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ASSISTANCE TO THE CEMENT INDUSTRY

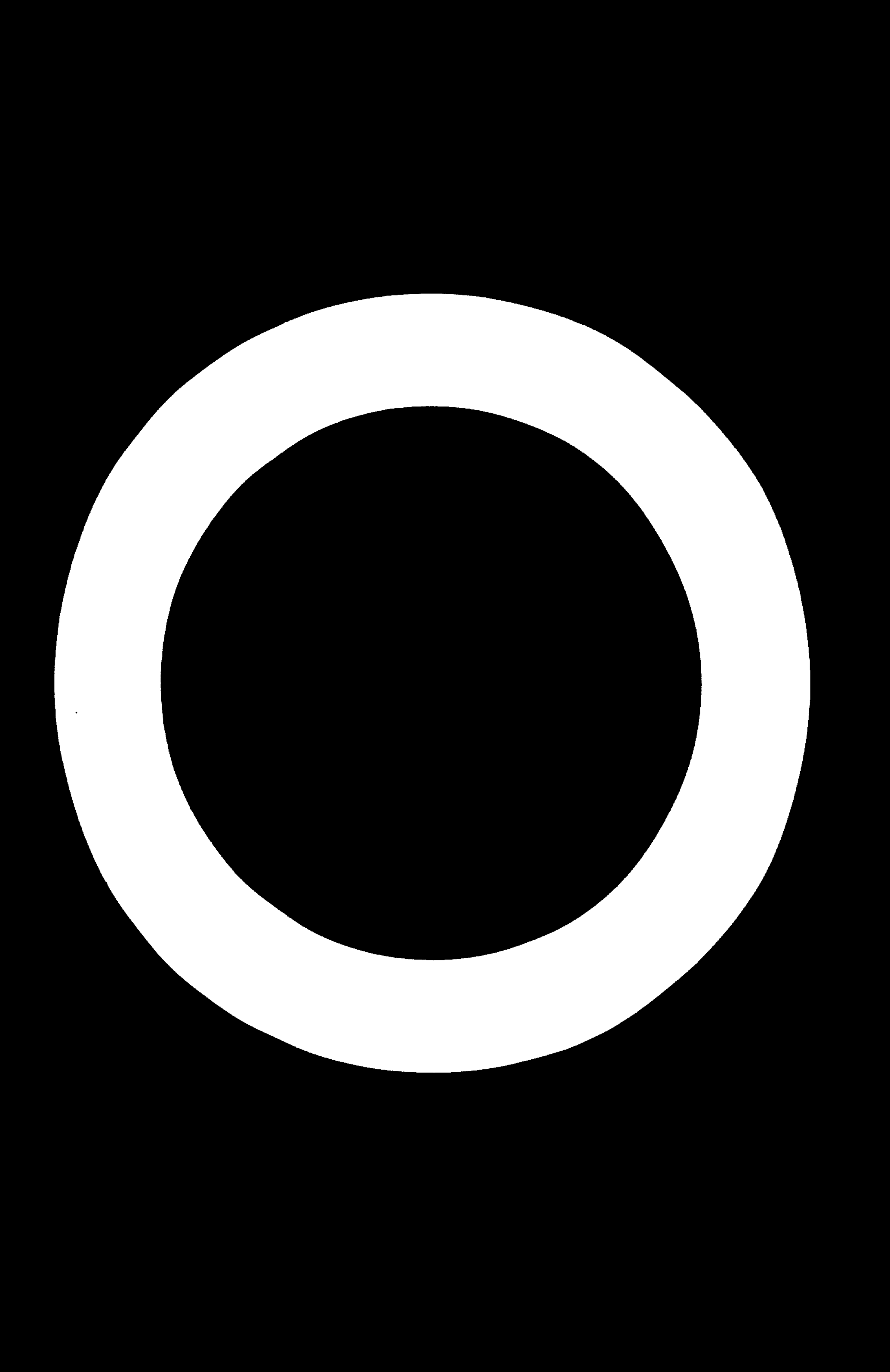
IS/LIB/72/808

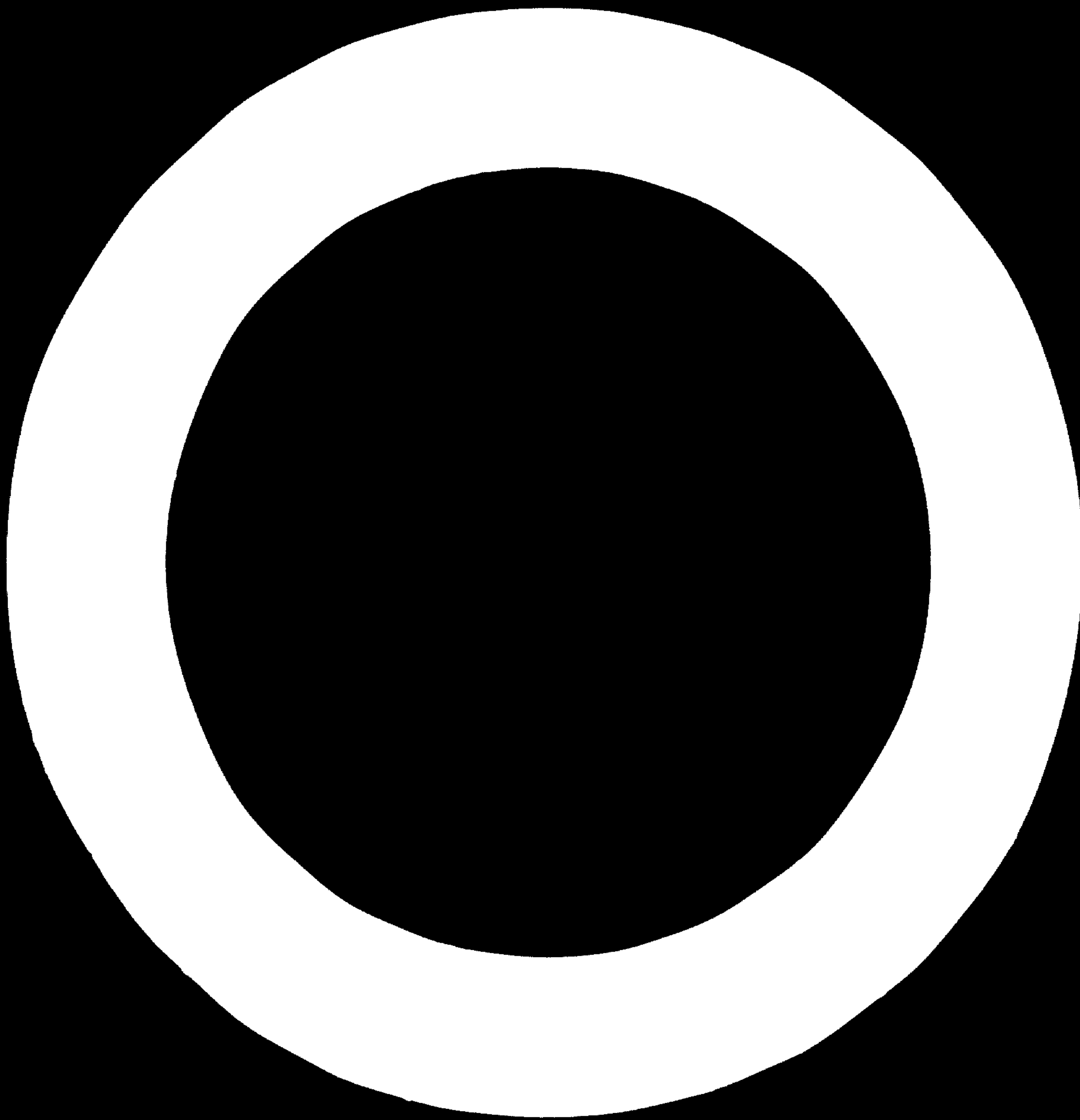
LIBYAN ARAB REPUBLIC

TERMINAL REPORT (1975).

Prepared for the Government
of the Libyan Arab Republic by the
United Nations Industrial Development Organization,
executing agency for the
United Nations Development Programme

United Nations Industrial Development Organization





United Nations Development Programme

ASSISTANCE TO THE

CEMENT INDUSTRY

IS/LIB/[illegible]/80

LIBYAN ARAB REPUBLIC

<u>Project findings and recommendations</u>

Prepared for the Government of the Libyan Arab Republic
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

<u>**Based on the work of Harald C. Boeck, mechanical engineer**</u>

United Nations Industrial Development Organization
Vienna 1975

Explanatory notes

Reference to "tons" indicates metric tons.

Use of a hyphen (-) between dates representing years signifies the full period involved, including the beginning and end years, e.g. 1971-1973.

A slash (/) indicates one year that is not a calendar year.

Reference to "dollars" ($) indicates United States dollars.

In a table, three dots (...) indicate that data are not available or are not separately reported. A dash (-) indicates that the amount is nil or negligible.

The following exchange rates are used in the conversion of country currencies to dollars:

Country	Currency	Exchange rate per dollar in April 1975
Denmark	krone (DKr)	5.42
Federal Republic of Germany	mark (DM)	2.35
France	franc (F)	4.20
Libyan Arab Republic	Libyan dinar (LD)	0.296

The following abbreviations are used in this report:

f.o.b.	free on board
NCC	National Cement Company (Libyan Arab Republic)
POLSERVICE-GEPOL	Geological Consulting Company (Poland)
SAUTI	Renardet-Sauti-Ice
SMU	service metre units

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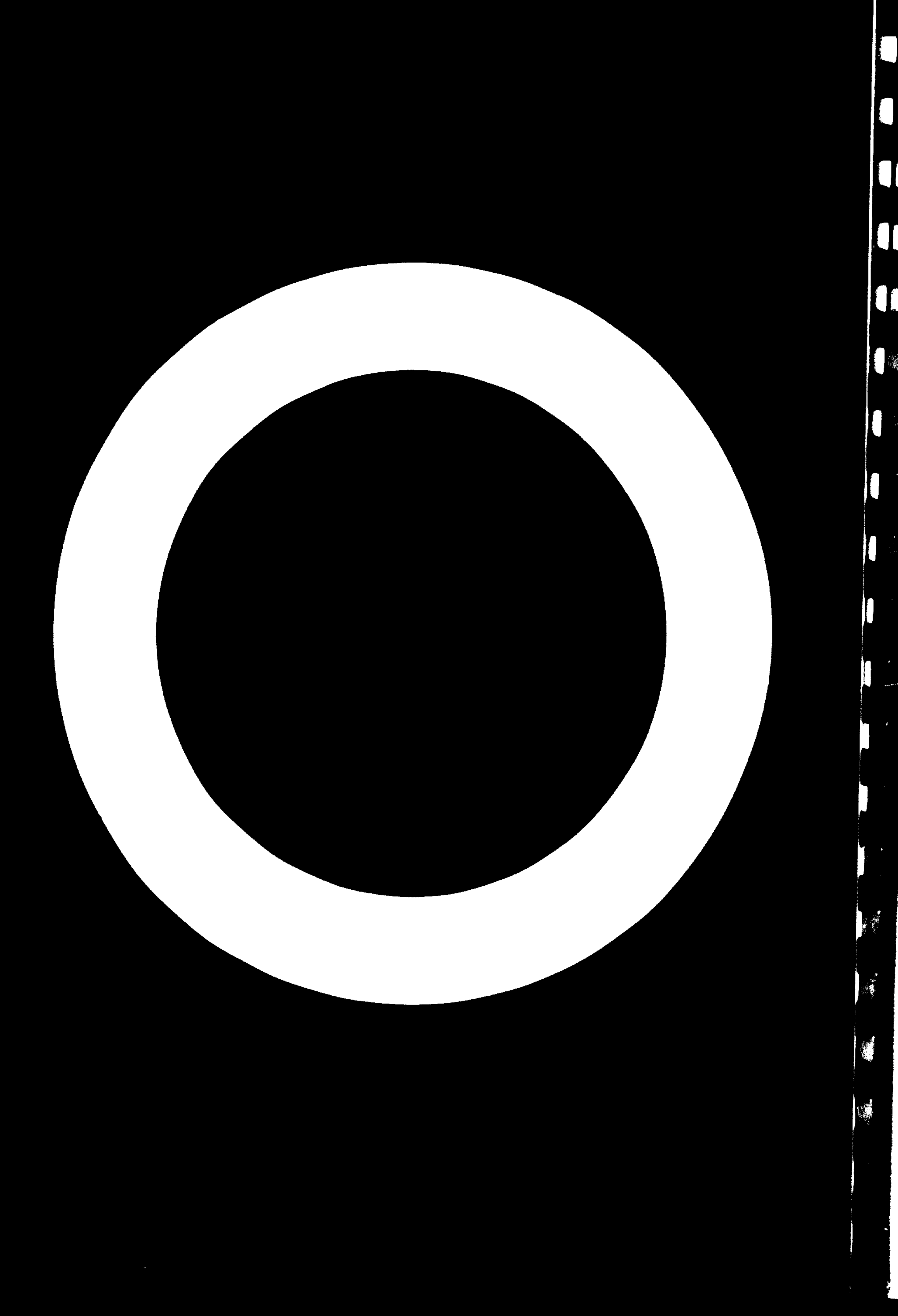


[illegible]

[illegible]

[illegible] "Assistance [illegible]" [illegible] /[illegible]), [illegible] with a [illegible] Government of the Libyan Arab [illegible] Nations Development Programme (UNDP) [illegible] the cement industry in [illegible] upgrading of [illegible] personnel. Specifically, [illegible] was [illegible] out daily duties in the factories; [illegible] and to advise on spare parts requirements; [illegible] plant administra[illegible] in obtaining competitive supplies of spare parts and equipment needed in [illegible] factory; to train local personnel to assume responsibility for the above-[illegible] tioned duties; to advise and assist in all aspects within the expert's compet[illegible] and experience; and to introduce lasting improvements in the country's cement industry.

The mission was carried out between January 1974 and May 1975, although not all of that time was spent by the expert in the Libyan Arab Republic owing to certain unforeseen circumstances. A first visit, paid from January to April 1974, was followed by a second, from September to December 1974, which was then extended several times to embrace the period ending in July 1975, except for a break of one month while the expert paid a necessary visit to Ecuador. In all, 12 months were spent in the Libyan Arab Republic. The work done covered the present and future situation of the Homs Cement Plant. The present report covers three aspects of the work centred at the Homs plant: the existing plant (Homs I); the new extension; and a propsed new one-million-ton-per-year cement plant (Homs II) for which tenders have been accepted.

