PRELIMINARY STUDY REPORT
ON
DERUDEB CEMENT PROJECT
IN
THE DEMOCRATIC REPUBLIC OF THE SUDAN

AUGUST, 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

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Name List

Among the members of the Project Finding Mission sent to the Sudan in November 1978 by Japan International Cooperation Agency, the following two-man team was in charge of studying Derudeb Cement Project and preparing this report.

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P R E F A C E

With a view to identify suitable projects for Japan's official economic and technical assistance to the Democratic Republic of the Sudan, a Project Finding Mission was sent to the country by the Japan International Cooperation Agency in November 1978. After exchanging views of mutual interest with the responsible governmental agencies including the Ministry of National Planning, the Mission came to believe that the Sudanese Government accorded top priority to (1) commodity aid; (2) electric power generation; (3) production of construction materials; (4) development of agriculture; and (5) construction of roads.

Of the afore-mentioned proposed projects, the Agency has already made feasibility studies on projects for the development of agriculture and the construction of roads, and therefore the Mission has forcused its attention on preliminary surveys on the electric power generation and the production of construction materials (Derudeb Cement Projects).

The result of the surveys was reported in March 1979 in a report titled "REPORT ON PROJECT FINDING MISSION TO THE DEMOCRATIC REPUBLIC OF THE SUDAN" (in Japanese language) which consists of:

- Summary
- Chapter 1. Economic Development in the Sudan-at Present and in Future
- Chapter 2. Positions in the Sudanese Economy of the Projects Studied by JICA Mission
- Chapter 3. Proposed Cement Project at Derudeb
- Chapter 4. Proposed North Khartoum Steam Power Plant Project

In addition, an English version of the Summary of the said report is *attached to it in a separate volume.*

The present report is an English version, made upon request of Arabian Cement Corporation which was one of the counterparts of the Mission, of Section 3 of Chapter 2 and the whole part of Chapter 3 (which relate to Derudeb Cement Project) of the aforementioned report, and includes various costs calculation bases of 1,500 t/d plant and 1,000 t/d plant, and chemical analysis data of Derudeb limestone deposit as well.

The Agency would be delighted if the present report could be of any assistance for the development of the Sudanese economy, inter alia, the development of the cement industry.

August 1979.

CHAPTER 1

POSITIONS IN THE SUDANESE ECONOMY

OF THE PROJECT STUDIED

BY JICA MISSION

Section 1. Cement Industry

1-1 Importance of Cement Industry

Among the various industries which supply materials to be used in the agricultrual sector, a strategically important one in the Sudan is the cement industry.
Irrigation by dams plays an important role in the Sudanese agriculture which depends on water from the Nile.
Besides, construction of dams brings such fabourable effects that they can be utilized multipurposely, e.g., for power generation, water supply, fish cultivating.
Furthermore, if the road network has been improved in the Sudan where all-weather roads have not yet sufficiently developed, then this will enable the traditional agricultural sector to produce marketable agricultural products.
In relation to agriculture, attention has been paid to the cement industry not only because cement is needed for the construction of dams and roads but also becuase it has a favourable effect to increase employment. The construction industry, the biggest of all the industries which employ unskilled workers flowing from agricultural regions to urban areas, is typical of the industries which use the products from the cement industry as the main material.
Consequently, it is necessary to steadily develop the construction industry from the viewpoint of employment policy, too, and, it is needless to say that it is disirable for the steady development of the construction industry, to develop the cement industry which supplies materials to the construction industry.
It may also be said that construction work in rural districts will provide side-jobs to farmers and this will contribute to an increase in their income.

It has been already pointed out that the construction industry plays an important role in the aspect of gross fixed capital formation. The increase in gross fixed capital formation causes the advance in the production capacity of the repsective production sectors. This advance in the production capacity causes the rise in the income of those who engage, whether directly or indirectly, in the production. Then, the rise in the income causes the decrease in Engel's coefficient, and therefore results in the rise in the demand for industrial products.
If this rise in the demand is to be covered by the domestic industrial sectors, this can be the clue to develop the domestic industries.

Furthermore, if the respective processes in the abovementioned sequence are kept going in such a manner that they are mutually and effectively combined together, then this will be the clue to independant development of the Sudanese economy which suffers from many unfavourable conditions.

Hence, it is obvious that the development of the cement industry should be given priority from a viewpoint of all the secondary and the tertiary ripple-effect which it brings with regard to the increase of production, employment and income.

1-2 The Cement Industry in the Sudan at Present and in Future

The cement production in the Sudan was commenced by Maspio Cement Corporation which had been established in 1947 at Atbara and went into operation in the following year. Afterwards Nile Cement Corporation was established at Rabak and began to produce cement in 1969. At present the domestic cement production in the Sudan is catered for by these two corporations. However, they, both of which are under the control of Building Materials Corporation, are facing various problems.

Maspio Cement Corporation started its operation with a 150-t/d plant, and then, in early 1950's an additional 560-t/d plant being installed, has come to have 710-t/d total production capacity (225,000 t/y). However, the operation rate (ratio of actual production to the production capacity) has been less than 60% on the average for these 16 years, or in other words the average actual production has been less than 130,000 t/y.

Pointed out to be the reasons for this are:

(1) Electric power supply was unstable due to the troubles of the diesel generating sets and shortage of the fuel.

(2) The transportation of the gypsum from Port Sudan was not in accordance with the schedule.

(3) It is only six 30-t wagons a day that have been allocated to the plant for shipping the produced cement by rail. Because of this, cement silos were often so full that the cement production must be stopped.

(4) The fact that the cement storage capacity is only 1,200 t has caused the declination of the cement production.

To overcome these obstacles against the cement production, Maspio Cement Corporation has been taking measures as follows:

- An expansion project of 750 t/d (235,000 t/y) under the contract made in 1976 between the corporation and F.L. Smidth of Denmark to supply equipment and technical assistance
- Rehabilitation of three 3-MW diesel generating sets
- Construction of 2 storage silos (one 4,000-t silo, one 2,500-t silo)
- Rehabilitation of the ropeway for limestone transporation and extension thereof to the quarry by the United Kingdom's aid.

However, the aforementioned expansion project is behind schedule due to the shortage in foreign currency on the side of the Civil work contractor, and therefore is expected to be completed one year or more later than the scheduled completion date of February, 1979.

Meanwhile, Nile Cement Corporation is suffering from more difficult problems, and therefore its operation rate has been a little more than 40% on the average for these 7 years. Only once in the past, the production achievement exceeded 50% the production capacity of 100,000 t/y in 1973.

The problems this corporation has are:

(1) The location of the raw material is 60km far from the plant because the geological survey on the quality and the reserves of the raw materials was reportedly insufficient. Furthermore, in rainy seasons which last for 5 or 6 months in a year the roads are in too bad condition to transport the raw material.

(2) The raw material crushing plant has less capacity than specified

(3) Spare parts and diesel oil were scarce.

(4) Training of the plant engineers was not enough.

(5) Shortage of funds on the side of Nile Cement Corporation.

To solve the Corporation's problems consultants from UNIDO, Egypt, etc. carried out a study in 1975, and proposed a rehabilitation plan.

As the result, in 1977 Building Material Corporation entered into a contract with Esch-Werke, a West German company, for rehabilitation of the crushing plant and also a contract with Klockner, a West German company, for rehabilitation of the cement production facilities. These rehabilitation works are now going on. As for the most problemetical raw material transportation, two plans were proposed; namely, to purchase twenty five 30-or 40-t trucks or to construct a railway upto the raw material quarry. However, the plan to construct a railway is opposed by National Railway Corporation from view-point of the quantity of the cargo to go through this railway, and on the other hand, reportedly Nile Cement Corporation has not found yet the way to purchase the said trucks due to its unfavourable financial status.

The third cement plant project is Derudeb cement project, which is the object of our study. To promote this project, Arab Cement Corporation was founded in 1976, and is preparing for this project. Meanwhile, the IFC's mission (International Finance Corporation=IFC) which visited the Sudan in September, 1978 pointed out, after studying the plan of this project, that the location of this project which is more than 800km far from the center of the biggest cement consumption, Khartoum, is a very disadvantageous fact under such circumstances that it is hardly possible to export cement and, therefore, cement should be produced keeping in mind mainly the domestic consumption.

Consequently, Sudan Development Corporation (SDC) which is the counterpart of IFC is carrying out a study comparing Derudeb project and the possibility of the third expansion of Atbara plant, and is expected to find a conclusion on the location after discussing with IFC.

The following are SDC's future plan in implementing Derudeb project:

(1) Sources of funds

1)	Investment from the Government	an amount equivalent to 20 million US$
2)	Investment from foreign investors	20 million US$
3)	Soft loan from foreign government	70 million US$
4)	Custom Debenture	20 million US$
	Total	130 million US$

(2) From a view to save foreign currency, plant facilities and equipment should be procured in divisible components under respective contracts, not under a turn-key contract.

