | 5 000 | 5 500 |
| Lime | 8 300 | 12 150 | 17 800 | 24 050 | 31 300 |
| Total | 12 000 | 16 150 | 22 300 | 29 050 | 36 800 |

a/ Demand for limestone will be covered by cement plants.

It is evident from these figures that new installations for the production of pulverized limestone as well as burnt and slaked lime ought to be designed and erected as soon as possible. Otherwise, there will be a rapid increase in imports of pulverized limestone, lime and its products and a consequent increase in foreign currency expenditure.

There is an urgent need to establish a new installation to start producing pulverized limestone as soon as possible. High-quality pure limestone is needed for this purpose. It should have the following composition:

| | Percentage | |
|---|---|---|
| $CaCO_3$ | 96.5 | min. |
| Insolubles | 2.0 | max. |
| $Fe_2O_3$ | 0.2 | max. |
| Manganese | 0.02 | max. |
| Copper | 0.005 | max. |

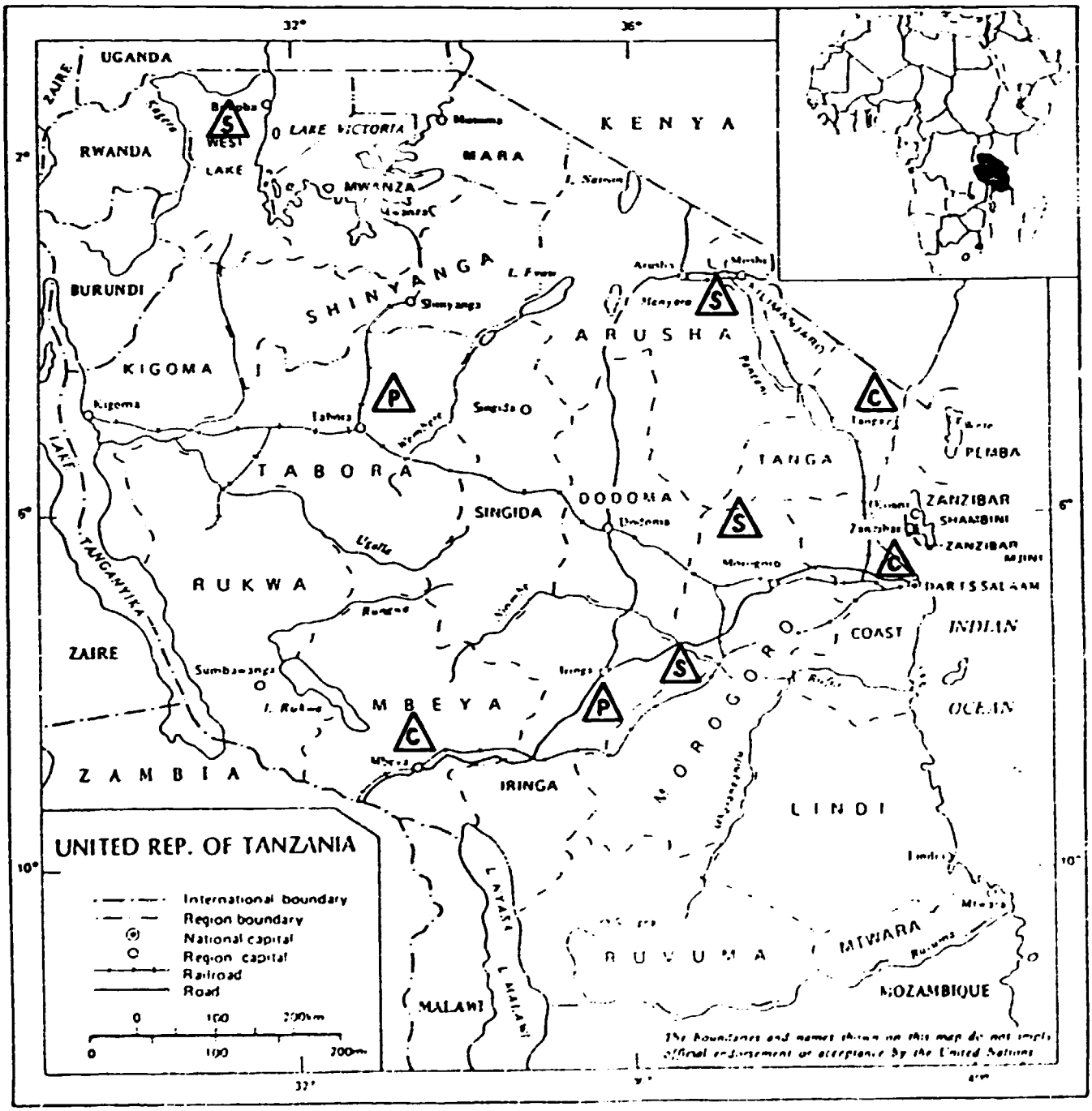
Pulverized limestone should be of the following quality:

| | | |
|---|---|---|
| Moisture | 0.5 | max. |
| Whiteness | 70.0 | min. |
| Brightness | 90.0 | min. |
| Degree of yellowish tinge | 10.0 | max. |
| Fineness: | | |
| residue on sieve no. 240 | 0.5 | max. |
| residue on sieve no. 100 | nil | |
| particles below 10 micron | 50.0 | min. |

A technological scheme for pulverized limestone is given in annex IV. A designed factory should have the following characteristics:

| | |
|---|---|
| Rate of production | 10,000 tonnes per year (= 35 tonnes per day, approximately) |
| Required land | 7,000 $m^2$ (approximately) |
| Building area | 1,200 $m^2$ (approximately) |
| Open-air installations | 800 $m^2$ (approximately) |

Figure III. Location of main limestone and/or lime consumers




Key:

- Sugar factory
- Paper pulp factory
- Cement plant

## Annex I

## CHEMICAL ANALYSIS OF SAMPLES

### A. Chemical analysis of limestone
(Percentage)

| | Location | | |
|---|---|---|---|
| | Ihengeza | Mbeya | Tanga |
| Loss of ignition | 42.29 | 43.76 | 43.41 |
| $SiO_2$ | 3.66 | 0.10 | 0.44 |
| $Fe_2O_3$ | 0.12 | 0.06 | 0.08 |
| $Al_2O_3$ | 0.71 | 0.26 | 0.26 |
| CaO | 51.72 | 53.99 | 55.04 |
| MgO | 1.41 | 1.25 | 0.31 |
| Total | 99.91 | 99.42 | 99.54 |

### B. Sample of Kiwira coal (taken at Mbeya on 30 October 1989)

| Composition | Percentage |
|---|---|
| Moisture (105° C) | 0.71 |
| Ash content | 15.84 |
| Volatile matter | 33.21 |
| Sulphur content | 1.03 |
| Net calorific value | 6 505 kcal/kg - 27 256 kJ/kg |

## Annex II

## DESCRIPTION OF THE KILN PROPOSED FOR THE MBEYA REGION

### A. Construction

The kiln will be 11.5 m high, of fired clay brick structure, reinforced with steel straps and lined with fireclay bricks. There will be a 7 cm insulation layer between the outer shell and the refractories. The outer shell and the lining will be connected by three bricks on every horizontal layer of brickwork. A 9.0 m shaft will be topped by a 2.5 m conical chimney with an internal diameter tapering from 1.2 m to 0.65 m.

The loading opening will be at a height of 9.35 m and closed by two double steel doors. There will be two firing chambers at a height of 3.2 m. Each chamber will be divided in two by a grate: the upper one being the firing part and the lower one the ash pan. Both chambers will be closed by firing and cleaning doors made of cast-iron.

At the base of the kiln, there will be two discharge openings. A timber platform covered with steel plates will be constructed round the kiln at this level for operation of two coal-fired furnaces. The platform will be connected to the ground level by a gangway. Coal to the platform will be delivered by wheelbarrow.

Because the kiln is to be located adjacent to the slope, the horizontal loading ramp will be connected to the top of the hill. Wheelbarrows can be used to deliver the necessary limestone and some of the coal required by the kiln (approximately 6-12 kg coal and 425 kg of limestone would be required per hour). The lime product will be drawn from two discharge openings by shovels and taken away to the slaking sheds in wheelbarrows.