I. PROJECT [illegible]

The Homs [illegible]

[illegible] Arab Republic. It was [illegible] (Federal Republic of Germany) in [illegible]. [illegible] a kiln with a capacity of [illegible]00 [illegible] preheater and a [illegible] KENTOL [illegible].

In January [illegible], the kiln started to produce clinker, and [illegible] been proved that the kiln is able to produce [illegible] tons of [illegible] average for one month (April [illegible]) [illegible] the foreseen annual production of 100,000 [illegible] technicians and skilled workers for running and maintaining [illegible] of this kind in the Libyan Arab Republic.

To solve this problem, the Government has in the past imported [illegible] from other countries such as Czechoslovakia, Egypt, Federal Republic of [illegible], Pakistan and Yugoslavia. Since September 1975, Indian technical [illegible] of approximately 15 engineers and technicians have joined the plant [illegible] to the previous Czechoslovak team. During the same period [illegible] managers have been in charge of the plant. The frequent changes in personnel have not been beneficial to the operation of the plant, in the view of the expert, and work has suffered from human problems along with technical ones. It will take time to consolidate the operation of the plant, and it seems unlikely that the problems can be solved quickly. Good planning and management are needed.

During the first stay of the expert in Homs, the factory was stopped for 15 days to reline the kiln with new refractory bricks and to make a preliminary overhaul. This work was done to ensure that the existing plant could be kept running until the new production lines were well under way, and this preliminary work was to be followed by a general overhaul. Owing to a serious lack of spare parts, the general overhaul will be difficult to execute, nor will there be enough workers to run two production lines simultaneously if production and maintenance staff cannot be quickly imported.

A complete technical description of the existing plant is contained in annex I.

The extension to Homs I

A[illegible] visit of the expert to the Libyan Arab Republic, [illegible] start up the new extension of the Homs Cement Plant, [illegible] line with a capacity of 1,000 tons of clinker per [illegible]. Like the original plant, the extension was equipped by the Polysius [illegible]. [illegible] Egyptian [illegible].

[illegible] equipped with a LEPOL counterflow preheater and a [illegible]. [illegible] preheater and [illegible], but the handling of raw material and clinker presents difficulties, and a large staff of technicians and skilled workers will be needed. This will be a serious problem.

It was expected that the general overhaul of the old plant would follow the preliminary overhaul carried out in February and March of [illegible], provided that the new extension of the plant was in proper operation at that time. Unfortunately, the latter was not the case owing to severe technical and human problems. It has therefore been necessary to keep the old line running in order to have some amount of production.

The capacity of the old and new lines, respectively, is 330 and 1,000 t/d of clinker.

On 13 August 1974, the new kiln was started up, but because of numerous problems, mostly small but a few serious, it has still not been possible to get the new extension running properly. In technical annex II, the new production line is described section by section, and suggestions are made for specific improvements.

Main problems

The main items of machinery, consisting of the preheater, the kiln and the cooler, are of good design and quality. The serious problems are the poor system of handling raw materials and moisture. Particularly from November to March the high moisture content of the raw material causes tremendous difficulties.

Assistance to the new line has so far been impossible, since it has still not been taken over by the National Cement Company (NCC), and the problems seem to multiply owing to the very bad layout of the plant. The supplier (Polysius) cannot be blamed for this, yet the company may well find that its reputation will suffer nevertheless.

It is estimated that it will cost not less than LD 5-6 million (about $[illegible] million) to bring the new plant to a suitable operating condition.

The expert left the site at the end of February 1975 to carry out duties at the NCC headquarters at Tripoli.

<u>The new plant: Homs II</u>

At the end of October 1974, the Chairman of the Special Committee, Said Al-Lishani, called upon the European consulting engineers Renardet-Sauti-Ice, hereafter called SAUTI, to prepare a complete set of tender documents for a one-million-ton-per-year cement plant located in the Homs area.

A preliminary geological survey at that time carried out by the consulting company POLSERVICE-GEOPOL of Poland (hereafter called POLSERVICE) had showed a quantity of limestone in the area; two boreholes were considered to contain particularly promising material. Based on the evidence of these two boreholes alone, the project was started, and cores were sent to the tenderers as representative samples. This expert considers such action extremely risky. POLSERVICE will submit a binding report concerning the quarrying system and the quantity and quality of the raw material at the end of October 1975. It seems to be a difficult quarry to operate, since the area is short of high-grade limestone.

In only one month's time SAUTI prepared the tender documents. To meet the deadline given them by the Special Committee, SAUTI copied extensively from an old document prepared last year for another cement plant in the Libyan Arab Republic.

Eight tenderers were invited, but only three replied. The three offers were received on 15 April for a new cement plant to be situated about 11 km from the existing plant. The expert assisted the Special Committee and the technical group in evaluating the tenders.

Among the three tenders received a difference is shown in the total price of a cement plant on a turn-key basis of more than LD 16.8 million (about $56.8 million).

The three tenderers are respectively from Denmark, France and the Federal Republic of Germany, and are hereafter called "Alpha", "Beta" and "Gamma".

Alpha

[illegible] from a company with [illegible] years of experience, [illegible] in the field, and specialising [illegible] in the manufacture of cement-making machinery. The special competence of this company is the [illegible] in establishing factories in difficult places and [illegible] company in the world can provide in this special [illegible]. [illegible] the Libyan Arab Republic badly needs.

The [illegible] is an extremely simple process, which means a high degree [illegible]. The price is a fair one and the lowest tendered.

Beta

This offer comes from a new company recently formed as a result of the merger of two well-known companies. It makes many other products besides cement-making machinery. The machinery from this company is of a high quality.

The layout is very good and specially suitable to the new plant site.

Some weak points are to be found in the raw mill department. The only other weak point is that the hot gases from the kiln are not used at all for preheating. Nevertheless, the idea is not too bad for conditions in the Libyan Arab Republic, though the handling of dust will create serious problems.

Since the layout can easily be changed, the offer is the most nearly competitive with Alpha. The price is a little high, being between Alpha and Gamma.

Gamma

This offer is made by another company that is also based on a recent merger of two experienced companies. The company makes other kinds of machinery besides cement-making machinery. It has the advantage of being well-known in the Libyan Arab Republic as the supplier of the Homs I Cement Plant. Also, it is highly supported by SAUTI. The layout is very good, but the capacity of some departments is larger than is required.

As mentioned before in this report, the company has suffered a severe loss of reputation owing to operational problems in the Homs I Cement Plant. It will have to be repeated here, that the problems at Homs I are mainly due to the consultants used before the supplier came into the picture. Nevertheless, it is hard to understand why such a powerful company cannot tackle the problems and bring the factory to a better state of efficiency. The true answer may be the weakness in the management of the factory and tremendous human problems.

The price of Gamma was the highest received.

Data on the three offers are given in annex III.

Revised tenders

Upon receipt of the offers, SAUTI was asked to carry out a pre-evaluation of tenders, which was subsequently, during June, submitted to the Special Committee for comments and discussion. Unfortunately, it was discovered that the pre-evaluation had not been done well, one of the tenders having been strongly supported and another strongly rejected, and the third being treated with moderation. If normal practice had been followed, the most costly offer would have been removed immediately and negotiations continued with the two remaining. The failure to follow the normal practice is regrettable, particularly as the tender rejected had undoubtedly been the best.

The three tenderers were requested to reconsider their prices, and considerable demands were made by SAUTI, requiring of each tenderer much effort and expense. The deadline was postponed from 30 July until 30 August 1975.

When the revised tenders are received, a new evaluation will take place. A final decision and choice of contractor should not be taken before a binding report from POLSERVICE has been submitted to NCC and the tenderers, that is, in October-November 1975.

- -

II. CONCLUSIONS AND RECOMMENDATIONS

[illegible] plant (Homs I)

Many [illegible] connected with cement production in the Libyan Arab Republic are [illegible] decisions made at an early stage, particularly [illegible] with little experience in the field. [illegible] have arisen that present serious [illegible] the industrialization of the country. Not [illegible] are the suppliers [illegible] of these poor beginnings, by loss of their reputation, [illegible] suffer from the consequent reluctance of foreign [illegible] companies to undertake projects in the country.

The expert wishes to draw the attention of the Government to the extremely [illegible] condition of the Homs I Cement Plant. It has recently been extended [illegible],000-t/d line, but the efficiency of the total plant reached only 47.0% [illegible] first six months of [illegible].

If changes are not made in planning and organizing and in the invitation [of] bids, the Government will find itself facing a high installed capacity of very low efficiency, producing a product that may be difficult to export, if that is desired.

Obviously, the experience gained at Homs can be turned to a good account in the execution of future projects. The following paragraphs contain some specific conclusions concerning this plant.

All sections of the Homs Cement Plant are in an unsatisfactory condition with the exception of the crushing department, the raw materials being very easy to crush.

Production loss for the period from January 1969, when the plant was started up, through December 1973 has reached 132,663 tons of clinker, equal to 136,307 tons of Portland cement. Assuming the price of imported Portland cement to have been on an average LD 7.34/t ($24.80/t) the real loss has been LD 1 million in five years, that is, $3,378,378.

During the preliminary overhaul of the factory performed 18 February-9 March 1974, the expert found the local workers working well and having a surprisingly good knowledge of the work, but suffering from lack of skilled workers and tools and spare parts. In [illegible] a good [illegible]. [illegible] busy [illegible], [illegible] and since they [illegible] not, [illegible].

The [illegible] Homs [illegible] plant, [illegible] extension, is [illegible] than 50-60% [illegible] owing to the inadequate raw materials handling [illegible] plant. [illegible] solution [illegible] basic [illegible] will be found [illegible].

The present [illegible] total plant is approximately LD [illegible] ($[illegible]0. million). [illegible] 10%, [illegible]% efficiency, 330 days of operation per year, total installed capacity [illegible] of clinker per day and [illegible]% gypsum added, the depreciation [illegible]:

$$\frac{[illegible],000,000}{10 \times 0.[illegible] \times [illegible]0 \times 330 \times 1.01} \qquad \text{LD 5.[illegible]/t [illegible]} \; (\$18.5[illegible]/t)$$

which will create a prime cost of at least LD [illegible]0/t ($[illegible].[illegible]0).

However, 90 per cent efficiency could be achieved by carrying out several modifications, of which the most costly would be to open a new quarry and to modernize the transport system in the plant. It is estimated that a new quarry would require an investment of LD 3 million ($10.[illegible] million).

An additional LD 2-3 million will be required for increasing plant efficiency from 70 to 90 per cent. Thus, the annual investment cost per ton capacity gained by increasing total capacity from 300,000 to 400,000 tons would be approximately

$$\frac{6,000,000}{100,000} = \text{LD 6 (\$20)}$$

which is not expensive when compared with specific costs of new plants.

The problems discussed above would be alleviated if the management of the Homs Cement Plant were fixed for at least five years and living conditions improved considerably.

A preventive maintenance programme should be carried out together with an efficient storekeeping system. Spare parts should be available for the overhaul of the old kiln. The maintenance cost for one ton of cement produced in Homs [illegible] LD [illegible] ($[illegible]). This means that the annual [illegible] Homs Cement Plant in the future will reach about [illegible] LD [illegible],360 ($[illegible]).

Production and maintenance should be strictly separated. In other words, [illegible] the maintenance department should be in the hands of the [illegible] and not the chief of production.

Long-term assistance to the existing cement plant is not recommended, [illegible] assistance in overhauling the old line and modifying the new line would [illegible] desirable. It might be advantageous to ask the successful contractor at the Homs II Cement Plant to submit an offer for improvement of the Homs I Cement Plant, and this offer would be subject to the main offer for the new plant.

It might even be better to forget the old plant completely (e.g. for one year) and concentrate the [illegible] manpower on the new extension only, or invite [illegible] contractors to submit bids for a turn-key overhaul.

The extension to Homs I

The extension to Homs I is, as mentioned earlier in this report, based on specifications prepared by a foreign consultant. The layout of the plant appears not to be designed for handling the flow of materials required for a modern, dry-process cement plant. In the opinion of the expert, modifications are required and experienced personnel is needed.

The chief of maintenance will have to be a mechanical engineer with at least 10 years of experience in the field. The maintenance team should consist of 1 mechanical engineer, 1 electrical engineer and 1 electronic engineer together with about 30 skilled workers (fitters, welders, electricians, mechanics, bricklayers and so on).

The need for experts in management, quarrying, production, maintenance, storekeeping, instrumentation and chemical engineering will be tremendous.

To put the works manager in a more independent position, it would be desirable to keep the office of the general manager at some distance from the plant.

A Telex connexion between the plant's main office and abroad is indispensable.

The laboratory should be [illegible] so that [illegible] materials, clinker and cement can be [illegible]. The [illegible] from the [illegible] points.