(3) In order to upgrade the technical level of the management staff, engineers and workers, a long-term technical advice service should be called for from outside the country under a separate contract.

There is a plan as the fourth cement project to establish a cement plant of 400,000 t/y capacity at Marsa Arakiyai along the Red Sea coast 75km north of Port Sudan. (All the cement produced in this plant is expected to be exported to Saudi Arabia provided that the Sudanese government has the right to purchase upto 100,000t a year). For this purpose, Cement Proudction (Sudan) Ltd. was established in 1975 as a joint-venture company by an American company and the Sudan. However, according to ACC's information, the abovementioned company is suspending its activity due to a reason regarding technical matter.

Fifthly, there is a plan to establish a cement plant of 100,000-t-y capacity at Kapoeta (250km east of Juba), and at present Klockner of West Germany is carrying out a preliminary pre-investment study.

Sixthly, there is a plan to establish a 100,000-t/y plant in the vicinity of Damazin, the capital of Blue Nile Province, but this project still remains in the stage of the preliminary study on the proposed raw material deposit.

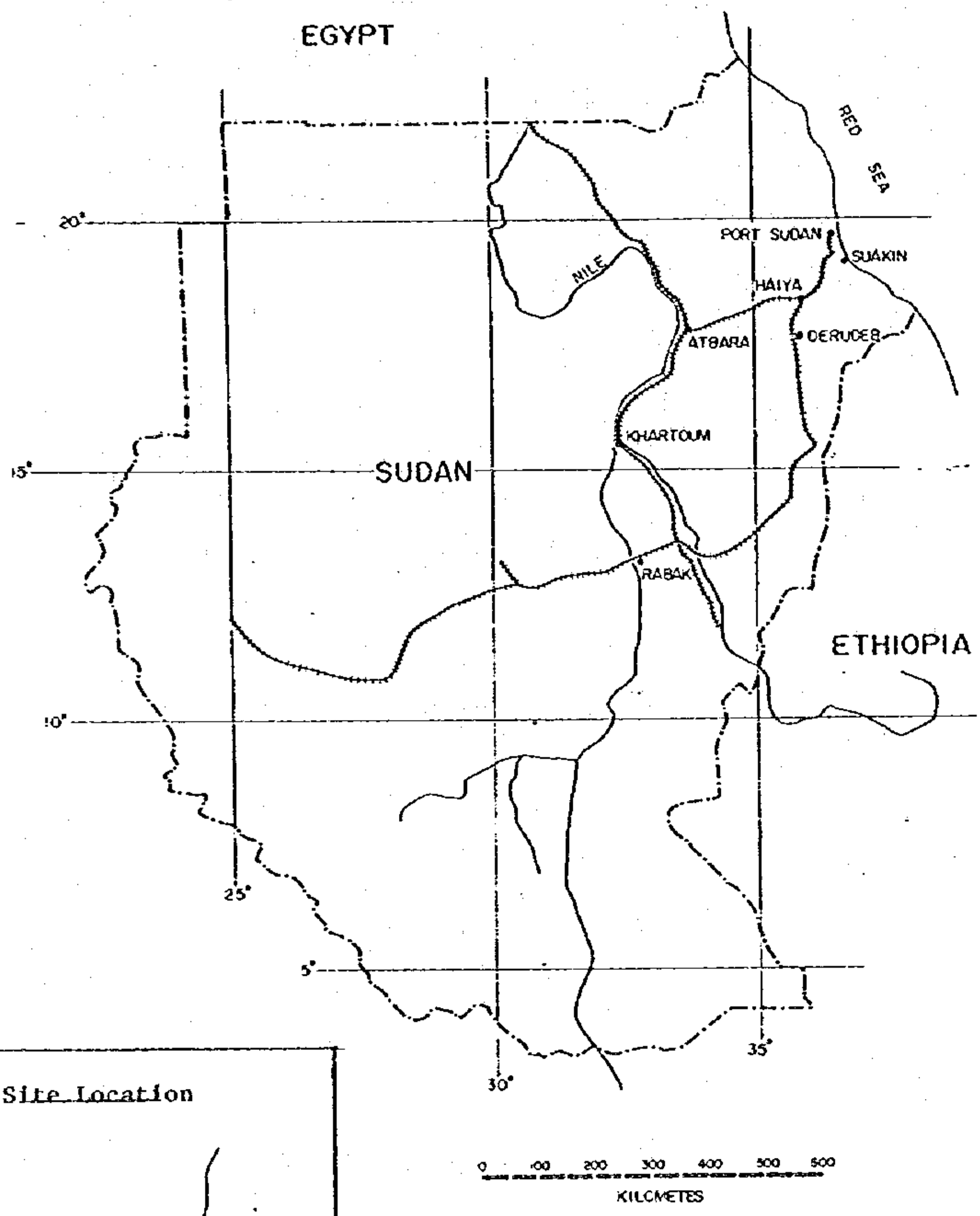
CHAPTER 2

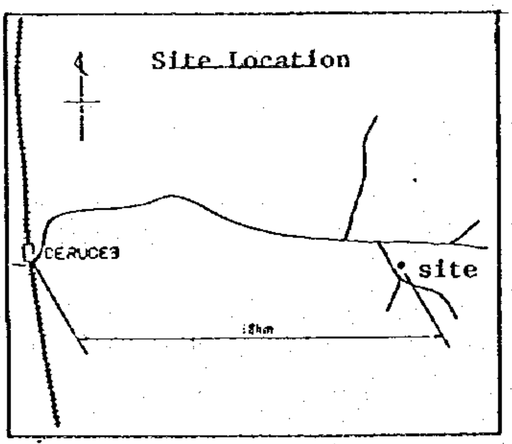
PROPOSED CEMENT PROJECT AT DERUDEB

Section 1. Outline of the Project

1-1. Location

Map of the Sudan and Site Location Map





1-2 Brief History of the Project

1972 - A preliminary study of the limestone deposit in Derudeb by a Soviet geologist

1974 - A feasibility study by an Argentine consultant employed by a Kuwait enterpriser with an intention to establish a joint-venture cement company in the Sudan. But afterwards the enterpriser withdrew from this project. (Reportedly, due to financial reason).

1976 - Establishment of ARAB CEMENT CORPORATION (hereinafter called ACC),an organization to establish and manage a cement plant in Derudeb (The paid-up capital at present is an amount in the local currency equivalent to 3 million US$ exclusively from the Sudenese government).

- The current Six-year Plan for Economic and Social Development (1977/1978---1982/1983) includes this Project.

1977 to 1978 - An investigation by ACC of the proposed limestone deposit (3 bore holes) and the proposed clay deposit.

- A feasibility study by a Sudanese consultant (SEMAC)

At present - An investigation (about 20 bore holes) of the proposed limestine is under way since the end of 1978. (Geological and Mineral Resources Dept. of Energy and Mining Ministry undertakes this investigation upon ACC's request at ACC's expenses).

1-3 Summary of the Previous Survey Reports

1-3-1 Preliminary Study by a Soviet Geologist

(1) The limestone deposit in Derudeb is worthy to be investigated in detail because the analysis of the surface samples collected by him shows that this limestone is suitable for cement manufacturing.

(2) Potential reserve of the limestone is approximately 100 million tons, based on a simplified measurement on the reserve area and an assumtion on the reserve depth (estimated at 50m).

1-3-2 Feasibility Study by an Argentine Consultant in 1974

(1) Plant capacity

- 1500t (clinker)/day *

  * Note: Supposing annual working days are 300 days and gypsum unit consumption is 5%, annual cement production is:

    1,500 x 300 x 1.05 = 472,500 tons/year

(2) Supply and demand forecast

"Theoretical cement consumption" in the Sudan at the time of the study was calculated based on the correlation between the per capita GDP and per capita cement consumption. The cement consumption growth rate after that was estimated at 5.3%, by estimating the pupulation growth rate and per capita GDP growth rate at 3.3% and 1.6% respectively).

Demand forecast ("theoretical") obtained in this way is:

in 1975	540,000 tons (29 kg/capita)
in 1985	900,000 tons.

(3) Investigation on raw materials

- Limestone

  93 borings by wagon drill were reportedly performed. (Up to 30m deep at the maximum). The quality was judged to suit for cement manufacturing and the quality was estimated at 51 million tons*.

  * Note: enough to support a 500,000-t/year cement plant for about 80 years.

- Clay

  19 borings by wagon drill and 22 test pitting were reportedly performed. The quality was judged to suit for cement manufacturing, and the quantity was estimated at 45 million tons*.

*Note: No endorsing data such as boring logs, location map chemical analysis data, etc. are not attached to the said report.

(4) Economic analysis

1) Investment --- US$47,532,000 (No breakdown attached)

2) Production cost (excluding interest) --- 19.932 US$/t

3) Cash flow analysis, etc. --- not provided

1-3-3 Feasibility study by a Sudanese Consultant

(1) Plant capacity ---- 1,500 ton(clinker)/day

(2) Supply and demand forecast

The consultant's own forecast is not provided, but the following two forecasts are referred to in the report.