The produced lime can be applied for agriculture, building and industrial purposes. High limestone quality and minimum level of impurities from coal facilitate the production of good quality burnt and slaked lime.

### B. Estimated costs of materials for kiln construction

The following list gives the estimated costs for kiln construction. It does not, however, include construction materials for kiln foundation, platforms, ramps, roofings etc.

| | TSh |
|---|---|
| Hard-burnt red bricks (50 $m^3$ = 25,500 pieces) | 255,000 |
| Mortar (cement:lime:sand = 1:1:6): 20 tonnes | 80,000 |
| Insulation (pozzolana or tuff rock size 0.5-2.0 mm:5.0 $m^3$ = 4,000 kg) | 4,000 |
| Fireclay bricks (10 $m^3$ = 20 tonnes with min. $Al_2O_3$ content 40 per cent) a/ | 3,000,000 |
| Fireclay mortar (2,000 kg) b/ | 250,000 |

| | |
|---|---|
| Reinforced steel rings (5 x 150 mm = 550 kg) | 385,000 |
| Double steel door for loading opening (120 kg) | 120,000 |
| Cast-iron door for firing and ash pan (4 pieces = 420 kg) | 420,000 |
| Grate bar (0.85 m long x 1 cm thick) (75 pieces = 260 kg) | 182,000 |
| Total | 4,696,000 |

| | |
|---|---|
| Imported materials included in the above-mentioned sum | $US 262,000 |
| Alternative (used fireclay bricks) | TSh 1,566,000 |
| Imported goods | $US 6,500 |

The monthly direct production costs are estimated as follows:

| Wages (bonuses and overtime, included) | TSh |
|---|---|
| Auxiliary workers (34 x 3,000) | 102,000 |
| Qualified workers (10 x 8,000) | 80,000 |
| Foreman (3 x 10,000) | 30,000 |
| Plant manager (15,000) | 15,000 |
| Total | 227,000 |

| Other costs: | TSh |
|---|---|
| Fuel (coal from the Kiwira mine: 6 x 30 x 0.227 x 7,180) | 294,000 |
| Paper bags (capacity 25 kg slaked lime: 6 x 30 x 40 x 40) | 288,000 |
| Tools (wheelbarrows, shovels etc.) | 40,000 |
| Total direct production costs | 849,000 |
| Value of monthly production (6 x 30 x 40 x 250 x 1.3) | 2,340,000 |

---

a/ The used and selected bricks from Mbeya Cement Company can be used instead of new ones.

b/ Instead of original mortar, used fireclay bricks crushed to size 0.5-2.0 mm from the Mbeya cement plant can be used together with 15 per cent of Portland cement.

## C. Technical data of the kiln

Technical data of the kiln are as follows:

| | |
|---|---|
| Rate of production | 6 tonnes per 24 h |
| Calcination system | coal-fired, natural draught, verticle shaft kiln with two outside grate firings |
| Mode of operation | continuous, manually operated |
| Raw material | limestone, hard type ($CaCO_3$: 90 per cent max; $MgCO_3$: 3.5 per cent; and insolubles 5-6 per cent); |
| Feed requirement | 10.2 tonnes per 24 h (425 kg/h) |
| Feed size | 50-100 mm |
| Fuel type | coal from the Kiwira mine (calorific value: 4,300-5,700 kcal/kg) |

| | | (Percentage) |
|---|---|---|
| Composition of fuel | Ash content | 22-34 |
| | Volatile matter | 22.3-31.0 |
| | Fixed carbon | 46.6-53.5 |
| Sieve analysis | Over 45 mm | 3.8-5.0 |
| | 25-45 mm | 16.0-25.0 |
| | 15-25 mm | 21.0-23.0 |
| | 7-15 mm | 22.0-23.0 |
| | 2-7 mm | 15.0-23.0 |
| | Under 2 mm | 11.0-12.0 |