The consultants or contractors [illegible] concerning:

(a) Equipment for the new [illegible]. (The existing [illegible] after one year more of full production.) A mobile crusher [illegible] situated at the quarry is advisable;

(b) Limestone and clay transport. Limestone [illegible] by trucks would be advisable;

(c) Clay drying and crushing plant (to avoid the [illegible]);

(d) Preblending plant;

(e) Bypass for the kilns (alkali and chlorine problems);

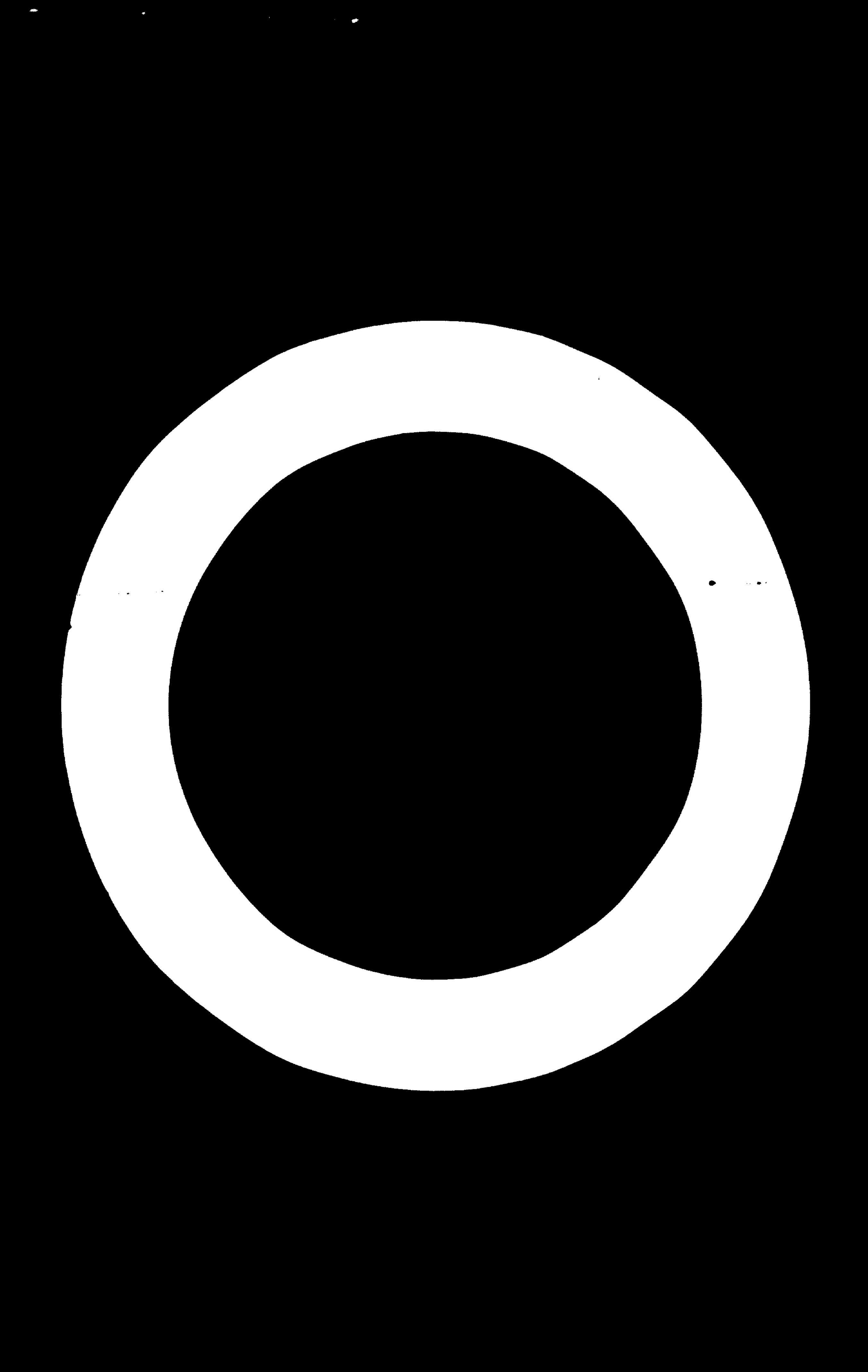
(f) Lift for the preheater and silos, which is indispensable for proper maintenance.

Further assistance to Homs I (the new production line) would be meaningless if given before the plant has been taken over by NCC and a substantial change in management policy has taken place.

The new Homs II Cement Plant, a million-ton-per-year plant that is expected to be in operation in 1978, could be the object of a large-scale technical assistance project, presumably under the UNIDO General Trust Fund and embracing a complete management and technical team for operating the factory and training personnel.

It would be advisable to postpone decisions regarding the new plant until both the raw material situation and questions related to infrastructure and civil engineering have been studied by the bidding companies. Otherwise, no company will be able to give a firm price and will therefore be obliged to state a high price to cover risks.

The three offers already received show a difference in the total price of more than LD 16.8 million (about $56.8 million), which is abnormally large and is unacceptable. (See annex II.)



[illegible]

[illegible]

[illegible]

[illegible]

A. [illegible]

[illegible] ripping, Caterpillar D-[illegible]. All [illegible] equipment is equipped with a [illegible] meter, which shows the [illegible] units (about hours) the engine has been under full load. As a general rule, the [illegible] should be renewed after 1[illegible],000 service meter units (SMU). After this time the maintenance cost will increase sharply.

The expert found the service meter of the D-[illegible] in Homs out of order, which shows something about the maintenance of this engine. The bulldozer has been in use for five years, which means for about 10,000 hours. It has been sent to Tripoli for a general overhaul. In the meantime, a leased bulldozer of the same type is being used.

The two excavators have been replaced by one wheel loader, Caterpiller 950, which is working very well and is quite new (1,500 SMU).

Unfortunately, the extension has been designed with the crushing department at the plant. The practice today is to crush the stones at the quarry and transport the crushed materials by rubber belts to the raw materials store, where prehomogenization takes place. At the Homs Cement Plant, trucks have to be used constantly, which makes the depreciation and maintenance costs high.

[illegible] and rates [illegible]. [illegible] . In countries [illegible] all, however, it may [illegible] .

[illegible]

[illegible], and the equipment is in good condition, which [illegible] raw material and to the failure [illegible] production of 100,000 tons of clinker per [illegible] in [illegible] .

[illegible]

The [illegible] has been in operation for [illegible] years with no replacement [illegible] plates. More than [illegible]00,000 tons of raw materials have passed through the crusher, but only turning the hammers was necessary, which was [illegible] overhaul in March 19[illegible].

[illegible] it is very important to start preventive maintenance in this department. For instance, [illegible] of the [illegible] hammers in the crusher can be replaced [illegible] available from the store. The store should have had 72 new hammers, [illegible] were ordered, one of which has been used for other purposes. In the [illegible] the worn hammers can be rewelded, ready for use the next time and so on.

Conveyors

The expert found conveyors of the same size running with different velocities. The supplier seems to have made a mistake; as a result some of the rubber belts are overloaded, which means a higher maintenance cost. Drives will have to be checked and the same velocity of the belts obtained.

Raw materials store

The raw materials store is an open stockpile store consisting of 2 x 3 hoppers on the ground floor. Three hoppers are for high-lime marl and three hoppers for low-lime marl. Below the hoppers the raw materials can be extracted by means of a rubber weighing-feeder belt from which the materials are fed to the raw mill. The expert found the system very weak and the feeding to the raw mill completely out of control. The mill should have had its own hoppers or silos for limestone, clay and additives, but it is too late to provide them now.

A roof for the raw materials store is foreseen, which will solve the problem of too much moisture. In the rainy season the moisture can reach 12-15%, and the raw mill has been designed for 8% maximum moisture in the feed.

Nevertheless, for the [illegible] the operation of the [illegible] plant will [illegible].

[illegible]

The production [illegible] of the [illegible] a little [illegible], which means there is a certain reserve, which should [illegible]. A [illegible] of this department [illegible] production [illegible] and maintenance.

Raw mill

The raw mill is an air-swept mill designed with a short drying chamber before the first grinding chamber. The expert would recommend removing the diaphragm and lifting shovels and replacing them with normal lining plates. Some problems will occur, since the mill motor and gear will be too small for an additional mill charge, and the mill will have to be operated with a lower charge of grinding media than normal. However, the maintenance cost will be lower.

Circulating air system

The circulating air system needs to be examined. The expert would recommend changing the pipe coming from the circulating air fan to the inlet of the mill. This pipe is connected at right angles to the connexion pipe between the auxiliary furnace and the mill. If the pipe could be connected at an angle of 15 or 30 degrees the system would be considerably improved. Much [illegible] air enters the system, since the double sluice (Hazemag) has been wrecked and is therefore not working.

Auxiliary furnace

The capacity of the auxiliary furnace is only calculated to dry out raw materials containing up to 8% maximum moisture. The expert believes that this capacity should be adequate, provided that the raw materials store is covered by roofing and the circulating air system improved.

Filter installation

The filter is designed for feed with 8% maximum moisture only. It is expected that the capacity of the filter will be adequate in the future. In the rainy period all other dedustings will have to be reduced as much as possible.

[illegible]

[illegible] the raw mill department to the homogenizing [illegible] compressed air [illegible] kg/[illegible]) system. The [illegible] compressors. One compressor has already been [illegible] has been repaired [illegible]. The plant will have to deal with this [illegible], since the transport of the raw meal can be a serious bottleneck.

Homogenizing and storage silos

The plant is equipped with two homogenizing and storage silos with a sufficient capacity for 2-3 days feeding to the kiln. The homogenizing silos are situated on the top of the storage silos. For maintaining an under-pressure in the silos, a suction filter is connected.

During the next general overhaul the aeration system in the homogenizing silos will have to be checked. It was impossible to do such checking during the preliminary overhaul, but it is certain that some of the porous plates are worn out and will have to be renewed. All valves in the air distributor will have to be changed, which can easily be done, since most of the valves are available in the store.

For the storage silos a new Roots blower was erected during the preliminary overhaul, which should ensure a trouble-free operation for the time being.

Kiln department

At present, the kiln department consists of one kiln with a capacity of 100 t/d of clinker and one kiln under erection with a capacity of 1,000 t/d of clinker. If the start-up of the new production line begins on schedule, the later kiln will start making clinker in September 1974.

In the meantime, the existing kiln will have to work, but production will be low because the cyclone-tower is in an extremely bad condition. During the preliminary overhaul, no manpower and spare parts were available to carry out repairs.

The kiln department suffers too much from power failures of the Homs power station and for that reason the RECUPOL cooler is nearly ruined. The existing plant has no auxiliary power station, but one is foreseen for the new extension. Such power failures are very costly to a cement plant, and it would be advisable for the Government to look into the matter at some future date.

To keep the Homs Cement Plant running at trouble-free production 1,200 tons of clinker per day, it must be assured a power supply of at least 10 MVA.

DOPOL tower (cyclone tower)

The DOPOL tower (DOPOL registered trade mark for double-pass preheater designed by Polysius) is in a miserable condition and a general overhaul of it will take at least two months. The caloric consumption now reaches about 1,200 kcal/kg clinker, which is about 40% more than what was guaranteed. In spite of the very cheap fuel oil in the Libyan Arab Republic, the plant at present is losing more than LD 50 per day ($169/day) on fuel.

The DOPOL tower consists of four stages of cyclones. In this report, stage I is the stage where the raw meal is supplied, that means the cyclones at the highest level of the tower. There is some confusion about the numeration, since some companies make it according to the flow of material and others according to the flow of hot gas. In general, it is more practical to make the numeration of processes or machinery in a cement plant according to the flow of material.

For the general overhaul, the following items need to be removed or repaired:

Stage I	4 flap valves
Stage II	2 flap valves
	2 central pipes (CrNi)
Stage III	1 central pipe for vortex vessel
	2 feed chutes
	1 double flap valve
Stage IV	2 central pipes (CrNi) available from the store
	2 flap valves

Nine new flap valves of the latest design should be ordered; since the supplier is on the spot, this order should be processed promptly. The supplier should also be consulted about chlorine and alkali problems. It may be necessary to install a by-pass. The new kiln is a GEPOL kiln, which is not sensitive to chlorines and alkalis, since no centrifugal forces occur in the critical temperature range 600° - 750°C.

The DOPOL [illegible] operation, especially at night, [illegible] possible. A [illegible] operation.

When the kiln [illegible], the temperatures are recorded at the control [illegible] together with the pressure before the induced draught fan (ID fan). It [illegible] useful also to have the pressure [illegible] cyclone tower.

The pipe [illegible] between cyclone stage I and the ID fan is insulated. To prevent [illegible] gas from going to the electrostatic precipitator, it would be useful to remove the insulation. The hot gas from the kiln is not used for drying in the raw mill, since the raw mill is situated at some distance from the kiln.

Rotary kiln

The rotary kiln, [illegible] diameter x [illegible] diameter x [illegible] m, was stopped on 18 February for relining of refractory bricks, and [illegible] m of lining was renewed by 2 x 12 men in 8 days, equal to 1,536 man-hours (about 14 man-hours per ton of removed and renewed bricks), which is a really good performance. At the same time the kiln alignment was checked optically and found to be satisfactory.

The whole kiln was lifted up 4 mm during the preliminary overhaul to obtain a better clearance between the big gear-wheel on the kiln and the pinion on the drive. This operation will save the kiln from serious damage to the kiln drive.

All the rollers were adjusted so that the kiln will mainly work in the upper position, since the seal between the kiln and the DOPOL tower is in bad condition. In this way, the entrance of false air can be limited and production increased. In the general overhaul the seal will have to be fixed very well. Many cup-springs will have to be ordered, since these are not available from the store.

Dust precipitator

The electrostatic dust precipitator, supplied by ELEX in Switzerland, is in a miserable condition. Fortunately, ELEX designed the filter with big explosion doors and these doors have really saved the filter many times, since the CO-analyser is not working at all.

The filter [illegible]; [illegible] ([illegible]) [illegible], [illegible].

Of [illegible] is.

A [illegible] down the [illegible] $[illegible]0^{\circ}$ [illegible] $[illegible]0^{\circ}C$ [illegible], [illegible] of $[illegible]0^{\circ}-180^{\circ}C$ and moisture [illegible] $[illegible]-[illegible]0\%$.

The [illegible].

Regarding chlorine and alkali products, it is [illegible] the kiln operation if the filter does not work too efficiently, since all the fine dust would pick it up if it did. Dispersing the fine dust through the chimney brings fertilizer to the area around the plant. In some cement plants the fine dust taken from the last compartment in the filter is sold as fertiliser and at a price [illegible] higher than that for the cement.

RECUPOL cooler

Most of the stoppages in the kiln department are due to problems with the cooler. The cooler has a sufficient surface, about [illegible] m², but it is narrow and long, which makes it thermally overloaded especially in the first part of the cooler, where hot clinker comes down at a temperature of about $1,[illegible]00^{\circ}C$. This kind of cooler has plenty of moving parts and it is equipped with a centralized lubrication system. The grease for the cooler should be heat resistant, but the expert found the system filled with normal grease, which is useless in the hot part of the cooler.

For the general overhaul it will be necessary to order a considerable number of spare parts. The delivery time for these parts may be over a year.

For this kind of cooler an auxiliary power station is indispensable. Because there is none, the cooler is in an extremely bad condition.

The new kiln is provided with a satellite cooler, which is easier to maintain during operation. An auxiliary power station is foreseen for the new extension. It would be advisable to make a connexion to the existing cooler, since the Homs Cement Plant suffers from power shortages.

Burner and fuel plant

To obtain complete combustion in the kiln the fuel has to be supplied at a [illegible] of about [illegible] Engel degrees, which for bunker "C" fuel will be about [illegible], and a pressure according to the type of burner, but normally about [illegible]. At the [illegible] plant a mixture of heavy and light fuel, which needs only a temperature of [illegible]0° - [illegible]0°C is used. The preheater for fuel oil gives trouble [illegible] a lack of spare parts, and the preliminary overhaul has not been very successful.