1) Forecast shown in the current Six-year Plan for Economic and Social Development (See the Table 1-1 below).

2) Forecast by an organization (see the Table 1-2 below).

Table 1-1 Six-year Plan projections of demand and domestic supply

Year	Demand	Domestic Supply	Shortage/Surplus
1976/77	450,000	250,000	-200,000
1977/78	500,000	290,000	-210,000
1978/79	545,000	300,000	-245,000
1979/80	600,000	430,000	-170,000
1980/81	660,000	550,000	-110,000
1981/82	725,000	850,000	+125,000
1982/83	800,000	1,050,000	+250,000

Table 1-2 Demand Forecast for cement 1978 - 1985

Year	Based on 5.5% Annual Rate of increase in Investment	Based on 9% Annual Rate of increase in Investment	Based on 13.8% Annual Rate of increase in Investment
1978	219,900	240,000	293,000
1979	231,100	261,000	341,000
1980	242,900	273,000	392,400
1981	255,300	397,100	433,400
1982	268,600	333,400	478,500
1983	282,500	362,000	528,500
1984	297,200	393,100	583,900
1985	312,700	427,100	645,200

Source: Study prepared for the "Grouped Industries Corporation" February 1975.

(3) Export of cement

Out of 500,000 tons of annual cement production, as great as 300,000 tons was estimated to be exported, referring to an information that the neighbouring countries were importing over 75% of their cement consumption.

(4) Economic analysis

1) Investment US$91,400,570 (including working capital but excluding cost of the related infrastructure)

2) Selling price

in 1981 For export 60 US$/t (On-truck at an exporting harbor)

For domestic market 80 US$/t (Ex-factory)

Price escalation for both export and domestic market was estimated at 7.5% annum. Thus, in 1991

For export	123.7 $/t
For domestic market	154.5 $/T

(3) Cash flow

Based on the assumption shown above, the cumulative cash flow in ten years after starting the plant operation was to reach $350 million.

1-3-4 ACC's Investigation on Raw Materials

Limestone : Samples from 3 borings were analysed and the respective analysis data are provided in its report.

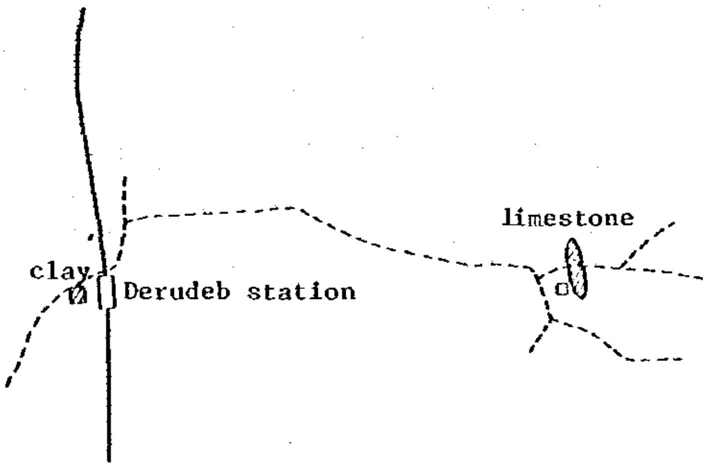
Clay : Respective analysis data of samples are provided in its report together with a map showing the sampling points.

Section 2. Basic Study of the Project

2-1 Raw Materials and Site Conditions

2-1-1 Raw Materials

The main raw materials of cement, limestone and clay, lie in the locations shown in the sketch map.



(1) Limestone

Most part of the proposed limestone deposits exists under the ground, although a part of its forms intermittent hills, the height of which is genera-ly not higher than 59 meters. In the beforementioned report presented by the Argentine Consultant, who seems to have carried out the survey most in detail, only the conclusion was mentioned, with no data provided. According to the conslusion, the limestone is suitable for cement manufacturing, and the reserves of the deposits are calculated as follows;

Hills	4,225,203 tons
Basal area	47,027,466 tons
Total	51,252,669 tons

The amount shown above is equivalent to the consumption in 80 years by a 500,000-t/year cement plant.

However, it is not possible to judge whether the amount shown above is correct or not because the detail data have not been presented. (All the survey teams have pointed out that matter, and ACC is now carrying out test borings for confirmation thereof).
As for the quality of limestone, the analysis data presented in the preliminary study report by the Soviet geologist and the data obtained from the analysis already carriout out by ACC show that it is suitable for cement manufacturing.
The analysis data of the samples, --- one sample for analyzing all the chemical compositions, and two other samples for chlorine contents, which we brought back from Sudan this time, shows good coincidence with the data in the past of the same sample (except the chlorine content). Chroline was not detected in our analysis, and this is an advantageous fact in selecting the cement manufacturing processes.

(2) Clay

As for the clay, like the case with the limestone, the Argentine Consultant has shown only the conclusion that the quality of clay is suitable for cement manufacturing and the reserves 44,855,040 tons.*(1)
However, also in this case, it is not possible to judge the reliability of them because no detail data are provided by the consultant. There is, on the other hand, a study report made on behalf of ACC, by a Sudanese governmental organization in 1978. This report clearly states the location of the investigation, sampling points and the analyis data.
As the comments on ACC's report, it can be said:

1) the clay is adequate for cement manufacturing, althouth some homogenization process will be needed due to the fluctuation in quality, and
2) the amount of the clay reserves, 3,320,000 tons*(2), seems to be acceptable as an approximate estimate although the accuracy of the investigation seems somewhat low.

Unlike limestone it will not become a serious problem even if clay has to be transported from a distant place because the consumption of clay is much less than that of limestone. The distance between the plant and the proposed clay quarry is 18km, as is often the case with a cement plant. However, it is recommendable to carry out an investigation to find clayey material near the plant site for saving the transportation cost.

Note *(1) Equivalent to the consumption for 300 year by a plant with annual production capacity of 500 thousand tons.

*(2) Equivalent to the consumption for 20 years.

2-1-2 Environmental Conditions for the Project

(1) Plant area

As a vacant plain area exists close to the limestone deposits, the plate site (approx. 30 ha.) can be selected within the plain area so that only some ground surface levelling is needed.

(2) Transporation

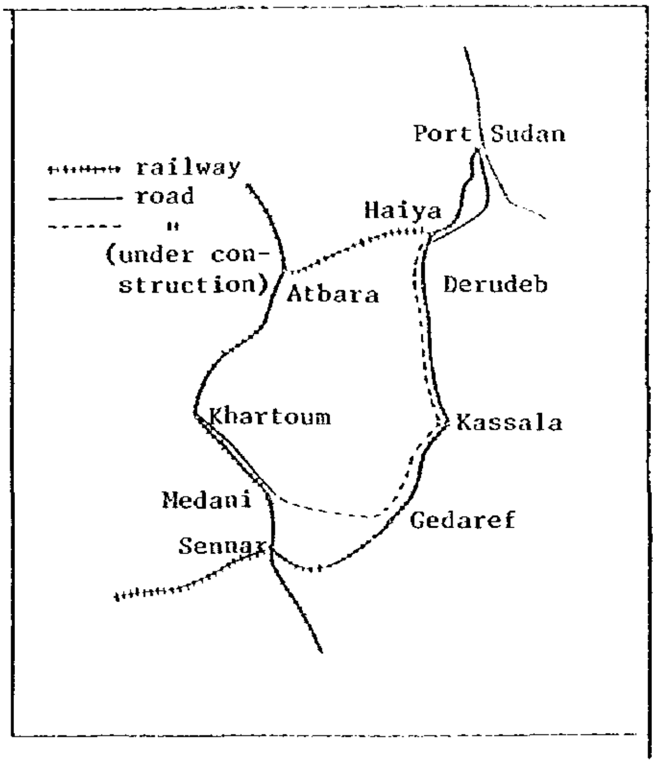
The nearest railway station to the proposed plant site is Derudeb Station. The distance is 18km and the height difference between the two points is approx. 40m (measured by a barometric altimeter. The proposed plant site is higher than the station). There is no artificial roads in this district at present. However, the topography of this area is fairly flat, and the ground surface is such that can allow travelling by jeeps without any treatment on the surface.