Fuel consumption 1,350 kcal/kg lime

| | | | |
|---|---|---|---|
| Manpower requirements | Quarry and transport | 14 | |
| | Kiln | 18 | (6 per shift) |
| | Slaking | 4 | |
| | Bagging | 8 | |
| | Foreman | 3 | (1 per shift) |
| | Plant manager | 1 | |
| | Total | 48 | |

Coal consumption 0.227 kg/kg lime
1,362 kg/24 h (56.75 kg/h)

| | |
|---|---|
| Number of grate furnaces | 2 |
| Total grate surface | 1.95 $m^2$ |
| Grate length | 2 x 0.65 = 1.3 m |
| Grate width | 2 x 0.75 = 1.5 m |
| Grate heat load | 15 x $10^4$ kcal/$m^2$/h (approximately) |

| | |
|---|---|
| Shaft diameter (internal) | 1.2 m |
| Shaft height (effective) | 9.0 m |
| Shaft shape | cylindrical |

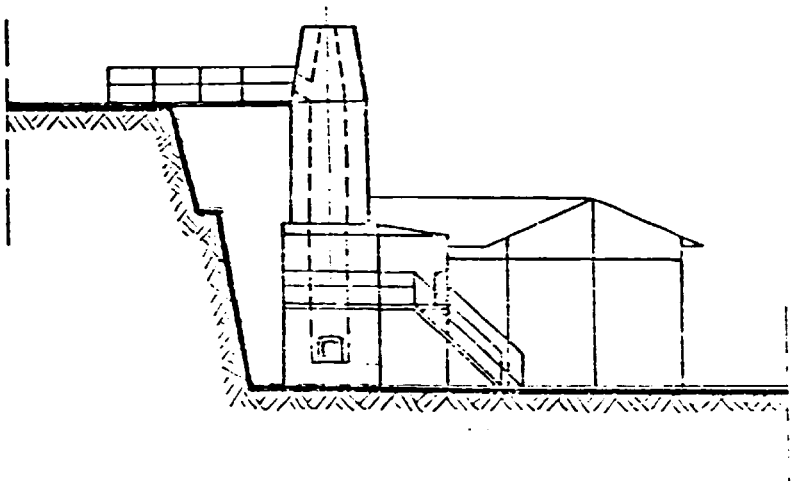
Annex III

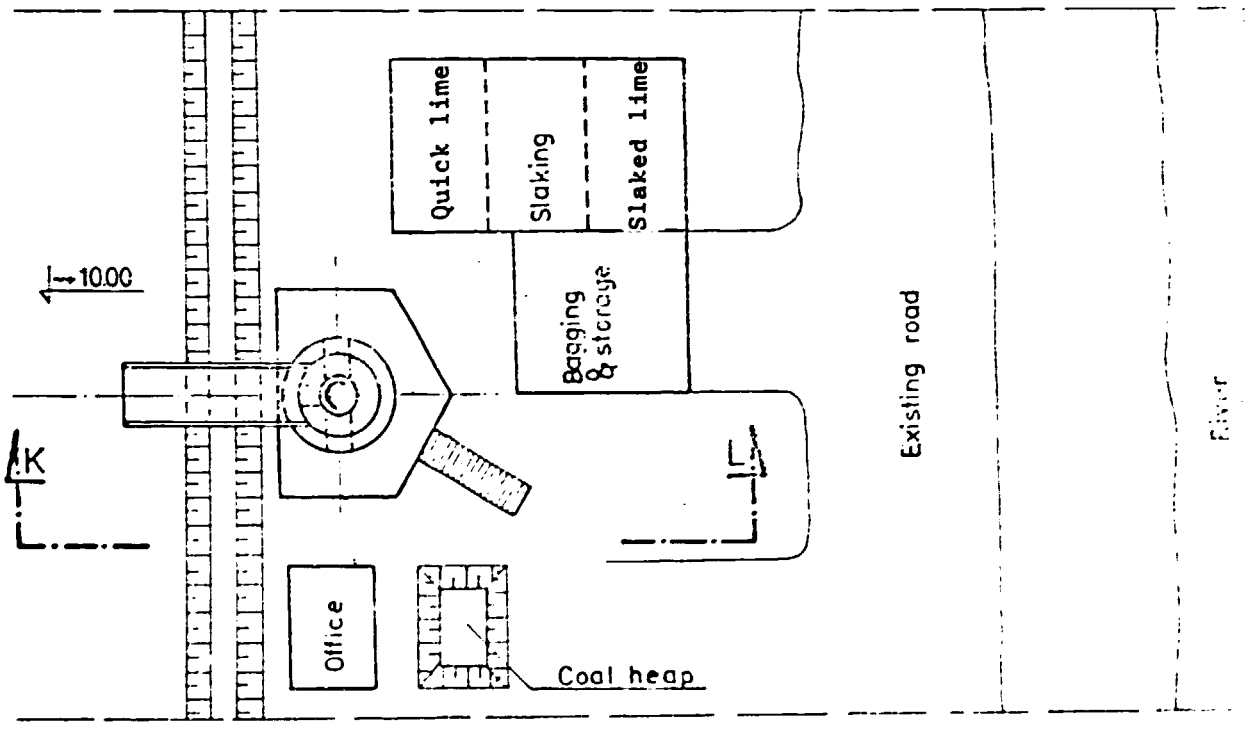
DIAGRAMS OF LIME PLANT AND KILNS

A. Lime plant with coal fired shaft kiln

Layout