Control panel

It is surprising that it is possible to run a kiln when only very few instruments are working. The kiln is run mainly visually by "eye-meter", which is possible only thanks to experienced burner masters. The lack of instruments that are in order is very serious, and all efforts should be made to renew and repair instruments that are not working.

It is advisable as soon as possible to order a complete set of O_2 and CO analysers (oxygen and carbon monoxide). The existing analysers are MAGNOS 5, magnetic oxygen analyser, and URAS 2, infra-red gas analyser.

All recorders should be repaired; a daily control will help to solve many production problems. The time for this overhaul is now, while the supplier is still on the spot.

Clinker transport

The clinker transport consists of a deep-bucket conveyor and a drag-chain conveyor. The former can be a serious bottleneck and therefore a study should be carried out on how to combine the clinker transport from the existing kiln and the new kiln. Two deep-bucket conveyors should be installed each with sufficient capacity for both kilns. Thus, one conveyor will always be available as a stand-by.

The present layout of the transport systems makes the maintenance complicated.

If the above-mentioned suggestion is not acceptable, it would be advisable to order a complete set of chains and buckets and once a year, during overhaul, change the whole set. In this way the mechanical workshop can do the maintenance little by little on the used set; and when finished, it can be stored, ready for use when the next overhaul takes place.

During the preliminary overhaul, the deep-bucket conveyor has been completely overhauled; but owing to a lack of spare parts, the conveyor has been provided with parts made in the workshop.

Clinker store

The clinker store is an open stockpile store covered only above the drag chain. The height of the pile is limited by the level of the drag chain.

To avoid developing too much clinker dust, the drag chain has been equipped with a water-spray device. The water spray should be moved away from the drag chain, since the links are so corroded that a breakdown can occur at any time. The water should be supplied at some point away from the drag chain.

Extraction system

For the existing kiln, there are only two extractors or feeders below the ground floor of the clinker store. It is impossible to empty the store completely without a bulldozer, and even with a bulldozer it is very difficult because of the many columns.

The same difficulties will occur for the extension, where the same system is going to be used. Great care will have to be taken by all movements of clinker by means of bulldozer or wheel loader, since all columns are very weak and the drag chain bridge can be deformed.

Today clinker silos are used. They can be constructed even for very hot clinker supplied from a satellite cooler.

Cement mill department

Since the production of clinker has been very low, no problems have arisen in grinding this clinker. No study of this department has been made. However, the expert would recommend converting the mill from 3 to 2 chambers to reduce the operation and maintenance costs. The water-injection system, which is out of order, needs to be repaired.

Packing plant

The packing plant was not investigated or overhauled during the UNIDO expert's stay, but according to information given by the local technical staff, there is a considerable shortage of spare parts for this department. These should be ordered as soon as possible.

Maintenance cost

[illegible] maintenance [illegible] plant [illegible] and [illegible]. [illegible], the maintenance of a cement [illegible] will [illegible] that preventive maintenance.

As an indicative figure, the maintenance cost will alternate between 2-5% of the f.o.b. price for the mechanical and electrical equipment with the highest [illegible] in the developing countries. It must be taken into consideration that all kinds of maintenance will [illegible] specialized companies as in industrialized countries.

The maintenance cost consists of the following items:

- Mechanical spare parts
- Electrical spare parts
- Normal replacement materials for the mechanical, electrical and auto-mechanic workshop
- Lubrication (0.15 kg/t of cement)
- Brick work ([illegible] kg of bricks/t of cement)
- Manpower

For the existing plant the f.o.b. price (in 1964) for mechanical and electrical equipment reached LD 1,284,900 ($4,342,960). A maintenance cost of 5% makes an annual cost of LD 64,245 ($217,148). Thus, for an annual production of 100,000 tons of cement the maintenance cost is LD 0.643 per ton of cement. Today this figure will easily reach LD 1,500 per ton because of the skyrocketing prices for equipment for cement plants. Also, it must be taken into consideration that the Libyan Arab Republic will have to import maintenance workers.

Nevertheless, it is possible to cut down the maintenance cost considerably and still keep the plant running efficiently if the plant has been well designed and machinery with a low maintenance cost has been chosen. This latter point is very important for the developing countries. It is too late to call for technical assistance when a plant has been set up and equipped with too complicated machinery and more simple machinery would have done as well.

Append[illegible]

DATA [illegible] THE EXI[illegible] [illegible] PLANT

[illegible] . [illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
January	[illegible]	[illegible]	[illegible]	[illegible]0	[illegible]	[illegible]
February	[illegible]	[illegible]	[illegible]	[illegible]0	[illegible]	[illegible]
March	[illegible]	[illegible]0	[illegible]	[illegible]0	[illegible]	[illegible]
April	[illegible]0,[illegible]0	[illegible]	[illegible]	[illegible]0	[illegible]0.	[illegible]
May	[illegible],0[illegible]0	[illegible]	[illegible]	[illegible],[illegible]40	[illegible]	[illegible]
June	11,[illegible]10	[illegible]	2[illegible]	[illegible],[illegible]10	[illegible]	[illegible]
July	[illegible],[illegible]0	[illegible]	28.[illegible]	[illegible]10	[illegible]	[illegible].0
August	[illegible],260	[illegible]	[illegible].0	[illegible],[illegible]0	[illegible]	[illegible].8
September	11,6[illegible]0	434	[illegible]	[illegible],[illegible]0	[illegible].8	[illegible]
October	8,[illegible]0	[illegible]00	[illegible]	[illegible],1[illegible]0	[illegible]	...
November	[illegible]0,[illegible]0	[illegible]	[illegible].0	[illegible]0	[illegible]	[illegible]
December	1[illegible],[illegible]0	[illegible]	[illegible]4.8	[illegible]0	[illegible]0.[illegible]	[illegible]
Total	127,640	[illegible],052		[illegible],603,[illegible]0		
Average	10,63[illegible]	421	[illegible]5.[illegible]	[illegible]00,[illegible]	[illegible]8.[illegible]	[illegible].2
Efficiency (%)	73.0	80.8	[illegible]0.[illegible]		[illegible]	

Performance guarantee	28 t/h, 8% R 4,[illegible]00 mesh/cm^2, final moisture 1%, initial moisture content of 8% maximum and a feed size ranging from 0-[illegible]0 mm, tolerance [illegible]%
Normal working hours per year	6,250
Normal electric energy consumption	18 kWh/t

Source: The local technical staff.

Table [illegible]. Production and consumption in the kiln department for [illegible]

Month	Raw [illegible] (t)	Clinker production (t)	Litre weight (g/l [illegible])	Gas consumption ([illegible])	Working period (h)	Heat [illegible]
January	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10.8
February	[illegible]	[illegible],000	[illegible]	[illegible]	[illegible]	10.[illegible]
March	[illegible]	5,000	[illegible]	...	477	10.5
April	11,518	[illegible],000	1,475	[illegible]50	618	11.3
May	10,[illegible]	6,540	1,525	350	597	1[illegible].0
June	10,983	6,636	1,608	390	581	11.4
July	9,970	6,030	1,505	370	520	11.6
August	13,387	8,100	1,504	370	632	12.8
September	10,122	6,094	1,498	390	516	11.8
October	11,622	7,008	1,468	390	620	11.3
November	10,761	6,508	1,400	370	572	11.4
December	11,822	7,152	1,433	380	641	11.2
Total	127,842	75,892			6,707	
Average	10,654	6,324	1,501	371	559	11.3
Efficiency(%)		75.9			83.8	

Performance guarantee	300 tons of well-burnt clinker per 24 hours, with a heat consumption of 850 kcal/kg clinker, referred to the net calorific power of the fuel (minimum 9,500 kcal/kg and a sulphur content not exceeding 3%), tolerance 3%
Normal working hours per year	8,000

Source: The local technical staff.

Table 3. Production and consumption in the cement mill department for [illegible]

Month	Cement production (t)	Working period (h)	Hourly output (t/h)	Residue on 4,900 mesh/cm² (percentage)	Energy consumption (kWh)	Specific consumption (kWh/t)
January	4,000	[illegible]84	14.[illegible]	4.[illegible]	[illegible],010	[illegible]
February	4,000	[illegible]	18.[illegible]	[illegible]	[illegible]	[illegible]
March	6,800	[illegible]	[illegible]	5.1	[illegible]	40.[illegible]
April	7,080	421	16.8	5.2	[illegible]	[illegible]
May	7,[illegible]00	4[illegible]1	16.8	4.[illegible]	308,310	[illegible].4
June	7,350	4[illegible]3	17.8	5.[illegible]	288,120	[illegible]
July	6,570	361	18.2	5.0	243,120	3[illegible].0
August	7,300	421	17.3	5.1	30[illegible],240	41.5
September	7,135	424	16.8	6.2	2[illegible]2,170	38.1
October	6,840	368	18.6	9.4	239,910	35.1
November	6,954	295	18.7	9.6	185,510	33.6
December	8,025	440	18.2	7.1	291,93[illegible]	36.4
Total	78,515	4,523			3,029,189	
Average	6,543	377	17.4	6.1	252,432	39.5
Efficiency (%)	69.8	72.4	96.7			

Performance guarantee	18 t/h, 5% R 4,900 mesh/cm², dry gypsum, lump size 0-25 mm with 20% oversize up to 50 mm admissible; clinker to be deposited for a fortnight at least; tolerance 3%
Normal working hours per year	6,250
Normal electric energy consumption	About 30 kWh/t

Source: The local technical staff.

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
January	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
February	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
March	[illegible]	[illegible]	[illegible]	[illegible],0[illegible]	[illegible]
April	[illegible],01[illegible]	[illegible]	[illegible]	[illegible],0[illegible]	[illegible]
May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]10.[illegible]
June	[illegible],0[illegible]	[illegible]	1,201	[illegible]	[illegible]
July	[illegible],41[illegible]	[illegible]	[illegible],232	[illegible]	[illegible]8.8
August	[illegible],116	85[illegible]	[illegible],058	841,[illegible]5	103.[illegible]
September	6,1[illegible]	[illegible]	1,[illegible]	[illegible]	130.2
October	[illegible],075	86[illegible]	1,231	688,[illegible]	[illegible]8.3
November	[illegible],354	77[illegible]	1,134	72[illegible]	112.1
December	8,026	8[illegible]	[illegible],225	[illegible]63,516	135.2
Total	[illegible]8,304	[illegible],00[illegible]		[illegible],251,173	
Average	[illegible],525	[illegible]51	1,188	[illegible]0,[illegible]31	124.2
Efficiency(%)			71.5		87.0

Energy requirement per ton of cement guaranteed not to exceed 108 kWh/t.
Read on the meter.
Heat consumption guaranteed not to exceed 850 kcal/kg of clinker.

Source: The local technical staff.

Table 5. Total clinker production at Homs Cement Plant, 1969-1973 (Tons)

Year		Clinker
1969		77,690
1970		90,006
1971		65,192
1972		58,883
1973		75,892
	Total	367,663

The [illegible] in A[illegible]0, [illegible] of clinker [illegible]/1. [illegible]/[illegible], [illegible] that an annual production [illegible],00,000 [illegible].

Table [illegible]. Ba[illegible] mills

Raw mil[illegible]

	Ball diameter ([illegible])	Weight ([illegible])
E[illegible] [illegible],[illegible] mm	[illegible]0	[illegible].0
[illegible] 38[illegible] mm	[illegible]0	[illegible].0
	[illegible]0	[illegible].[illegible]
	[illegible]0	[illegible].0
	40	10.0
	30	[illegible].0
Total		4[illegible].[illegible]

[illegible]ement mill

Compartment	Effective length (mm)	Ball diameter (mm)	Weight (thousand kg)
1.	3,288	100	2.[illegible]
		90	3.[illegible]
		80	3.3
		70	3.3
		60	2.0
			14.5
2.	2,756	60	2.0
		50	2.2
		40	3.3
		30	4.5
			12.0
		Dimensions of cylpebs (mm)	Weight (thousand kg)
3.	6,710	20 20	11.0
		18 18	11.0
		16 16	8.0
			30.0
Total			56.5

Appendix 2

QUARRY EQUIPMENT FOR THE EXISTING PLANT

Number	Item	Specifications
1	Bulldozer, Caterpillar D9G	Power = 385 hp Service meter units (SMU), about 12,000 (out of service) Total weight 30,600 kg
2	Universal diesel excavator with faceshovel attachment, type "DEMAG BL 312", dipper capacity	Power = 110 hp SMU = estimated at about 8,000 hours Struck filling 1.2 m^3 ([illegible] t) Heaped filling 1.3 m^3
1	Front-wheel loader, Caterpillar 950	Power = 130 hp at 2,150 rev/min Operating weight (minimum) 10,900 kg Heaped capacity about 2 m^3 = 3.6 t SMU = 1,600
6	Rear-end dump trucks, Mercedes-Benz, 6 x 4 Trough capacity	Power = 195 hp Struck filling 8.5 m^3 = 15 t Heaped filling 10 m^3 = 18 t
1	Movable air-cooled compressor, Atlas Copco Specific fuel consumption at full load and [illegible] kg/cm^2	Power = approximately 100 hp Capacity [illegible].7 m^3/min at 7 kg/cm^2 26 g/m^3 = 15 kg/h = 18 litre/h
8	Air connexion hoses	20 mm diameter x 15 m
4	Dry blower type jackhammer drills	Weight = 27 kg each Capacity 4.4 m^3/min at 6 kg/cm^2
4	Set of drill rods, each consisting of	

Diameter (mm)		Length (mm)
1 x 40	x	800
1 x 39	x	1,600
1 x 38	x	2,400
1 x 37	x	3,200

Total motor ratings (hp)

1	Bulldozer	385
2	Excavators	220 (out of service)
1	Front-wheel loader	130
6	Rear-end dump trucks	1,170
1	Compressor	82
	Total	1,987

Appendix [illegible]

EQUIPMENT FOR THE CRUSHING DEPARTMENT

Performance guarantee

Capacity	120 t/h
Working time	8 h/day - 6 days/week
Feed lump size	500 x 700 x 900 mm
Final grain	20 mm

Main machinery

Number	Item	Power (kW)
1	Apron feeder, 1,[illegible]00 mm x 10 m, 120 t/h	7.5
1	Double-shafted hammer crusher, 2 x 1,400 mm, 72 hammers each 29 kg, 120 t/h from 500 x 700 x 900 mm to 0 - 20 mm, motors 2 x 65 kW	130.0
1	Impact flat belt, 1,400 mm x 6 m, 120 t/h, vel. = 1.25 m/sec	5.0
1	Rubber belt conveyor, 650 mm x 125 m, 120 t/h, vel. = 2.0 m/sec	24.5
1	Rubber belt conveyor, movable and reversible, 650 mm x 15 m, 120 t/h, vel. = 1 m/sec	6.6
1	Rubber belt conveyor, 650 mm x 16 m, 120 t/h, vel. = 1.25 m/sec	3.7
1	Rubber belt conveyor, movable and reversible, 650 mm x 15 m, 120 t/h, vel. = 1 m/sec	6.6
1	Suction bag filter, total/effective 336/299 m^2, 32,000 m^3/h	2.2
1	Exhaust fan, 33,600 m^3/h, 20°C, 220 mm WG, 1,000 rev/min	37.0
	Total	223.1

Appendix [illegible]

RAW MILL DEPARTMENT

Calculation of the size of the exhaust fan and filter

Conditions:

Moisture of 8% maximum in the raw material and a nominal production of 28 t/h with a residual moisture of 1%. Temperature inlet/outlet of the mill = 580/80°C.