(3) Railway

The distance from Derudeb station to the main cities are as follows;

Derudeb - Haiya - Khartoum	715km
Derudeb - Kassala - Khartoum	1,015
Derudeb - Port Sudan	315
Derudeb - Kassala	225
Derudeb - Gedaref	485

(Refer to the map attached)

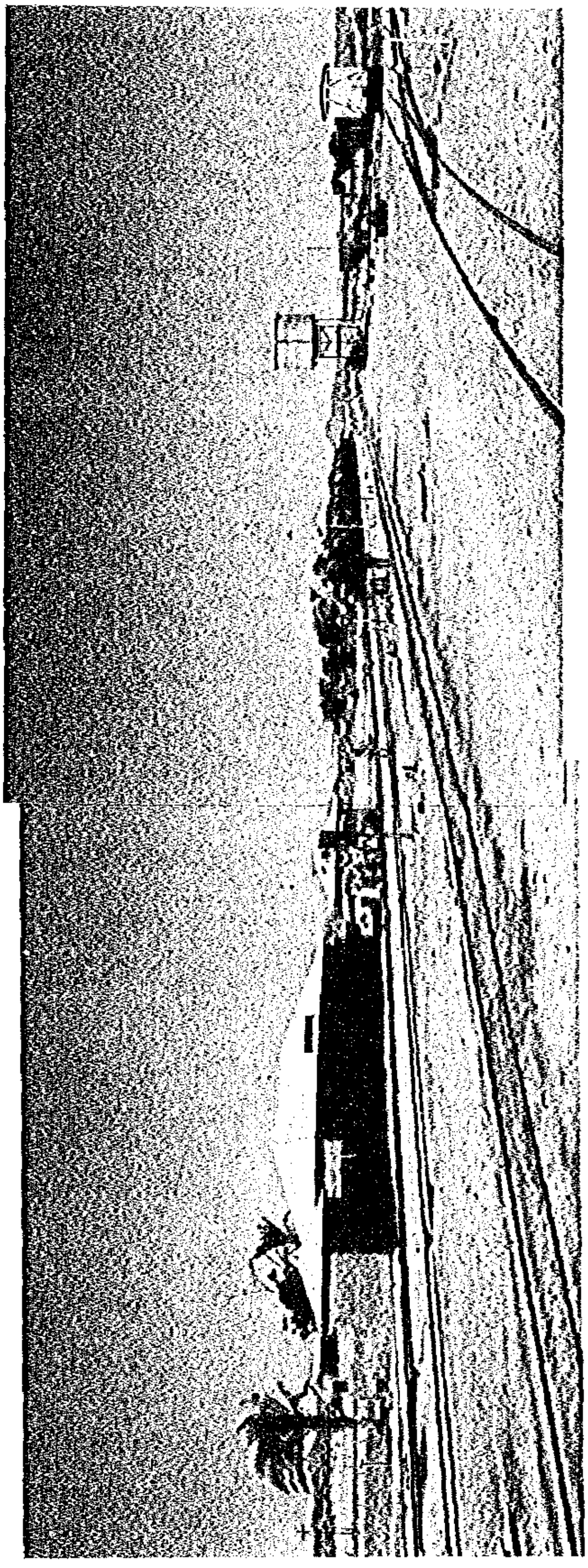


(4) Roads

At present a highway (7m wide) connecting Port Sudan to the capital Khartoum is under construction and partly completed. This highway is to pass by the Derudeb station.

(5) Communication

There is no telephone system in Derudeb at present. The site office near Derudeb station of a foreign construction company (which is excuting the said highway construction) is equipped with a wireless telephone for its exclusive use to communicate with its Khartoum office.



Derudeb Railway Station

Villages near Derudeb Station

Water pipeline passing by
Derudeb Station

(6) Climate

The climate in Derudeb is of desert and there is little reinfall, annually 100mm or so. The average maximum daily temperature (on the average from 1941 to 1970) is highest in May (41.2°C) and the average minimum daily temperature (ditto) is lowest in January (16°C).

(7) Labour Sources

There is a small village near Derudeb station, the population of which is not certain. Anyway, it is too little to supply the workers for the plant. (Refer to the photos of the village).

(8) Water supply

Ground water exists around Derudeb station and the proposed plant site. However, it is not investigated whether or not the ground water gets dryed up when it is used continuously for the cement plant. There is another water source, i.e. a pipeline passing by the Derudeb station. This pipeline is used for supplying water necessary for the abovementioned road construction. The water source is the Atbara River.

Considering the above situation, it will be necessary to develop the following infrastructure when implementing this project.

1) New installation of a road connecting the plant site with the Derudeb station (Pavement width: 7m length: 18km).
2) New installation of a railway connecting the plant with Derudeb station.(single track railway of 18km long. In addition, a shunting yard must be provided in the plant site).

3) Installation of a wireless telephone system as a communication means (At least with a capacity to communicate with Khartoum).

4) Arrangement of houses for employees (about 320 houses or 80% of the total number of employees which is assumed to be 400 men).

5) Purchase of the existing water pipeline or acquisition of right-to-use of the water and new instllation of water pipeline to the plant (approx. 18km)
(Refer to 2-4 regarding the estimation of the construction cost for the above).

2-2 Production Capacity of the Plant

2-2-1 Daily and annual production capacity

According to the available reports (as belowmentioned) the production capacity is planned as follows:

In Report 1* and Report 2*		
Cement dinker	Daily	1,500 tons
Cement	Annually	500,000 tons**
In Report 3*		
Cement	Annually	500,000 tons**

Note: *Report 1-Feasibility Study Report by an Argentine consultant (1974)
Report 2- Feasibility Study Report by a Sudanese consultant (1978)
Report 3- Six-Year Plan for Economic and Social Development by the Government (July 1976 - June 1982)

Note ** In case of the daily production capacity of 1,500 tons, the annual production capacity is calculated as follows:
Assuming the plant operation days a year and the percentage of addition of gypsum as 300 days and 5%,
1,500 t/d x 300 d/y x 1.05 = 473,000 t/y

However, annual cement production 500,000 tons (equivalent to 317 days' operation) is not impossible if the operators are well trained.

2-2-2 Basis used in the determination on the Production Capacity

There is no particular description as to the decision of daily, or annual, production capacity in all the reports shown above. Supposedly, the production capacity, in every case, has been decided based on the cement demand forecast.

(1) Cement demand forecast in Report 1*

1975: 540 thousand tons (Theoretically calculated cement consumption in the Sudan, based on the statistics of per capita GDP and cement consumption in other countries)

1985: 900 thousand tons

Product of population growth rate (3.3%/annum) and per capita GDP growth rate (1.6%/annum) was used as cement consumption growth rate, i.e. 5.3%/annum.

Note:* As expressed, in the report, as a "theoretical consumption", this figure should not be called "demand forecast" in usual sence.

(2) Cement demand forecast in Report 2

The fugure in Table 3-1 are presented refering to the Report 3.

Table 3-1 Supply and demand forecast by a Sudanese consultant

(Tons in thousand)

Year	Demand	Domestic Supply	Shortage/Surplus)
1976/77	450	250 *(1)	-200
77/78	500	290 *(2)	-290
78/79	545	300 *(3)	-245
79/80	600	430 *(4)	-170
80/81	660	550 *(5)	-110
81/82	725	850 *(6)	+125
82/83	800	1,050 *(7)	+250

Note *(1) 77% of total rated capacity of two existing plants (hereinafter called [A]).

*(2) 89% of [A]

*(3) 92% of [A]

*(4) Sum of [A] and 47% of the expanded capacity (225,000 t/y) of an existing plant (hereinafter called [B]).

*(5) Sum of [A] and [B]

*(6) Sum of the figure in case *(5) and 60%, or 300 thousand tons, of the annual production capacity of this project (hereinafter called [C]).

*(7) Sum of the figure in case *(5) and [C].

2-2-3 Consideration on the Annual Production Capacity

According to the cement demand/supply plan in Report 2, as shown in Table 3-1, in 1981/82 a plant with an annual production capacity of 500 thousand tons is to be completed and the surplus in 1981/82 is to reach 125,000 tons and 250,000 tons respectively.
Even if the surplus is not exported at all, the average operation rate of the whole cement plants in the Sudan is;

$800 \div 1,050 \times 100 = 76\%$

This is within a commonly accepted range. Therefore, it would be reasonable that this project has been planned to have 500,000 t/year rated capacity,only if the supply and demand grow in accordance with the plan in Table 3-1. However, according to informations obtained by us this time, there has already been difference between the said plan and the achievement. We therefore, made a review and check on the planned rated capacity of 500,000 ton/year, as shown below.

Shown below is the difference between the supply/demand plan and the achivement until now.

1) The plant expansion project (capacity: 225,000 t/y) of the existing plant (at Atbara) is in delay (one year, according to the concerned source), which was scheduled to be completed in February, 1978. (Adjustment of supply forecast needed).

2) Actual cement production by the existing plants (Atbara and Rabak) was less than expected. (in 1977, actual production of 170 thousand tons vs. expected production of 250 thousand tons).

3) Against the expected shortage of 200 thousand tons in supply in 1976/77, the actual import of cement was approx. 130 thousand tons.

4) Due to the facts shown in 2) and 3) above, the actual consumption in 1976/77 was only approx. 270 thousand tons, though expected to be 450 thousand tons.

5) At present, it is no longer possible to complete this Derudeb project by 1981/82. The earliest time of completion will be 1983 or 1984 even if this project is implemented just now. (Refer to 2-3 as to the construction period).