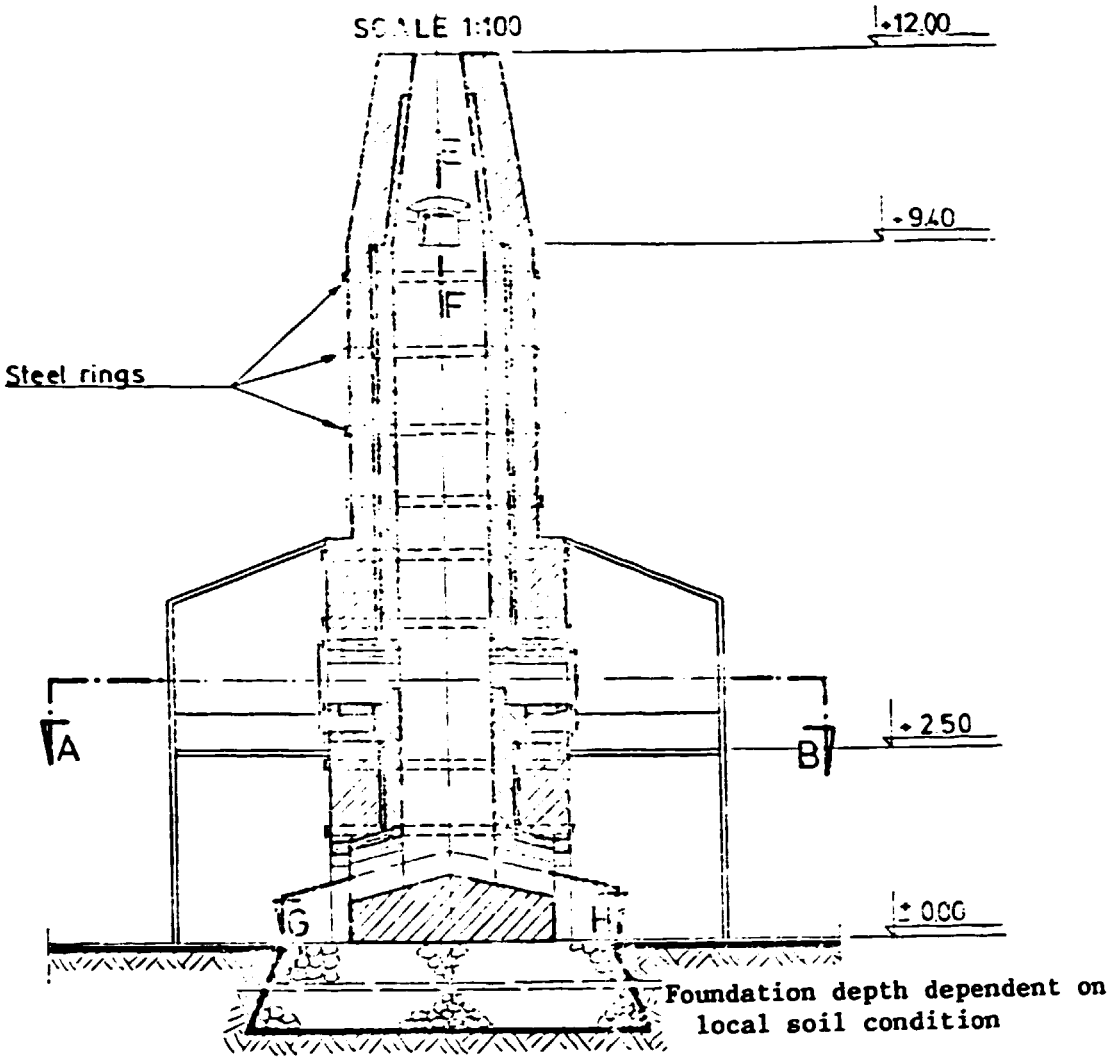
SECTION K-L



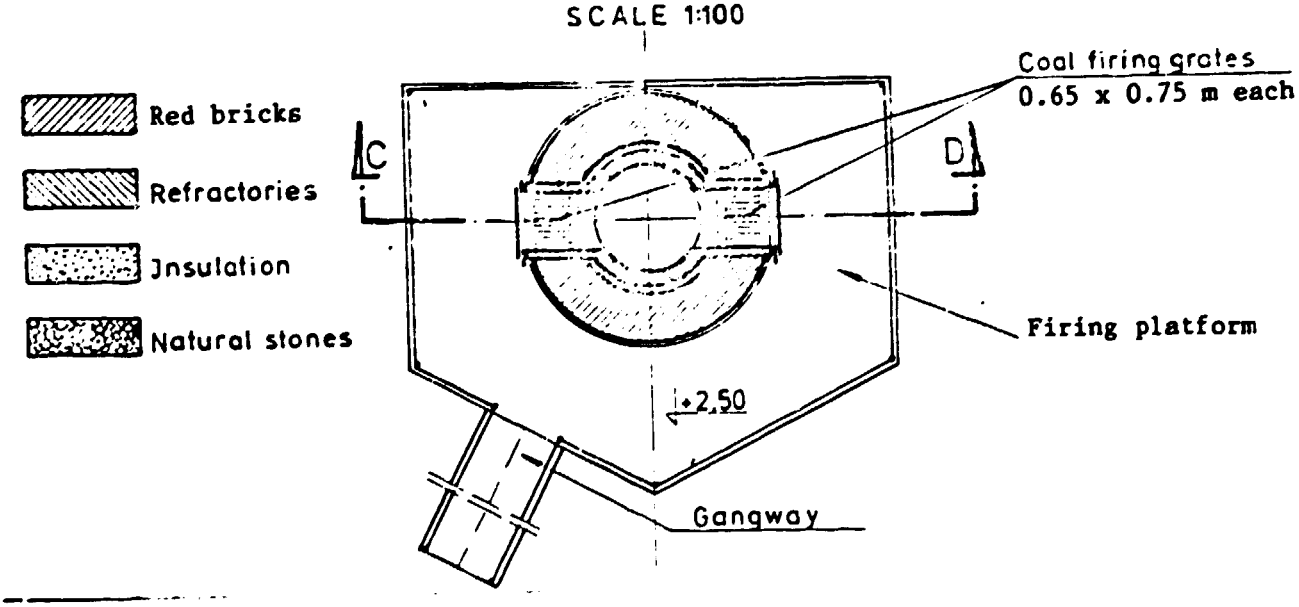


## B. The vertical shaft kiln, coal fired continuously operating
## Nominal capacity 6 tonnes per day

SECTION C-D



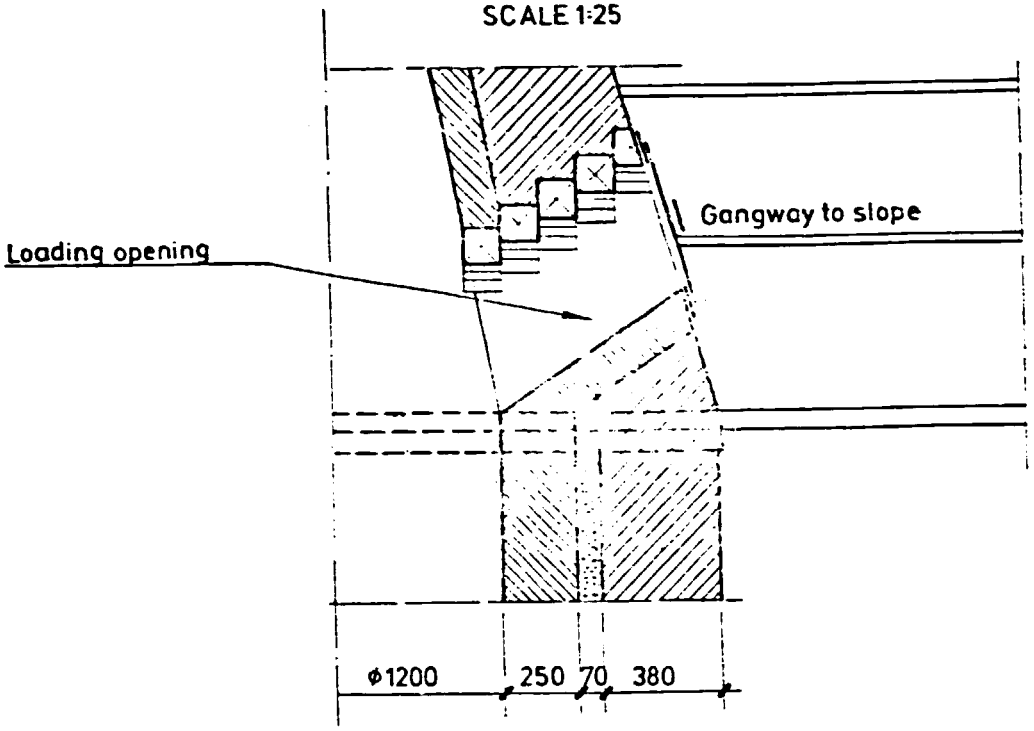

SECTION A-B