The amount of water to be evaporated:

$$W_a = T_r \frac{w - w_r}{100 - w} = 28{,}000 \frac{8 - 1}{100 - 8} = 28{,}000 \frac{7}{92} = 2{,}130 \text{ kg } H_2O/h$$

Heat consumption:

Heat required for drying limestone with a moisture of 8% is $W_a \times k$, where $k = 1{,}200$ kcal/kg water. 2,130 x 1,200 = 2,556,000 kcal/h

Amount of heating gas in Nm^3/h:

$$G_h = \frac{W_a \times k}{t \times s_g} = \frac{2{,}130 \times 1{,}200}{500 \times 0.33} = 15{,}491 \text{ Nm}^3/h$$

Allowance for false air:

The allowance for false air is estimated to be about 10% of the circulating air. The amount of circulating air is 2 m^3 per kg of ground raw material.

The total amount of gas to be removed from the mill:

$$G_m = \frac{15{,}491 \times 353}{273} = \quad 20{,}030 \text{ m}^3/h \text{ at } 80^\circ C$$

Allowance for false air = 2 x 28,000 x 0.1 = 5,600 m^3/h at 80°C

Water vapour to be removed = $\frac{2{,}130 \times 1.25 \times 353}{273}$ = 3,443 m^3/h at 80°C

Total: 29,073 m^3/h at 80°C

Abbreviations

T_r	Dried raw material with W_r % moisture, in kg
W	Initial moisture content, referred to moist material, in %
W_r	Residual moisture content, referred to moist material, in %
W_a	Amount of water that must be driven off in drying the material to W_r % residual moisture, in kg
G_h	Amount of heating gas, in N m^3/h
G_a	Amount of exhaust gas in m^3/h at exhaust gas temperature
k	Kcal/kg of water to be evaporated
t	Difference between inlet and outlet gas temperature
s_g	Specific heat of heating gas

Filter installation

Manufacturer	BETH, Federal Republic of Germany
Compartments	10
Bags	10 x 18 = 180
Bag dimensions	200 mm diameter x 3,250 mm = 2.04 m^2
Loads	90 $m^3/h/m^2$

Fan for the filter

Manufacturer	BETH, Federal Republic of Germany	
Number	24260	Capacity 28.500 m^3/h at 80°C
Rev/min	1,450	
Operating pressure	200 kg/m^2	Motor 31 KW

Annex II

TECHNICAL DESCRIPTION OF THE EXTENSION OF HOMS I

Quarry and quarry equipment

Description

For the time being the raw materials for the clinker production are quarried in the deposit named Ras El-Margheb, hereafter called Margheb quarry, situated only 100-500 m from the plant. Unfortunately, the Margheb quarry is short of high-grade limestone. It is estimated that if the Homs I Cement Plant runs at 80% efficiency, raw materials of the right composition will be available for only the next eight or nine months.

Opening of a new, urgently needed quarry is under way. There are two deposits a few hundred metres apart, Ras El-Manubia and Ras El-Kabir, hereafter called Manubia and Kabir. The Manubia deposit will be used first and should cover the necessary raw materials for the next 10-15 years.

The new quarry is rich in pure limestone, which could be very important for the new Homs II Cement Plant as corrective. The Libyan Arab Republic is short of pure limestone.

The new quarry is situated about 3 km from the plant site. A 500-t/h crushing plant at the deposit Manubia is to be installed. The crushed materials will be transported to the plant by a 800-mm-wide rubber belt conveyor or by lorries.

The opening of the new quarry and the erection of the new crushing plant and rubber belt conveyor will take time. It is unlikely that the quarry will be in operation before October 1976. In the meantime a serious situation could arise regarding the raw materials supply to the Homs I Cement Plant.

Recommendations

The new quarry at Manubia should be opened as soon as possible. At least 125,000 tons of raw materials, covering two months' consumption, should be transported by truck to the vicinity of the existing crushing department to build up a stockpile.

[illegible] (LE [illegible]0/[illegible]) [illegible]. A[illegible] [illegible],000 [illegible] LE [illegible]0,000.

[illegible] is available in the vicinity [illegible] Plant, [illegible] provided with a clay crushing and drying [illegible]. [illegible] a conside-rable [illegible], which would have to be removed. However, a clay-preparation [illegible] fast return on investment.

[illegible]

The main equipment supplied for the extension is listed below.

Number	Item
2	Bulldozer, Caterpillar D9G
2	Wheel loader, Caterpillar 988
1	Wheel loader, Caterpillar 930
1	Bulldozer, Caterpillar D6C
4	Compressor, Atlas Copco, 3 x PR 700 + 1 x ST 95
1	Compressor, Ingersoll-Rand DXL 750
2	Crawler drill, Atlas Copco ROC 301
2	Wagon drill, Atlas Copco BVB 25
5	Hammer drill, Atlas Copco RH 571-3L
5	Dump truck, Daimler Benz, 17.5 t payload
1	Mobile workshop
1	Servicing lorry
2	Ignition apparatus
1	Ohmmeter

The equipment is suitable for the new Manubia quarry, where the selective quarrying will have to be done in two benches, the upper bench of pure limestone by blasting and the next bench of marl by ripping.

For the new quarry the purchase of 30-t off-highway rear dump trucks (Caterpillar 796 B) is foreseen. The wheel loader, Caterpillar 988, and the dump truck, Daimler Benz, 17.5-t payload, do not go together, but later on, with the 30-t trucks, there will be no problem. It is a practical and economically sound rule that the wheel loader should be able to load the truck in three loads without waste and overloading the truck.

The small dump trucks [illegible] Man[illegible] is near the new crushing plant and the [illegible] hopper [illegible].

However, this crushing plant [illegible] until the new crushing plant at the Manubia quarry [illegible] (is installed).

The wheel loaders, Caterpillar [illegible], are equipped with [illegible] general-purpose bucket without teeth. A [illegible] capacity.

Crushing department

The new crushing plant is situated beside the old one and has a capacity of 250 t/h, which is too low for a one-shift operation. A crushing plant normally operates only 1,600 h/a, which is also the normal annual working time at the quarry. This consideration is particularly important in the Libyan Arab Republic, where there is a shortage of manpower. For a 1,000 t/d clinker production line the crusher should have a capacity of

$$\frac{1{,}000 \times 1.75 \times 330}{1{,}600} = 361, \text{ roughly } 350 \text{ t/h},$$

assuming 1.75 tons of materials for production of 1 ton of clinker and the kiln working 330 d/a.

As mentioned earlier the new crushing plant is operating only temporarily, since a new 500-t/h crushing plant, which will meet the requirements of the two kilns, will be built at the new Manubia quarry if final agreement reached in this respect. In the meantime, this plant is a serious bottle neck owing to its smallness and also to the system of feeding to the crusher. Furthermore, the plant can be stopped at any time by a careless driver, which would bring the whole production-line of 1,000 t/d clinker to a halt. The new crushing plant at the Manubia quarry is therefore urgently needed.

Hopper and feeder

The capacity of the receiving hopper is about 50 tons, which corresponds to three 16-ton loads from the small new dump trucks.

The feeder below the hopper is a reciprocating tray feeder. This type of feeder is old-fashioned and undesirable in a cement plant today. The feeder has the following specifications:

Length of tray: 1,[illegible]00 mm

Width of tray: [illegible],[illegible]00 mm

Nominal conveying capacity: [illegible]50 t/h

Materials fed: limestone, marl

Feed lump size: [illegible]00 x [illegible]00 x 500 mm

Feed moisture content: [illegible]-[illegible]%

Power requirement: [illegible]0 kW

Power of motor: [illegible] kW

Speed of motor: 1,[illegible]00 rev/min

The extension has recently stopped operations completely owing to troubles with this feeder, and therefore the reciprocating tray feeder must be considered one of the most serious bottlenecks in the extension.

Hammer crusher

The crushing department is equipped with a single-shafted hammer crusher with the following technical specifications:

Type of crusher: EHB 2020/4

Diameter of crushing mechanism: 2,050 mm

Housing width: about 2,000 mm

Feed opening: 1,[illegible]00 x 1,950 mm

Materials fed: limestone, marl

Throughput: 250 t/h

Feed moisture content: 4-7%

Feed lump size: 900 x 700 x 500 mm

Final grain size: 0-20
with a small oversize portion

Power requirement: 300 kW

Motor power required: 360 kW

Speed of motor: 990 rev/min

As mentioned before, this crusher will be replaced by one with a capacity of 500 t/h at the new quarry.

Conveyors

Since the new crushing plant is a serious bottleneck, the old crushing plant should be connected by belt conveyors to the new raw materials store to keep the new line operating at the highest efficiency. The roll crusher has a capacity of [illegible]0 t/h. If it is operated in three shifts, it should be able to supply enough raw materials for the new line.

Raw materials store

The dimensions of the raw materials store are [illegible]8 x [illegible] m = [illegible],100 m², with a capacity of approximately [illegible]0,000 tons. Unfortunately, the design of the store is not suitable for a dry process plant, where the preblending of the raw materials is extremely important.

The store should immediately be made accessible by bulldozers or wheel loaders so that it can be emptied completely. Without using bulldozers or loaders, the capacity of the store is only about 60%.

It would be advisable to install a completely new preblending plant, with a roof for protection against rain. Otherwise, the efficiency of the new production line will remain very low.

Belt stacker

The belt stacker, which feeds the raw materials to the store, has the following technical specifications:

Working radius of stacker conveyor: 25 m

Width: 800 mm

Conveying speed: 2.09 m/sec

Power of drive: 22 kW

Materials handled: limestone, marl

Capacity: 500 t/h

Grain size: 0-20 mm

Inclination of conveyor: 19°

The standard belt stacker has a centre distance of 25 m, corresponding to a projection of 24 m. A special feature is the material feeding device, which is so arranged that, when turning, lifting and lowering the belt stacker, the flow of material is always directed towards the middle of the store.

Mobile slewing grab cranes

The open raw materials store is provided with two mobile slewing grab cranes with the following technical specifications:

[illegible] capacity: [illegible]0 t maximum

Working radius: [illegible]

Lifting height: [illegible]

Width of [illegible]: [illegible]

Transport [illegible]: [illegible]0 t/h

Capacity of grab: [illegible].0 m

Materials handled: limestone, marl

Grain size: 0-[illegible]0 mm

The [illegible] is equipped with two sets of hoppers, and it is foreseen that each crane will be able to operate at any hopper.

No pre-blending takes place before feeding to the hoppers. It has been impossible to cover the store with a roof owing to the height of the two cranes. Such a roof would have to be enormous and for that reason has not been provided. These disadvantages are very serious.

Any kind of grab cranes are undesirable today in a cement plant owing to intermittent operation and high maintenance cost. The aim should be to provide a continuous flow of materials, particularly where large quantities of materials have to be handled.

It would be desirable to transfer the two cranes to some harbour, e.g. Misurata or Tripoli, where better use could be made of them.

Mill feed hoppers

There are 4 hoppers in the raw materials store, each with a capacity of approximately 600 tons. Two hoppers are for limestone and two for marl. It is anticipated that one set of hoppers for the limestone and marl will be able also to feed the old raw mill if so desired. That means one set of hoppers can be a stand-by for either the new or the old raw mill.

In the raw materials store the limestone containing 60-80% $CaCO_3$ and the marl containing 40-60% $CaCO_3$ are stored without any partition, which can make it hard for the crane operator, especially at night, to supply limestone to the limestone hopper and marl to the marl hopper. As a consequence, the raw mix to the raw mill may vary by more than ±5%, which is the maximum foreseen, and therefore create problems in the homogenising silos.

Since the hoppers are [illegible], [illegible] to be adapted, especially in the [illegible] raw materials [illegible].

Box-type feeders

For extracting raw materials from the [illegible] hoppers and [illegible] weigh belts, four box-type feeders are provided, [illegible], with the following specifications:

	Limestone	Marl
Centre distance (mm):	[illegible]	[illegible]
Width (mm):	[illegible]	[illegible]
Capacity (t/h):	10	100
Power of drive (kW):	[illegible]	[illegible]
Speed of drive (rev/min):	1,500/150	[illegible]

Below each box feeder is a cleaner (scraper). This cleaner is not functioning continuously, but it should be. It should also be electrically interlocked with the weigh belt.

Weigh belts

From the box feeders the raw materials are fed to weigh belts of varying capacities according to the material and the kiln requirements whether of kiln I or II. It is foreseen that the new raw materials store can also supply raw materials to the old kiln II.

The four weigh belts for the raw materials have the following specifications:

Marl for kiln II

Capacity: 120 t/h
Range of control: 1:10
Width of belt conveyor: 800 mm
Centre distance: 16.4 m
Belt speed: 0.56 m/sec
Power requirement: 3.0 kW
Power of motor: 4.0 kW

Marl for kilns I and II

Capacity: 120 and 30 t/h
2 ranges of control: 1:10 and 1:4

[illegible] I and II

Capacity of weigh belt I: [illegible]

Capacity of weigh belt II: [illegible]

Range of control: [illegible]

Width of conveyor: [illegible] mm

Centre distance: [illegible] each

Belt speed of weigh belt I: 0.[illegible] m/s

Belt speed of weigh belt II: 0.[illegible] m/s

Power [illegible]: [illegible] kW each

Power [illegible]: [illegible] kW each

Storage silos for iron ore and bauxite

For the iron ore and bauxite additives the new plant is provided with two small steel silos in contrast to the old plant, which has only one silo for both iron ore and bauxite. For the extraction of the iron ore and bauxite, each silo is equipped with a single weigh belt with a capacity of [illegible] t/h and a range of control of [illegible].