According to the explanation given to our question, the cement consumption forecast was found based on (1) the theoretical cement consumption in the year just before the first year of of the forecast and (2) the cement consumption growth rate based on the growth rates of the population and the per capita GDP. The method for calculating the theoretical consumption and the data used for the calculation are not mentioned in the expalanation, but it is known from the above expalanation that theoretical consumption in 1975/76 has been estimated at 410,000 tons. Meanwhile, the actual consumption in the same fiscal year is 250,000 tons (average of consumptions in 1975 calender year and 1976 calender year).

Thus, the figures in Table 3-1 are considered to be a target rather than a forecast. Since this target is, as mentioned above, based on as much theoretical consumption as 1.6 times the actual achievement, considerable years must, in our opinion, elapse until the actual consumption reaches the target. (at least until self-sufficiency of cement is attained).

In this sence, Table 3-1 is not considered to be a forecast of actual cement consumption. In fact, the achivement in 1976/77 is only 60% the forecast (250,000 ÷ 450,000 = 0.6. See the description 4) above).

From the abovementioned viewpoint, we have worked out a forecast on cement consumption and demand, basing on available data at present. The results are as shown in Table 3-2.

Table 3-2 Supply and Demand Forecast

(Tons in thousand)

Year	Demand	Production Atbara		Total	Supply and Demand gap	Derudeb 750t/d case Production	Gap	Derudeb 1000t/d case Production	Gap	Derudeb 1500t/d case Production	Gap
1978	340	140	30	170	*(2) △170						
79	370	150	70	220	*(3) △150						
80	390	220	*(4) 80	300	△ 90						
81	430	340	*(5) 80	420	△ 10						
82	460	390	*(6) 80	470	+ 10						
83	500	390	80	470	△ 30						
84	540	390	80	470	△ 70	130	+ 60	170	+100	250	+180
85	580	390	80	470	△110	150	+ 40	200	+ 90	300	+190
86	630	390	80	470	△160	180	+ 20	230	+ 70	350	+190
87	680	390	80	470	△210	200	△ 10	270	+ 60	400	+190
88	730	390	80	470	△260	230	△ 30	300	+ 40	450	+190
89	790	390	80	470	△320	230	△ 90	300	△ 20	450	+130
90	850	390	80	470	△380	230	△150	300	△ 80	450	+ 70
91	920	390	80	470	△450	230	△220	300	△150	450	0
92	990	390	80	470	△520	230	△290	300	△220	450	△ 70

Note: *(1) In each case, Derudeb Cement Plant is expected to start operation in 1984 and is assumed that the operation rate is 50% in the first year, 60%, 70% and 80% in the second, third and fourth year respectively and 90% thereafter.

*(2) Approx. 52% of total of rated capacity (320,000t) of two existing plant

*(3) Approx. 70% of the same as above

*(4) 80% of existing capacity, 220,000 t/y(Note 1) plus 20% of expansion capacity, 230,000 t/y

*(5) 80% of existing capacity, 220,000 t/y

*(6) 80% " 220,000 t/y plus 90% of expansion capacity, 230,000 t/y (Note 2)

Note 1: One of the reasons to have estimated the maximum proudction by the existing plants at 80% the rated capacity is that one of the two production lines in Atbara Cement Plant has been working for about 30 years since 1948.
In the case that this line (150 t/d) is stopped and only the remaining one (560 t/d) is operated fully (100%), the average plant operation rate is 80%.

Note 2: In order to achieve self-sufficiency of cement from now on, the production capacity must always be in excess of the consumption. This means that the operation rate does not reach to 100%. (Refer to the explanatory sketch. In the Table 3-2 above, the years, 1984 and thereafter, fall on this case).
Therefore, the operation rate for the expansion lines is set 90% at the maximum.

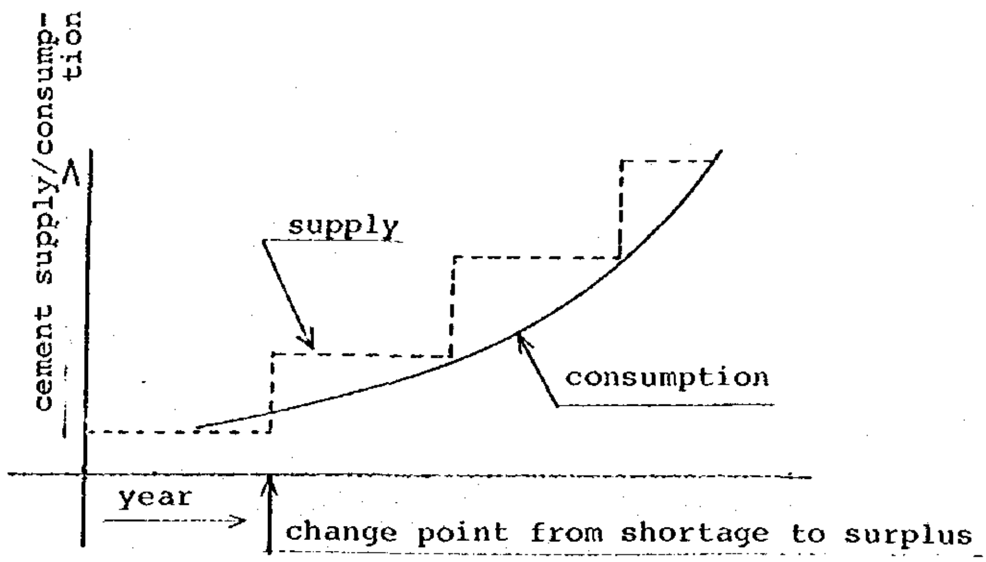


Table 3-2 tells:

- in spite that the future cement consumption forecast by us is far less than the one shown in Table 3-1, in 1984, which is the possible earliest completion date of this Project, (See "Construction Period" hereafter mentioned) the cement shorage will still exist.
- therefore, a cement Project is needed to cope with the said cement shortage.

Also shown in Table 3-2 are demand/supply balances in 3 cases which correspond to tentatively assumed rated capacities of 750 t/d, 1,000 t/d and 1,500 t/d.

The advantages and disadvantages in the cases of large capacity and small capacity plants are as follows:

(1) Case of large capacity plant

<u>Advantages</u>

1) Production cost is lower owing to the scale merit. Expecially in the case, like this project, an amount of cost for infrastructures is needed irrespective of the plant capacity, the scale merit is bigger.
2) There is capacity-wise possibility to export cement when foreign markets are open.
3) It is possible to cope with unexpected rapid increase of demand (e.g. big scale project).

<u>Disadvantages</u>

1) At the time of completion of a plants, the supply capacity will be much more than the actual demand, and therefore the plant operation rate will be lowered. It will take longer time for the plant operation rate to reach 100%.

2) Case of small capacity plant

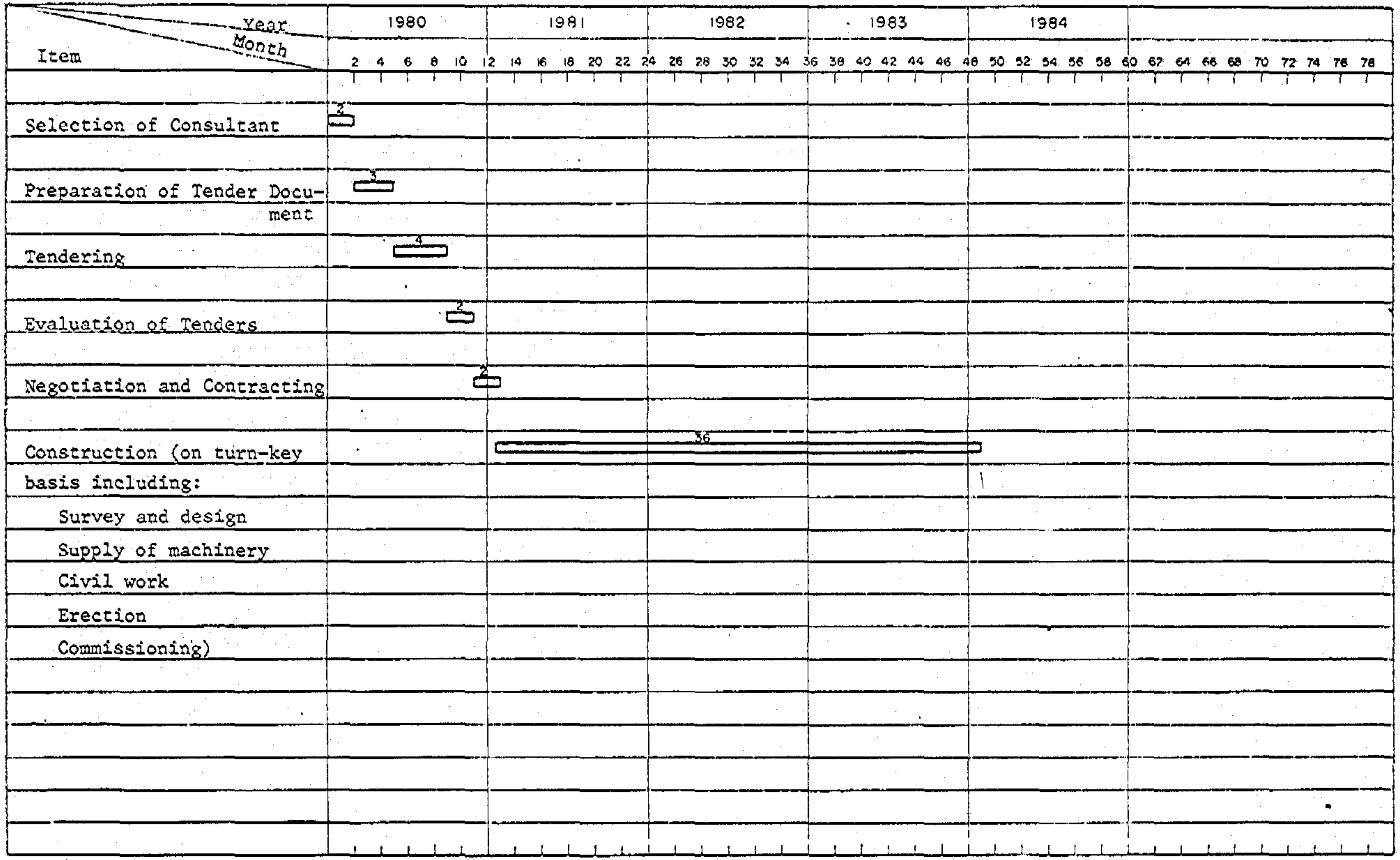
Opposite to the case of large capacity plant.