## C. The shaft kiln - Sections

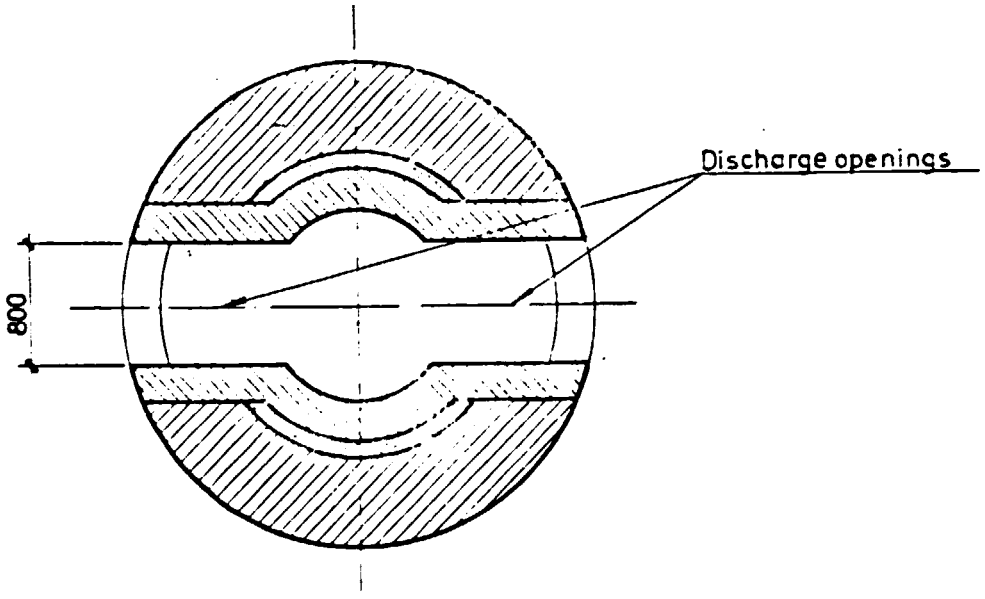
SECTION E-F

SCALE 1:25




SECTION G-H

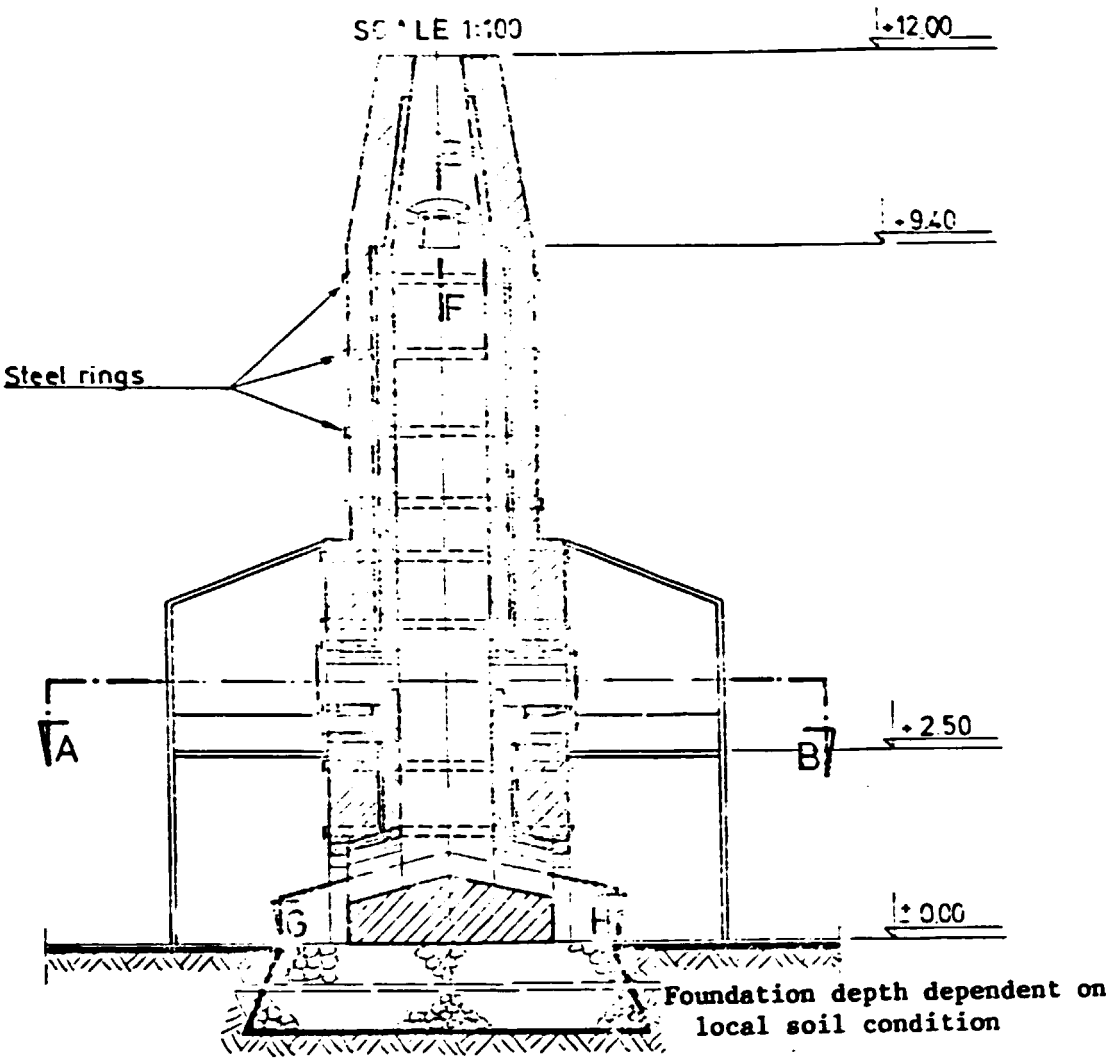
SCALE 1:50



B. The vertical shaft kiln, coal fired continuously operating
Nominal capacity 6 tonnes per day

SECTION C-D

SCALE 1:100




SECTION A-B

SCALE 1:100