Conclusions

The design of the raw materials store is obsolete. It will be hard to improve it owing to the enormous civil engineering work already done. It is absolutely indispensable to provide the new extension with a preblending plant of the latest design in order to increase productivity in the kiln department.

Raw mill department

The raw mill department is designed to meet the following performance by means of an air-swept mill:

Working time (h/d): 22
(d/week): 7

Materials fed (%): Limestone and marl, 97; iron ore, 2; bauxite, 1

Feed grain size (mm): Limestone and marl, 0-20; iron ore, 0-30; bauxite, 0-30

Feed moisture content (% H_2O): 4-7

Throughput (t/h): 95

End fineness: 12-14% residue on 4,900 mesh/cm^2

The moisture content of the raw materials during the rainy season (October – March) may reach peaks of [illegible]%, which creates a serious problem in this department. The problem would be reduced considerably if the raw materials stores were roofed. Feeding raw materials with a high moisture content means that the materials have to pass the mill slowly, which results in over-fineness, which in turn causes troubles in the weigh feeder (too low litre weight).

If the raw materials leave the mill too moist, the air slide between the grit separator and the mill will jam and cause serious problems in the raw meal silos (grit will reach the silos).

Air-swept mill

The raw mill is an air-swept, one-chamber mill for girth gear drive and connected with the kiln and a hot gas generator to make use of the hot gases for drying the raw material.

The mill has the following technical specifications:

Output: [illegible]5 t/h

Inside diameter of cylinder: 4.2 m

Length of cylinder: 7.5 m

Thickness of cylinder plate: 38 mm

Material: SM boiler plate

Diameter of neck-bearing trunnion: 2,000 mm

Speed of mill: 15.5 rev/min

Number of pinion shaft bearings: 2

Power requirement of mill: 1,400 kW

Necessary grinding media charge: 106 t

Lining of end walls: KMD oil-hardened

Lining of cylinder 2,500 mm: VS 190

Lining of cylinder 5,000 mm: Simodur

Gear boxes	Main	Auxiliary
Speed of motor (rev/min):	990	1,470
Power of motor (kW):	1,700	27

The raw mill has suffered from lining plates of an inferior quality, which seems to be due to the very short delivery time. In the meantime the supplier has provided a new set of lining plates, but these plates have not yet been erected.

[illegible] grinding [illegible], and [illegible] of grinding balls not exceeding 40 mm in diameter should be [illegible]. [illegible] plates would [illegible] protected against [illegible] impact [illegible].

It should also be mentioned here that the contractor warned against the insufficient drying capacity of the raw mill and, to improve matters, offered certain items of equipment, including a predrier, but the offer was refused by the consultant because of the prolonged delivery time. It will be hard to [illegible] the mill, and production will be reduced considerably in the rainy season.

Static grit separator and cyclones

Because of moist raw material, the static grit separator has been jammed in the air slide for grit between the grit separator and the mill inlet, which has caused serious problems in the homogenizing silos and the weigh feeder for the TEPOL preheater. It would therefore be advisable to use a screw conveyor instead of an air-slide conveyor.

Regarding maintenance of the grit separator, man-holes are provided only on the top cover, which is not very practical, since welding will have to be done on the inner cone. A man-hole should be made in the most suitable position for the above-mentioned repair welding.

The expert had no comment to make on the cyclones.

Circulating air fan

The circulating air fan has the following specifications:

Air volume: 230,000 m^3/h
Air temperature: 90°C
Static pressure: 580 mm WG
Power requirement: 495 kW
Power of motor: 650 kW
Speed of motor: 985 rev/min

Air-slide conveyors

An air slide is an excellent conveyor because it consumes little electric power and has no moving parts except a small high-pressure fan, 500-600 mm WG. However, the material transported has to be a fine, dry powder and preferably also hot. Otherwise, tremendous problems can occur, as has happened when moist or coarse material has entered the air slides.

[illegible] raw meal [illegible]:

(a) [illegible];

(b) [illegible];

(c) [illegible];

(d) [illegible] %.

Hot gas generator

For drying the raw material, both the exhaust gas from the LEPOL preheater and the gas from the hot gas generator can be used, but the exhaust gas from the LEPOL preheater can be used only for raw material with a moisture content of not more than [illegible]%. The capacity of the hot gas generator permits raw material with a [illegible]% higher moisture content to be dried, which means that the maximum permissible moisture content of the raw material fed to the mill is [illegible]%, provided that the kiln is operating at full capacity.

The technical specifications for the hot gas generator are as follows:

Capacity: 4×10^6 kcal/h

Combustion air fan, capacity: [illegible],000 m^3/h

Total pressure: [illegible]00 mm WC

Power of motor: 5.5 kW

Speed of motor: [illegible],900 rev/min

The expert recommended that a stand-by hot gas generator of the same size as the existing one be provided.

Raw meal blending and storage department

The finished raw meal is transferred from the raw mill to the blending silos by an air-lift.

The blending and storage plant consists of two sets of double silos, an upper and a lower silo. In the upper silo the homogenizing takes place, after which the homogenized raw meal is conveyed to one of the lower silos for storing, ready for use. Between the upper and lower silos a cross conveying system has been installed, but from the lower silos to the respective bucket elevators there is only one-way conveying. From the bucket elevator the raw meal goes to the prehopper for the weigh feeder.

In case of some mistake in the $CaCO_3$ content of the raw meal in a completely filled blending silo, there is no possibility of transferring the raw meal to the other blending silo for correction. To avoid such a situation, which may occur when there is no preblending plant, only half of the blending silo should be filled and the $CaCO_3$ content should then be checked. After that, the silo can be filled completely.

The entire homogenizing system is too complicated and obsolete. Today more simple systems are available, such as blending chambers and "Channel flow" systems, which have been in operation for several years. The advantage of these systems is that only one silo is required in which storage and blending are performed simultaneously.

In any case, a plant to blend the raw materials before they come to the raw mill is essential for a modern dry-process cement plant. Unfortunately, the Homs I Cement Plant is not equipped with such a preblending plant.

Technical data for the homogenizing department are as follows:

Working period: Depending on mill operation
Conveying capacity: 110 t/h
Capacity: 2 x 3,000 m^3
Discharge capacity: 2 x 75 t/h

Pneumatic raw meal conveying system

The finished raw meal is conveyed from the mill to the blending silos, a distance of 70 m, with a gain in height of 60 m, by two air-lifts, one for each silo, each with the following specifications:

Capacity: 115 t/h
Roots blower: 2
Intake volume: 120 m^3
Power requirement: 118 kW
Power of motor: 132 kW
Speed of motor: 1,480 rev/min

The air-lift conveying system is simple to operate and has low investment costs, but a large and properly working filter is essential in order to dedust the large amount of air tranferred to the silos along with the raw meal. The consumption of electric energy is high. Alternatively, bucket elevators could have been installed. Their investment costs are about three times as high, but consumption of electric energy is very low, and only a small filter is necessary.

Homogenizing silos

Since the homogenizing system is of the intermittent type, the homogenizing silos are situated on top of the storage silos so that the homogenized raw meal, after about 40 minutes of aeration, can be easily transferred to the storage silos situated below.

The homogenizing, or blending, silos have the following specifications:

Inside diameter: 12 m
Effective height: 15 m
Capacity: 1,500 m^3, or 1,500 t
Aeration area per silo: 97.5 m^2
Number of screw compressors: 3
Suction rate: 42 m^3/min
Pressure difference: 15,000 mm WG
Power requirement: 100 kW
Nominal power of motor: 120 kW
Speed of motor: 1,480 rev/min

The $CaCO_3$ content of the raw meal fed to the silos should not vary more than $\pm$5%; after homogenizing, the variation should not exceed $\pm$0.2%.

Storage silos

The two storage silos have a total capacity of 2 x 3,000 = 6,000 m^3 equal to the consumption of 3.75 days of production of 1,000 t/d of clinker.

Each of the storage silos has the following specifications:

Discharge capacity: 75 t/h
Number of Roots blowers: 2
Suction rate: 6.2 m^3/min
Pressure difference: 6,000 mm WG
Power requirement: 8.8 kW
Nominal power of motor: 13.8 kW
Speed of motor: 2,940 rev/min

The dedusting filter for the whole department has the following specifications:

Height of housing: [illegible],500 mm

Dust-collector surface, gross/net: [illegible] m^2

Geared motor for the cleaning system, nominal power: 1 x 1.1 kW

Geared motor for the dust extraction,
screw conveyor, nominal power: 1 x [illegible] kW

Waste gas fans	I	II
Volume handled:	[illegible],500 m^3/h	[illegible],000 m^3/h
Power requirement:	[illegible] kW	[illegible] kW
Nominal power of motor:	50 kW	13.8 kW
Speed of motor:	1,4[illegible] rev/min	[illegible],940 rev/min

Waste gas fan II serves to dedust the additional blending air during blending.

Compressor room

All compressors are located in one big room close to the two blending and storage silos. To supply the room with clean air and sufficient air for the cooling of the motors, fans with the following specifications are provided:

Air capacity: 2 x 1[illegible],500 m^3/h

Power requirement: 2 x 2.9 kW

Power of motor: 2 x 5.5 kW

Speed of motor: 1,500 rev/min

Air capacity of roof fans: 2 x 9,100 m^3/h

Power of motor: 2 x 0.9 kW

Conveyors

The conveyors consist mainly of 315-mm-wide air slides (110 t/h) except those from the blending silos to the storage silos, where 500-mm-wide air slides (500 t/h) are installed. Raw meal from the storage silos to the weigh feeder for the CEPOL preheater is lifted up 19.2 m by a bucket elevator, one for each silo, with the following specifications:

Capacity: 90 t/h

Centre distance: 19.2 m

Width of buckets: 800 mm

Power requirement: [illegible] kW

Power of motor: [illegible] kW

Speed of motor: [illegible],140 rev/min

Kiln department

[illegible] operate properly [illegible]. However, [illegible] points in this department [illegible] the following measures should be taken:

(a) Provide the weigh feeder with a more adequate [illegible] system;

(b) Provide the GEPOL preheater with a lift [illegible] to maintain [illegible] cyclones at the top;

(c) Provide the GEPOL preheater with compressed-air [illegible] points;

(d) Modify the [illegible] in order to keep a high run factor and avoid ring formation;

(e) Investigate possibilities for an emergency clinker transport;

(f) Provide the fan behind the electrostatic precipitator with a cleaning system for accumulated dust.

These measures should be easy to carry out. When the preheater receives a regular feeding, the clinker production will certainly reach more than 1,000 t/d, but naturally more fuel and more hot clinker will be required. It should also be pointed out that nobody at the plant is familiar with the GEPOL system, so the human factor will have to be taken heavily into account in undertaking improvements.

Cement mill department

The new cement mill department consists of two closed-circuit, 3.0-m diameter x 11 m two-chamber tube mills, each with a capacity of 32 t/h of Portland cement, 3,000 cm^2/g Blaine, fed by 96% clinker and 4% gypsum. Each mill is equipped with a 1,200-kW motor. The open-circuit system is a common and proved system with water injection and an electrostatic precipitator. Therefore, this department should be able to run properly.

Nevertheless, one point should be noted. The clinker is fed to the mills by 14 electronic weigh feeders each with a capacity of 4-40 t/h and situated [illegible] the open clinker store. Normally each mill should be provided with only [illegible] weigh feeder for clinker and a hopper of approximately [illegible]00-t capacity above the mill inlet. To maintain 11 instead of 2 electronic weigh feeders will surely cause tremendous problems for the electricians, and the Homs I Cement Plant up to now has had no electrical engineer.

Since it is hard to modify such a system, the staff will have to cope with difficulties as best they can.

Packing and loading plant

The packing and loading plant consists of 2 x 5,000 m^3 silos, each 12 m in diameter and 40 m high. From these silos the cement goes either to the two ROTO packers, each with a capacity of 100 t/h, or direct through the two bulk loading stations, each with a capacity of 150 t/h, which makes a total capacity of 500 t/h. The bulk loading stations have never been used, since no special bulk cement carriers have been available. It is still too early to judge operations, since adjustments are still being made.

The spillage caused when paper bags rip has been considerable, but only 3-ply bags are used. For such thin bags the machinery needs to be adjusted precisely. Putting cement in paper bags should be avoided as much as possible. It is a wasteful practice. There is not wood enough in the world for that purpose. Small consumers will quickly learn to use bulk cement if they know, for example, that they can get 100 kg more cement for each 1,000 kg they buy.

Proposals for improvements

Three proposals for improvements in the Homs I Cement Plant are presented below.

Alternative I

Location	Number	Item
New quarry	1	Stationary crushing plant, 500 t/h
	3	30-t off-highway truck
	1	Rubber belt conveyor, about 2,700 m long, 800 mm wide

Location	Number	Item
Factory	1	Complete preblending plant covered by roof and sufficient for both kilns, total clinker production, 1,330 t/d; existing hoppers and feeders to be used
	1	By-pass installation including silo for both kilns together; essential for kiln I, but may be not for kiln II
	1	Clay crushing and drying plant
	1	Lift for the GEPOL preheater and silos
	1	Complete overhaul of the old plant including modifications

Alternative II

Location	Number	Item
New quarry	1	Stationary crushing plant, 500 t/h
	3	30-t off-highway trucks
	1	Rubber belt conveyor, about 2,700 m long, 800 mm wide
Plant	1	Complete preblending plant covered by roof and sufficient for both kilns, total clinker production, 1,330 t/d; existing hoppers and feeders to be used
	1	A special arrangement for removal of fine dust from the electrostatic precipitator for kiln II; for kiln I provide only one (the last) chamber with collecting and emission electrodes to remove alkali and chlorine through the chimney
	1	Lift for the GEPOL preheater and silos
	1	Complete overhaul of the old plant including modifications

Alternative III

The clinker-grinding facilities and the packing plant supplying clinker from the new Homs II Cement Plant would be used. Then the existing raw material store could be used as the clinker store. The two kilns, preheaters and raw mills could be offered as a bilateral aid to some less developed country, e.g. Niger.