According to the results of profitability calculation made by us taking into account the scale merit and the operation rate, for the cases of 1,500 t/d and 1,000 t/d plant capacity, 1,500-t/d plant is more profitable (Refer to 2-6 Evaluation of the Project). In addition to this, considering the not-to-be-measured advantages of a large capacity plant shown in 2) and 3) above, the proposed production capacity of 1,500 t/d is judged to be reasonable.

2-3 Construction Period

According to ACC, when to implement this project is not decided yet because it depends on the timing of the financing,but the period from the commencement of the construction to the completion is estimated at 30 months.
This period of 30 months for construction is a little shorter than worked examples of other cement plant construction.
For example, the expansion project under construction in the existing plant was contracted in May, L976, and expected to be completed in February, 1979 (33 months after the contract). But, at present it is 12 months behind schedule.
Judging from this fact and another fact that similar projects in Saudi Arabia, etc., take as long time as 33-36 months for the construction, the construction period for this project, too, should be estimated at about 36 months (3 years).
Under such circumstance that the financing matter for this Project has not been settled yet, it is surely difficult to predict the completion date of this project. Nevertheless, we assumed the completion date of this Project to be beginning of 1984 as shown in the Time Schedule bar-chart attached hereto, because the completion date is essential for the judgement to decide the plant capacity as described hereinafter.

Time Schedule



2-4 Construction Cost

2-4-1 Construction Cost Estimated by the Sudan

The construction cost of this Project estimated by ACC is as follows:

Item	Budget (US$ in thousands)	Remark (DM in thousands)
Design and geological survey Machinery and equipment Erection of machinery and equipment Commissioning Spare parts for two years operation	50,200	(120,480)
Ocean freight, insurance and inland transportation	7,500	(18,000)
Buildings and structures	18,500	(44,400)
Power station (20MW)	16,000	38,400
Sub-total (Plant construction cost)	92,200	(221,280)
Water supply Houser for employees Railway Roads	20,000	
Total	112,200	

According to the explanation by ACC, the plant construction cost in the budget above was calculated "based on the international prevailing rates". As a mtter of fact, this budget is the same as the quotation submitted in 1977 to ACC by an European plant manufacturer on a turn-key basis.

2-4-2 Our Estimate on the Investment Cost

(1) Plant construction cost

Considering the circumstances as mentioned above, this budget (quotation) should be reviewed from the following viewpoints:

1) Variation of currency exchange rates after 1977.
2) Delay in implementation of the Project (The validity of the said quotation has expired).
3) Degree of competition when the said quotation was submitted.

Following are our comments on these 3 points:
The said quotation was expressed in Deutsch Mark (DM), and the quoted price, after being converted into US$ at the rate of 2.4 DM/US$, became the beforementioned budget.

Afterwards, the value of US$ has declined. Therefore, it is, in our opinion, questionable to adopt the price based on the exchange rate in 1977 as the budget.

Since 1977 until now (January 1979) the value of US$ has declined by nearly 10% against SDR. Taking this factor into consideration, the aforementioned budget, 92,200,000 US$, is adjusted as follows:

$$92{,}200{,}000 \div (1 - 0.1) = 102{,}000{,}000 \text{ US\$}$$

As for the abovementioned second point (delay in implementation), it is noticed that there is approximately one-year time difference between the dates of the said quotation (in 1977) and our visit to the Sudan (December 1978). Therefore, there should be an adjustment due to the inflation during this time difference. However, on the condition that an international bidding be called for under keen competition, the price can be lower than otherwise. Assuming that this factor and the said inflation factor cancel each other, only the adjustment due to the declination of US$ is applied to the budget.

Thus, our estimate on the plant construction cost at present is, as claculated above, 102,000,000 US$, or roughly 100 million US$.

We made a further review on the construction cost from a different viewpoint as shown below.

The budget for the expansion project which is going on in Atbara plant is:

1.	Design of Civil Work Supply of Machinery and Equipment Assistance in Erection	150 million D.Kr. (Contract in 1976 and Additional contract in 1977)
2.	Civil Work, Erection, Freight and other expenses	8 million £S

The inflation rate in Denmark upto now from the contract date being 13% according to the official statistics, the present value of the price of item 1 above is:

D.Kr 150,000,000 x 1.13 ÷ 5.1 D.Kr/US$ = 33,000,000 US$

As for the item 2 above, assuming that the inflation rates in the Sudan during the same period as above be 50% (See note below), the present value is considered to be:

8,000,000 £S x 1.5 x 2.0 US$/£S = 24,000,000 US$

This menas that if the expansion project were implemented from now it would cost 33,000,000 + 24,000,000 = 57,000,000 US$.

Generally speaking, if the size of a project is doubled (2 x 750 = 1,500 t/d in this case), the construction cost of the double-sized project becomes $2^{0.6}$ to $2^{0.7}$ times the cost of the original.

Applying $2^{0.65}$ (as the average of $2^{0.6}$ and $2^{0.7}$) to above-mentioned 750 t/d expansion, the cost for 1,500 t/d expansion is estimated at

$57,000,000 \times 2^{0.65} = 57,000,000 \times 1.57 = 89,000,000$ US$

say, 90 million US$.

In case of an expansion project, cost for ancillary facilities such as office, laboratory, workshop, etc. is not needed any more. Therefore, the construction cost of an expansion project is less by so much than that of a new installation.
From this viewpoint, too, the construction cost estimate, 100 million US$, as calculated hereabove can be regarded as reasonable.

* NOte: There has been an economic change in the foreign exchange rate from 2.5 US$/£S to 2.0 US$/£S.

(2) Expenses other than construction cost

In the budget provided by ACC, a roughly estimated amount of 20 million US$ is appropriated for the involved infrastructures. However, in addition, the following should be taken into account:

1. Pre-operation expense
2. Consulting fee
3. Fee for plant operation management
4. Working capital

Following are our estimation for the above expenses as well as for infrastructure.

1) Cost necessary for infrastructures

Road

A new road from Derudeb station to the proposed plant site is to be constructed. The distance is approx. 18km, and the cost will be

18km x 130,000 £S/km x 2.0 $/£S = US$4.7 mil.

where, the unit construction cost used hereabove is of the highway construction now under way in the Sudan.

Railway

A new installation of 18km railway as long as the abovementioned road, is necessary. In addition, shunting yards both in Derudeb station and the plant site are necessary. Assuming that the total length of the railway is 24km

24km x 65,000 £S/km x 2.0 $/£S = US$ 3.1 mil.

where, the unit price is the one given by ACC.

Water pipeline

The pipeline, which is supplying water of the Atbara River to the area along the highway under construction, is to be purchased after completion of the highway construction. Furthermore, a branch pipeline from this water pipeline to the plant (18km long) is necessary. According to ACC's estimate, the expense for the above is:

£S 2.0 mil. x 2.0 $/£S = US$ 4.0 mil.

Houses for employees

In the vicinity of the Project site, there is no town big enough to supply all the workers necessary for the plant operation. Accordingly, 320 employees, or 80% of the total workers, are assumed to be recruited from other places, and to be lent houses.

Hence,

Houses: 320 x 60 m^2/house x 200 £S/m^2 x 2.0 $/£S = US$ 3.8 mil.

Ancillary facitilies: 20% of the above, US$ 0.8 mil.