Appendix I

JOB DESCRIPTION

POST CODE	IS/LIB/72/903/11-01/C
POST TITLE	Expert in Cement Production and Factory Supervision
DURATION	Six months (with three months' extension)
DUTY STATION	Homs, with travel within the country
PURPOSE OF PROJECT	To introduce lasting improvements in the cement industry of the Libyan Arab Republic
DUTIES	The expert will be assigned to the Government of the Libyan Arab Republic to assist the cement industry in upgrading local know-how and training of personnel. Specifically, he will be expected to:

(1) Assist the factory administration in carrying out daily duties in the factories;

(2) Assist in establishing maintenance routines and advise on spare parts requirements;

(3) Assist the factory administration in obtaining competitive supplies of spare parts and equipment needed in the factory;

(4) Train local personnel in assuming responsibility for the above-mentioned duties;

(5) Advise and assist in all aspects within the expert's competence and experience.

QUALIFICATIONS	Mechanical engineer with the relevant experience in cement factories

Appendix 2

CEMENT PLANTS IN THE LIBYAN ARAB REPUBLIC

Plant	Kiln number	Kiln size diam. (m) x length (m)	Preheater	Cooler type	Capacity (t/d)	Starting date	Supplier	Remarks
Homs I	1.	3.2 x 3.0 x 40	4-stage DOPOL	RECUPOL, [illegible] travelling grate	[illegible]	[illegible]	[illegible]-Krupp	[illegible]
	2.	4.0 x 60	5-stage [illegible]POL	Satellite [illegible]	[illegible],000	[illegible]	[illegible]-Krupp	[illegible]
Homs II (expected figures)	1.	5.5 x 90	4-stage	Grate cooler	[illegible],000	[illegible]		[illegible]
Benghasi I	1.	Unknown	4-stage	Grate cooler	[illegible]00	[illegible]	[illegible]-Wedag	Operat[illegible]
	2.	Unknown	4-stage	Grate cooler	[illegible],000	Ma[illegible]	Hum[illegible]-Wedag	Operat[illegible]
	3.	Unknown	4-stage	Grate cooler	[illegible],000		[illegible]-Wedag	[illegible]
Benghasi II	1.	4.4 x 60	4-stage	Grate cooler	[illegible],500		[illegible]-Wedag	[illegible]
(Hawary plant)	2.	4.4 x 60	4-stage	Grate cooler	[illegible],500	[illegible]	[illegible]-Wedag	[illegible]
Souk El-Khamis	1.	4.4 x 60	4-stage	Grate cooler	[illegible],500	Ma[illegible]	[illegible]-Wedag	[illegible]
	2.	4.4 x 60	4-stage	Grate cooler	[illegible],500	Ma[illegible]	[illegible]-Wedag	[illegible]

Projects under discussion

Mart/Derna (300 km east of Benghasi): Consultancy [illegible] x 10[illegible] plant.

Sabha (600 km south of Tripoli): Tendering for consultancy [illegible] 0.[illegible] x 10[illegible] t/a plant [illegible].

[illegible]

Appendix 3

EFFICIENCY OF KILN DEPARTMENT

100% efficiency based on:	Annual capacity (tons)
Kiln No. 1 : 330 days x 330 t/d	108,900
Kiln No. 2 : 330 days x 1,000 t/d	330,000
Total = 100% efficiency/12 months	438,900

Clinker production, January - June 1975 (tons)	
Kiln No. 1 (DOPOL)	32,585
Kiln No. 2 ([illegible]POL)	71,846
Total	104,431

$$\text{Efficiency} = \frac{104{,}431 \times 100 \times 12}{438{,}900 \times 6} = 47.6\%$$

Appendix 4

DATA ON HOMS CEMENT PLANT WITH EXTENSION

Table 7. Production and consumption, raw mill No. 1, January 1974–June 1975

	Production of raw meal (t)	Working time (h)	Hourly output (t/h)	Energy consumption (kWh)	Specific energy consumption (kWh/t)	Residue on 900 and 4,900 mesh/cm2 (percentage)
1974						
January	13,430	560	24.0	394,390	29.4	-/8.1
February	9,652	373	25.9	274,430	28.4	-/9.1
March	6,155	277	22.3	282,580	45.9	-/7.5
April	12,700	539	23.7	394,550	31.0	-/8.0
May	13,440	481	27.9	355,170	26.5	-/8.1
June	12,010	408	29.6	307,200	28.0	-/8.1
July	13,642	460	29.8	302,190	22.1	-/9.5
August	15,900	469	29.8	261,770	19.0	-/8.3
September	12,510	422	26.6	278,390	21.5	-/8.2
October	4,900	170	28.8	133,040	27.2	-/11.0
November and December	Figures still being prepared.					
	143,297 tons of raw meal were delivered from the new line.					
1975						
January	7,000	438	16.0	335,950	47.9	-/-
February	5,251	297	17.6	235,920	44.9	-/9.2
March	3,796	191	20.0	150,080	39.5	-/9.5
April	12,418	543	22.9	306,670	24.7	-/8.6
May	9,699	411	23.6	372,800	38.5	-/9.9
June	5,509	237	23.2	166,300	30.5	-/8.8
Total/average	43,673	2,117	20.6	1,567,720	37.7	-/9.2

Source: Monthly report of works manager to general manager, HCC.

Note: The raw mill No. 1 (old line) is in an extremely bad condition and the department not very well designed. Raw meal can be supplied from the new raw mill to the old line. The energy consumption should not exceed 18 kWh/h by 8% R 4,900 mesh/cm^2.

[illegible]. P[illegible] and consumption, raw [illegible],
[illegible]

	Production of raw meal (t)	Working time (h)	Hourly output (t/h)	Energy consumption (kWh)	Specific energy consumption (kWh/t)	Residue on 900 and 4,900 mesh/ (percentage)
[illegible]						
[illegible]	[illegible],000	60	[illegible]0.0	...	...	...
August	[illegible],000	80	[illegible].0	...	...	-/[illegible]
September	[illegible]	[illegible]	[illegible]	[illegible]	[illegible].0	-/10.[illegible]
October	[illegible],500	8[illegible]	[illegible]	[illegible]	13.8	-/1[illegible].2
November and December	Figures still being prepared.					
[illegible]						
January	[illegible],065	68	75.0	9[illegible],414	1[illegible].2	...
February	1[illegible],390	177	103.8	236,108	12.8	[illegible]/16.[illegible]
March	4[illegible],294	500	94.6	583,166	12.3	3.[illegible]/16.4
April	2,625	31	84.7	64,300	24.5	2.3/16.1
May	37,899	385	98.4	449,2[illegible]	11.9	4.5/18.1
June	24,217	251	96.5	318,800	13.2	3.7/17.3
Total/ average	135,490	1,412	92.2	1,749,099	15.2	3.5/16.9

Performance guarantee for raw mill No. 2 in the new line

Capacity	95 t/h
Feed size	0-20 mm with a certain portion of oversize
Feed moisture content	Maximum 7%
Residue of raw meal	12-14% R 4,900 mesh/cm^2 according to DIN 4188
Specific energy consumption	22 kWh/t raw meal

Note: Residue on 900 mesh/cm^2 seems too high, which makes free CaO in the clinker high. Please check with contractor.

Table [illegible]. Production and consumption [illegible], January [illegible]

	[illegible] production (t)	[illegible] consumption (t)	W[illegible] (t)	[illegible]	[illegible]	[illegible]
[illegible]						
January	[illegible]	881	[illegible]	[illegible]	[illegible]	...
February	[illegible]	506	[illegible]	[illegible]	[illegible]	...
March (preliminary overhaul)	[illegible]	788	[illegible]	[illegible]	[illegible]	...
April	7,888	866	[illegible]	[illegible]	[illegible]	...
May	8,039	863	[illegible]	[illegible]	[illegible]	...
June	7,889	788	[illegible]	[illegible]	[illegible]	...
July	9,055	876	[illegible]	[illegible]	[illegible]	...
August	8,126	841	644	[illegible]	1,410	...
September	7,764	837	656	[illegible]	[illegible]	[illegible]
October	8,002	894	[illegible]	[illegible]	[illegible]	...
November and December	Figures still being prepared.					
Total/average	88,586	9,796	6,906	[illegible]		

Efficiency = 81.3% (100% efficiency = 330 days x 330 t = 108,900 t/a)

Run factor = 87.2% (100% run factor = 330 days x 24 h = 7,920 h/a)

1975						
January	5,836	704	562	1,064	1,412	...
February	2,251	319	229	1,250	1,344	...
March	5,832	641	565	969	1,440	...
April	7,638	768	642	887	1,370	1.96
May	6,334	649	568	904	1,387	2.00
June	4,694	486	423	913	1,446	1.42
Total/average	32,585	3,567	2,989	998 (850 = guarantee)	1,400	1.79

Efficiency = 59.8%

Run factor = 75.5%

Source: Monthly report of works manager to general manager, NCC.

a/ Bunker "C" fuel. Heating value H_1 = 9,800 kcal/kg and litre weight = 0.9kg.

Table 18. Production and consumption, kiln No. 2, Gepel, 1,000 t d, August 1974–June 1975

	Days	Production of clinker (t)	Consumption of fuel (t)	Heat consumption (kcal/kg clinker/month) a/	Efficiency (percentage)	Working time (h)	Litre weight (g/litre)	Free lime (percentage)
1974								
August b/	18	13,400	1,240	907	74	450	1,427	...
September	30	8,703	838 (835)	933 (932)	29	265	1,466	0.74
October c/	31	nil	nil	nil				
November	30	8,102	805	964	27	...	...	...
December	31	4,089	727	1,742	13	...	...	...
1975								
January d/	30	nil	nil	nil				
February	28	12,401	1,173	921	45	565	1,440	1.45
March	31	23,700	2,071	856		677	1,420	1.30
April		1,840	204	1,031		84	1,308	1.52
May		21,061	1,805	870		616	1,400	1.20
June		12,675	1,154	892		372	1,404	1.12

Run factor 53.1%

Source: Monthly report of works manager to general manager, NCC.

Note: 100% efficiency would mean a production of 330 d/a x 1,000 t/d = 330,000 t/a clinker.
100% run factor would mean operation for 330 d/a x 24 h/d = 7,920 h/a.

a/ Bunker "C" fuel. Heating value H_i = 9,800 kcal/kg and litre weight = 0.9 kg.

b/ The new kiln was started on 13 August 1974.

c/ Plant stopped, ID-fan out of balance.

d/ Plant stopped, disagreement between NCC and contractor.

Table 11. Techno-[illegible] data [illegible] II [illegible] Plant [illegible]

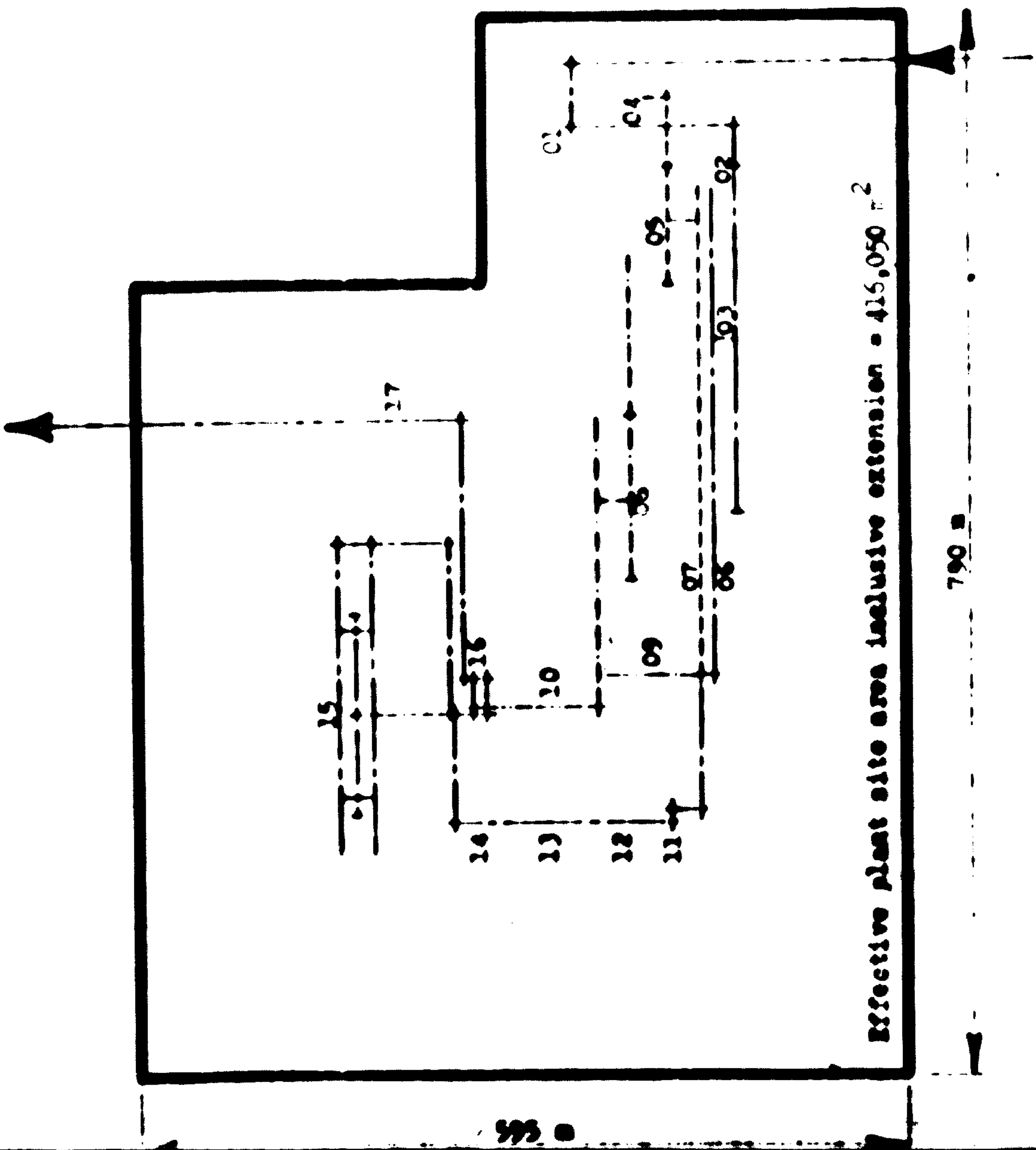
Item	Unit	ALPHA	BETA	GAMMA
Mechanical equipment f.o.b. price as percentage of total price	%	[illegible]	[illegible]	[illegible]
Electrical equipment f.o.b. price as percentage of total price	%	1.0[illegible]	[illegible].11	[illegible]
Mechanical equipment f.o.b. price	LD/kg $/kg	0.[illegible]42 3.18	1.13[illegible] 3.85	[illegible].1[illegible]8 [illegible].[illegible]5
Electrical equipment f.o.b. price	LD/kg $/kg	2.319 7.84	3.100 10.[illegible]4	[illegible].84[illegible] 1[illegible].[illegible]8
Mechanical equipment f.o.b. price as percentage of the total f.o.b. price	%	76.73	[illegible]3.4[illegible]	[illegible].70
Electrical equipment f.o.b. price as percentage of total f.o.b. price	%	10.73	13.97	-
Mechanical spare parts f.o.b. price as percentage of mechanical equipment f.o.b. price	%	13.97	14.00	-
Electrical spare parts f.o.b. price as percentage of electrical equipment f.o.b. price	%	16 95	16.10	-
Civil works price as percentage of the total price	%	35.48	41.25	42.62
Erection works price as percentage of the f.o.b. price	%	46.75	42.02	36.91
Erection works price as percentage of the total price	%	17.65	16.37	13.78
Specific erection price	LD/kg $/kg	0.442 1.49	0.483 1.63	- -
Transport price as percentage of the total f.o.b. price	%	19.74	8.75	16.82
Transport price as percentage of the total price	%	7.46	3.41	6.28
Specific transport price	LD/kg $/kg	0.187 0.63	0.101 0.34	- -
Depreciation cost of the plant for 15 years	LD/t $/t	3.120 10.55	3.910 13.22	4.120 13.93