Total : US$ 4.8 mil.

Summing up the above, the cost for developing infrastructure totals as follows:

Roads	US$ 4.7 mil.
Railway	3.1
Water pipeline	4.0
Houses for employees	4.6
Total:	US$ 16.4 mil.

2) Pre-operation expenses

Assuming all the employees are trained for 6 months on the average, before starting operation

400 men x 6 months x 300 $/man.month *(1) = US$ 0.72 mil.

Adding US$ 1.5 mil. *(2) as the working expenses of ACC's office before starting the plant operation, the total amount is, Approx. US$ 2.2 mil.

Note *(1) According to the report by the Sudanese consultant

*(2) Paid-up capital of ACC at present is US$ 3.0 mil.

3) Consulting fee

As mentioned herebefore in 2-7, the excution body for this project has no experience in this kind of projects, turnkey system should be applied, and even in this case, a consultant is to be employed in charge of preparation of tender documents, evaluation of tenders and overall supervision of the construction. The fee for such consultant is estimated at US$ 2.0 mil.

4) Fee for plant operation management

For the same reason as mentioned above, it is necessary to employ an appropriate consultant for the plant management and operation.

Though expenses for this will greatly depend on the ability of the plant employees, it is roughly estimated at,

240 man.month x 10,000 $/man.month - US$ 2.4 mil.

5) Working capital

Working capital necessary for the plant operation, such as reserving certain amount of raw materials, fuel, cement clinker and cement respectively, is roughly estimated at US$ 1.0 mil.

Summing up all the abovementioned,the funds necessary for the implementation of this project is estimated as follows:

	Estimate (US$ in mil.)	Foreign currency portion included (US$ in mil.)
Plant construction cost	100	80 *(1)
Infrastructure	16.4	4 *(2)
Miscellaneous	7.8	4 *(3)
(Pre-operation expenses)	(2.2)	
(Consulting fee)	(2.0)	
(Fee for the plant operation management)	(2.4)	
(Working Capital)	(1.2)	
Total	124.2 mil US$	(88 mil US$)

* Note (1): Estimate of the foreign currency portion is very rough because the construction cost estimate itself is rough.

(2): Cost for the water pipeline

(3): Most part of the sum of fees.

2-5 Forecast of Supply and Demand of Cement

2-5-1 Actual Conditions of Supply and Demand of Cement

As shown in Table 3-3, since the Atbara Plant started its operation in 1948, cement consumption in the Sudan increased rather favorably up to 1964, followed by a sharp decline in 1965 due to the remarkable decrease in the amount of production and import. Accordingly, the Sudan seems to have newly initiated its consumption from a low level and finally broke the 300,000-ton level in 1977. The volume, however, merely accounts for about 60 percent of the target listed in the working Six Year Plan.

2-5-2 Demand Forecast

Taking into account the difference between the acutally performed record and the target figure in the current Six Year Plan, the Sudan will suffer from a shortage of cement for a long period until self-sufficiency is achieved.
The decision on the scale of the plant mentioned in 2-2 is so closely connected with the demand forecast around the year when the Project is implemented that we have made an estimate of cement demand in the manner stated below, based on the result of 1965 through 1977.

(1) Trend analysis
Trend analysis is applied to the linear, quadratic, exponential and Gompertz curve equations. Respective equations and correlative coefficients are shown as follows, of which the most appropriate is the quadratic equation:

Table 3-3 Consumption Records of Cement in Thousand Tons

Year	Production Atbara	Production Rebak	Production Total	Import	Import ratio (%)	Export	Consumption	Per capita consumption (Kg)
1948	5		5	31	(86)		36	4
1949	20		20	33	(62)		53	6
1950	25		25	13	(37)	3	35	4
1951	30		30	16	(36)	1	45	5
1952	30		30	34	(53)		64	7
1953	30		30	29	(49)		59	6
1954	45		45	34	(44)	2	77	8
1955	45		45	24	(36)	3	66	7
1956	50		50	11	(19)	4	57	6
1957	55		55	67	(55)		122	12
1958	85		85	18	(17)		103	10
1959	90		90	19	(17)		109	10
1960	91		91	25	(22)		116	10
1961	95		95	72	(43)		167	15
1962	104		104	210	(67)		314	27
1963	116		116	279	(71)		395	34
1964	83		83	331	(80)		414	34
1965	49		49	83	(63)		132	11
1966	105		105	46	(30)		151	12
1967	133		133	17	(11)		150	12
1968	145		145	8	(5)		153	12
1969	169	1	170	5	(3)		175	13
1970	156	16	172	2	(1)		174	13
1971	147	37	184	4	(2)		188	13
1972	146	49	195	1	(1)		196	14
1973	150	53	203	6	(3)		209	14
1974	157	37	194	5	(3)		199	13
1975	147	35	182	77	(30)		259	17
1976	129	37	166	65	(28)		231	14
1977	140	37	177	136	(43)		313	19

The linear equation

$$y = 11.9t + 111.7 \quad \ldots\ldots\ldots\ldots \quad (1)$$

$$r = 0.920$$

where, y: estimated annual cement consumption (tons in thousands)

t: years elapsed from 1965

r: correlative coeficient

The quadratic equation

$$y = 0.9t^2 - 0.5t + 142.7 \quad \ldots\ldots\ldots \quad (2)$$

$$r = 0.947$$

where, t: years elapsed from 1965

The exponential equation

$$y = 40.39 \times 1.14t + 107.45 \quad \ldots\ldots \quad (3)$$

$$r = 0.942$$

where, t: years elapsed from 1966

The gompertz curve equation

$$y = 78.27 \times 1.88^{1.065t} \quad \ldots\ldots\ldots\ldots \quad (4)$$

$$r = 0.939$$

where, t: years elapsed from 1967

(2) Correlation analysis

Correlation analysis is carried out on the bais of the simple correlation with the real GDP based on 1976/77

$$y = 0.18x - 60.96 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

$$r = 0.928$$

where, y: estimated annual cement consumption (tons in thousands)

x: real GDP (£S. in millions)

The future cement consumption here is estimated on the assumption of the future real growth rate at 7.5 percent, the same rate as aimed in the Six Year Plan of Economic and Social Development starting in July, 1977.

Table 3-4 shows the actual records of yearly GDP and its projections appearing the Six Year Plan.

Table 3-4 <u>Actual Records of GDP and its Projections</u>

Fiscal year	*1 Population in millions	GDP at constant price (1976/77)		
		GDP *2 £S. in millions	Per capita £S	Growth rate (%)
1966/67	12.1	1,166	96	-
1967/68	12.5	1,238	99	6.2
1968/69	12.9	1,312	102	6.0
1969/70	13.2	1,257	95	Δ4.2
1970/71	13.6	1,319	97	4.9
1971/72	14.0	1,365	98	3.5
1972/73	14.4	1,438	100	5.3
1973/74	14.8	1,513	102	5.2
1974/75	15.2	1,662	109	9.8
1975/76	15.7	1,740	111	4.7
1976/77	16.1	1,822	113	4.7
1977/78	16.5	1,959	119	7.5
1978/79	16.9	2,106	125	7.5
1979/80	17.4	2,264	130	7.5
1980/81	17.8	2,434	137	7.5
1981/82	18.3	2,616	143	7.5
1982/83	18.8	2,812	150	7.5

*1 As the Six Year Plan shows the population in the years 1969 and 1976 through 1982, we have calculated the growth rate of population in the years before 1968 and 1970 through 1975 at the same yearly rate as in the years between 1969 and 1976, i.e. 2.9 percent.

*2 The Six Year Plan describes the GDP in the years 1966/67 through 1974/75 at 1974/75 prices, states that the GDP has grown by 4.7 percent per annum over the two year period and that the price level in 1976/77 is higher than that of 1974/75 by 10 percent, and sets the goal of the future GDP at 1976/77 prices. With these points in mind, we have amended the GDP figures up to 1975/76 on the basis of constant prices of 1976/77.

(3) Estimation based on similar cases

It is very difficult to make a fair comparison when considering several different countries because they are not alike in terms of their stage of economic development, historical background and geographical factors. However, the Sudan is still in the initial stage of its development and to provide similar cases we have selected some neighboring countries in Africa as shown in Table 3-5.