Exchange rates: 1 LD = DKr 18.32 = F 14.20 = DM 7.94 = $ 3.38 (4 April 1975)

Annex III

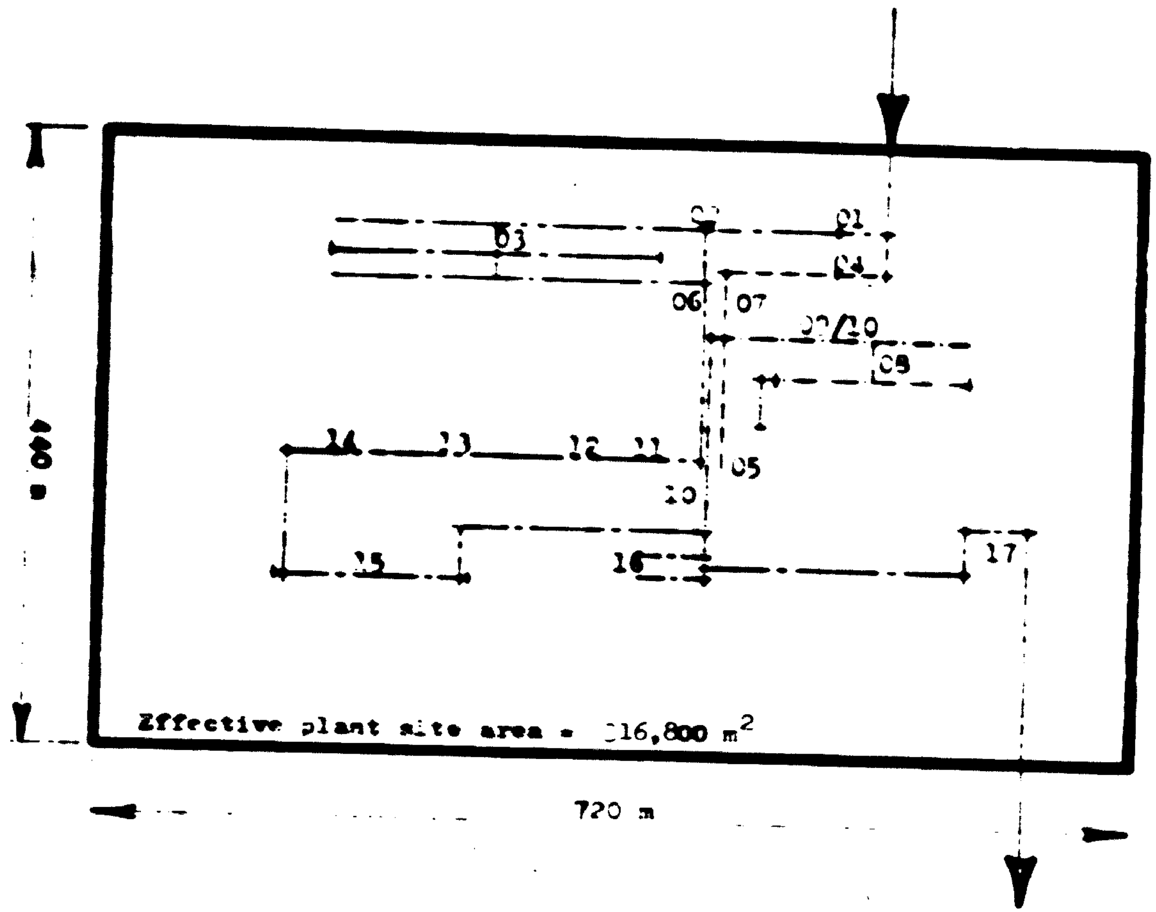
COMPARATIVE INFORMATION AND DATA ON OFFERS RECEIVED
FOR HOMS II CEMENT PLANT

01. Limestone crusher
02. Limestone sampling
03. Limestone store
04. Clay crusher
05. Clay store
06. Limestone transport
07. Clay transport
08. Additive store
09. Iron ore and/or pure limestone transport
10. Gypsum transport
11. Vertical raw mill
12. Four-stage preheater
13. Rotary kiln
14. Grate cooler
15. Clinker store
16. Cement mills (2x)
17. Packing plant



Scale 1:15,000

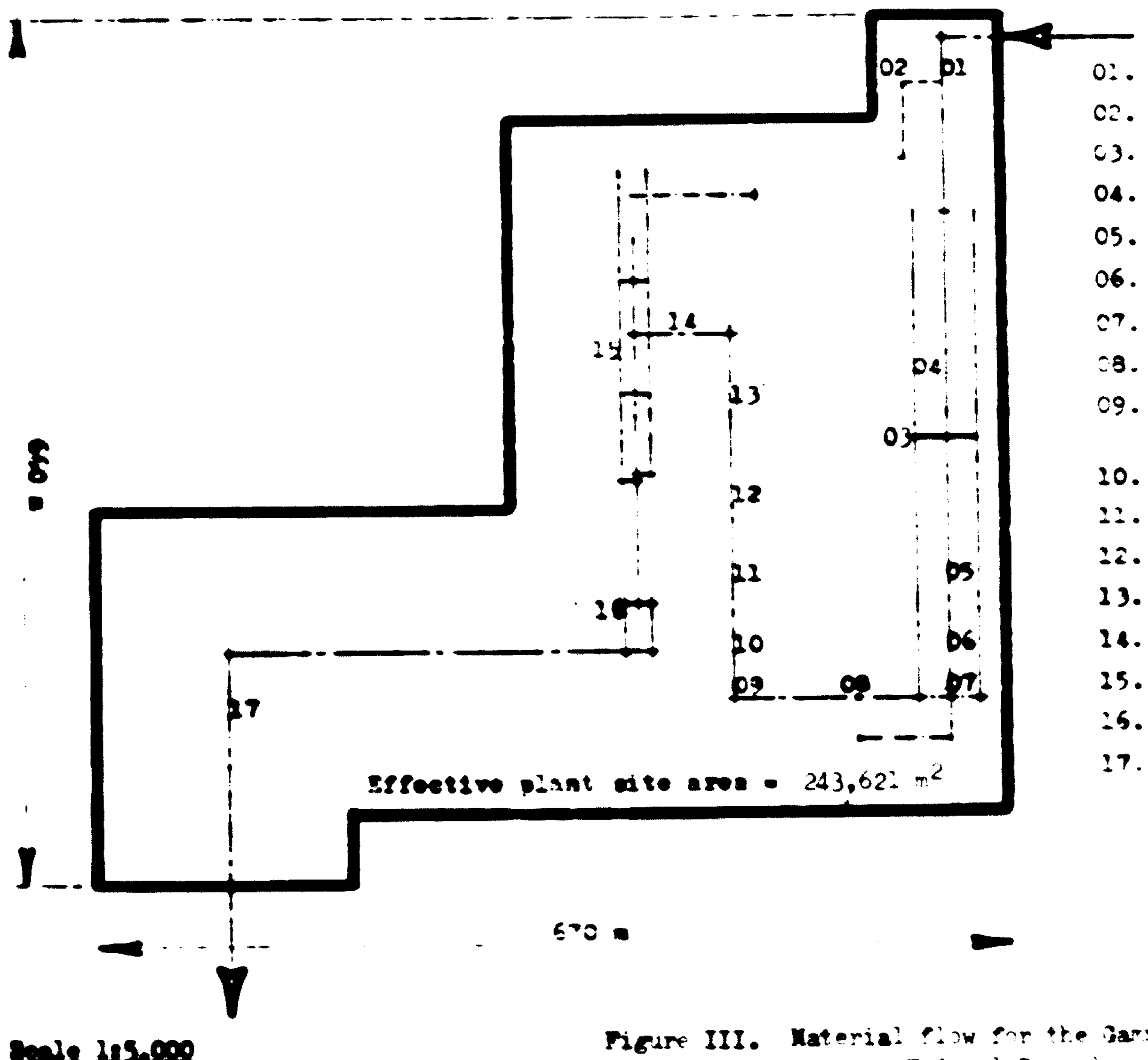
Figure I. Material flow for the Alpha - offer from Denmark



01. Limestone crusher
02. Limestone sampling
03. Limestone store
04. Clay crusher and drier
05. Silo for dried clay
06. Limestone transport
07. Clay transport
08. Additive store
09. Iron ore and/or pure limestone transport
10. Gypsum transport
11. Raw mill
12. Four-stage preheater
13. Rotary kiln
14. Grate cooler
15. Clinker store
16. Cement mills (two)
17. Packing plant

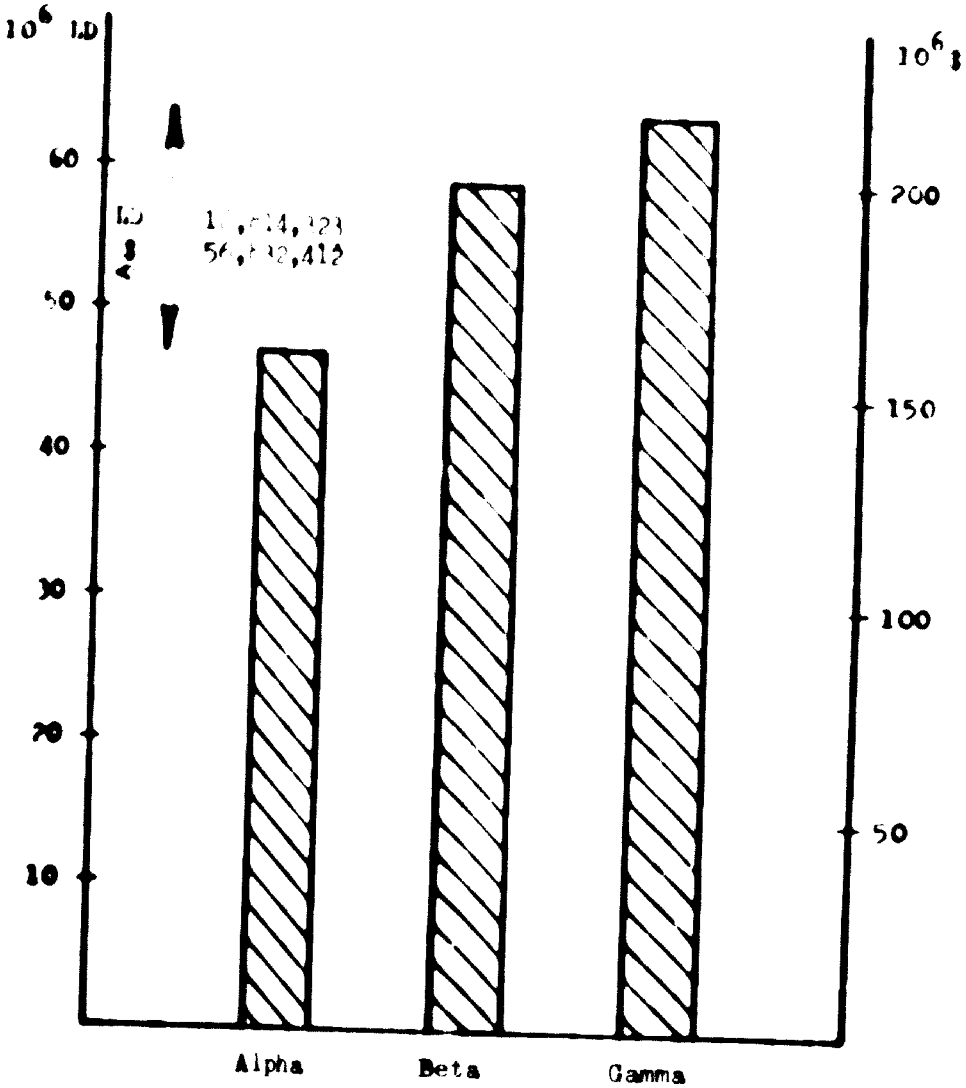
Scale 1:5,000

Figure II. Material flow for the Beta - offer from France



01. Limestone crusher
02. Clay dryer and crusher
03. Raw material store
04. Low-grade limestone
05. High-grade limestone
06. Clay
07. Iron ore
08. Sampling station
09. Limestone/clay, high-grade limestone and iron-ore silos
10. Air-swept raw mill
11. Preheater
12. Rotary kiln
13. Grate cooler
14. Clinker transport
15. Clinker and gypsum store
16. Cement mills (two)
17. Packing plant

Figure III. Material flow for the Gamma - offer from the Federal Republic of Germany



Alpha	LD 46,821,259 = $158,255,855		Subject to escalation
Beta	LD 58,647,406 = $198,228,232		Partly (46%) firm price
Gamma	LD 63,635,582 = $215,088,267		Firm price excluding spare parts for the mechanical equipment

Exchange rates (April 1975): LD 1 = DKr 18.32 = F 14.20 = DM 7.94 = $ 3.38

Figure IV. Total prices from the tenderers submitted to NCC on 15 April 1975 for Homs II Cement Plant

[redacted]

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