Taking these matters into consideration and to make the comparison easier with other projected figures, we have assumed the case of 8 percent increase per annum, i.e.

$$y = 313\ (1 + 0.08)^t \quad \text{..........} \quad (6)$$

where; y: estimated annual cement consumption (tons in thousands)

t: years elapsed from 1978

Table 3-5 Annual Average Growth Rate of Cement Consumption in African Countries

Countries	Area in thousand km^2	Population in millions	GDP US$ in millions	GDP Per capita US$	Period	Growth ratio (%)
Chad	1,284	4.12	490	119	1965-76	8.7
Somalia	638	3.26	320	98	1962-76	8.7
Niger	1,267	4.73	600	127	1960-76	7.7
Ethiopia	1,222	28.68	2,860	100	1957-76	7.3
Zaire	2,345	25.63	3,740	146	1962-76	6.6
Central African Empire	623	2.61	410	157	1969-74	6.2
Egypt	1,001	38.22	11,550	302	1957-76	5.8
Kenya	583	13.85	2,900	209	1957-76	5.0
Mali	1,240	6.31	540	86	1966-76	4.7
Tanzania	945	15.61	2,560	164	1957-76	4.6
Madagascar	587	8.27	1,730	209	1958-71	4.4
Mozambique	783	9.44	2,850	302	1957-76	4.0

(4) Estimated results

From the above equations future cement consumption has been estimated as shown in Table 3-6 and Figure 3-1. Among these estimations we have adopted the forecast conducted with the equation (6) as the basis for this report. However, the following should be taken into consideration in judging the figures; The data only for the past 13 years were referred to in the calculation and are deemed to be insufficient as the basis for the long-term forecast. Moreover, past data indicate the actual figures under such circumstances of cement shortage that the forecast based on past data does not exactly show the future trend after the self-sufficiency in cement is attained. (Per capita consumption record in the Sudan was 14 kg in 1976 and 20 kg in 1978 and ranks lowest in African countries as shown in Table 3-7, i.e., the 31st place among 39 nations in 1976 and the 25th place when the figure of 1978 in the Sudan is compared with those of 1976 in other countries.
This suggests that the Sudan has great prospect for cement demand hereafter).

Table 3-6 Cement Demand Forecast by Respective Methods

(Tons in thousands)

Year	(1)	(2)	(3)	(4)	(5)	(6)	For reference	
							Six Year Plan	Estimation by Argentine consultant
1978	280	310	310	300	310	340	500	630
1979	290	330	330	330	340	370	545	660
1980	300	360	370	360	370	390	600	700
1981	310	390	400	400	400	430	660	740
1982	330	420	440	440	430	460	725	770
1983	340	450	490	490	470	500	800	820
1984	350	490	550	560	510	540		860
1985	360	520	610	630	550	580		900
1986	370	560	680	730	600	630		
1987	390	600	760	840	650	680		
1988	400	640	850	980	700	730		
1989	410	680	960	1150	760	790		
1990	420	730	1080	1370	820	850		
1991	430	770	1210	1650	890	920		
1992	440	820	1370	2020	960	990		

2-5-3 Export Potentiality

(1) Saudi Arabia

Saudi Arabia, the present largest importer of cement, is expected to have an annual demand of 7 to 7.5 million tons. However, once the Five Year Plan (1975-1980) is terminated and and the large-scale projects are implemented, further increase of demand will not be anticipated from the viewpoint of a small pupulation.

Lately Saudi Arabia has produced 1.2 to 1.3 million tons every year, while its production capacity is supposed to rapidly increase as follows:

1977	1.5 million tons
1978	3.2 "
1979	3.8 "
1980	5.3 "

The current Five Year Plan has aimed at achieving the supply of not less than 10 million tons in the year of 1980, the last year of the Plan, but is likely to be delayed by several years. AT any rate, at the time when Saudi Arabia completes its Plan, it will probably appropriate part of cement surplus to the export. Therefore, apart from the present time, the future export to Saudi Arabia cannot be expected to be much. However, depending on the political consideration and regional imbalance, the import at a level of 100,000 to 200,000 tons might be possible from the viewpoint of its consumption scale. In addition, the price should be competitive with those applied to the cement imported from East Europe now at US$56-57 CIF Saudi ports. On the other hand, the production surplus on the part of the Sudan is approximately 200,000 tons per year as shown in Table 3-8.
In case larger projects are carried on within the territory, the Sudan cannot always be said to have an exporting margin.

(2) Egypt

Egypt has originally been an exporting country, though at the same time it is recently importing from other countries. Egypt, however, is not considered to be a stable and a continuous importer of cement.

(3) Others

From the geographical point of view, Ethiopia, Somalia and Yemen are the most promising countries for cement export from the Sudan, however, we have too little information to pass our judgement on their possibility for export.

As mentioned above, it is quite difficult to assume a favourable export environment several years hence. We have carried out the demand forecast mainly centering around the domestic supply and demand of cement.

Table 3-7 <u>Per capita Cement Consumption in African Countries in Kg</u>

Country	Per * capita GNP US$	1957	'58	'59	'60	'61	'62	'63	'64	'65	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77
Morocco	570	42	42	42	42	51	56	59	72	57	63	61	69	77	93	104	102	102	112	130	163	187
Algeria	1110	84	109	133	144	124	62	71	67	53	45	54	67	83	99	102	112	162	181	175	190	217
Tunisia	860	50	49	49	57	63	75	70	73	97	109	113	102	95	112	110	122	125	172	203	215	270
Libya	6680	53	64	83	118	129	166	192	211	293	369	404	422	356	260	303	680	866	1309	1267	1306	1283
Egypt	310	53	53	53	66	55	68	80	84	81	81	80	72	86	100	74	87	86	85	97	104	99
Ethiopia	110	3	5	4	5	4	2	3	3	4	4	5	5	8	8	7	6	6	6	4	4	4
Somalia	110	5	4	6	7	8	15	11	18	16	11	11	11	11	6	24	19	14	24	31	15	15
Kenya	270	28	28	30	26	16	13	12	9	12	16	20	24	25	24	35	39	35	31	31	32	33
Uganda	260	17	18	14	12	11	9	10	12	18	17	19	19	22	22	22	19	13	13	9	7	7
Tanzania	200	15	15	13	15	14	13	12	16	18	16	20	19	20	27	45	45	39	24	21	19	21
Mauritius	760	73	83	100	148	140	140	115	139	129	105	114	84	95	80	100	111	158	178	225	247	278
Madagascar	210	25	18	23	18	20	23	21	19	10	19	17	20	21	22	25	18	15	11	13	13	12
Mozambique	150	24	29	30	35	33	27	25	27	32	30	32	37	38	50	51	56	72	52	19	18	15
S. Africa	1340	165	175	167	166	156	154	168	196	212	194	196	214	236	261	253	281	281	280	270	258	235
S. Rhodesia	500	85	81	59	51	45	34	32	49	51	56	53	68	67	79	106	110	114	124	109	83	72
Zambia	450								46	68	92	84	93	52	97	107	108	89	93	94	89	82
Malawi	140								8	9	11	10	13	20	17	16	17	19	19	23	17	17
Nigeria	420	18	19	19	23	22	22	16	14	20	20	14	10	11	16	29	31	32	36	48	51	97

Country	Per * capita GNP US$	1957	'58	'59	'60	'61	'62	'63	'64	'65	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77
Ghana	380	58	63	72	69	72	64	69	86	68	52	58	41	47	50	57	45	41	54	67	65	56
Sierra Leone	200	21	27	21	21	22	26	28	25	29	35	23	20	25	25	23	27	33	23	37	20	20
Gambia	200	21	17	28	19	23	39	26	25	28	29	35	45	20	41	30	65	36	31	30	31	33
Senegal	420									52	54	45	52	48	44	46	61	60	61	67	71	62
Mali	110									7	8	6	3	5	8	11	9	10	8	12	11	13
Guinea	230			18	21	14	21	7	10	13	4	9	12	12	12	12	15	15	16	14	11	11
Ivory Coast	710			41	46	41	50	47	65	66	68	64	83	96	93	95	121	129	121	125	133	177
Benin	200			24	33	28	24	30	24	25	23	26	26	30	31	36	39	42	42	42	42	40
Upper Volta	110			1	1	5	6	6	5	7	5	4	4	7	4	6	6	3	9	8	11	12
Niger	160			12	4	4	6	3	4	4	6	6	5	9	8	6	7	7	5	8	8	10
Mauritania	270										10	11	12	13	26	12	15	23	23	43	44	65
Togo	300	20	23	24	28	25	29	26	19	26	35	31	35	47	44	48	58	56	59	68	68	92
Gabon	3730					51	78	70	81	71	85	84	88	89	120	114	154	163	194	255	551	566
Congo	500					66	74	59	70	51	51	74	86	79	100	106	114	66	59	62	53	64
Chad	130					4	6	3	4	2	2	3	6	4	4	3	3	4	3	3	3	3
C. Africa Empire	250					13	17	13	15	11	13	14	20	2	1	17	9	9	7	11	9	8

Country	Per * capita GNP US$	1957	'58	'59	'60	'61	'62	'63	'64	'65	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77
Cameroun	340	27	24	19	14	17	16	16	17	14	21	24	26	18	24	22	32	36	34	39	44	58
Zaire	130	32	29	22	11	6	10	11	16	14	16	15	15	18	20	22	20	22	23	24	19	17
Rwanda & Burundi	130											4	4	3	4	4	4	5	5	5	6	5
Angola	330	35	38	34	34	32	32	33	31	32	34	50	57	61	69	85	92	98	91	45	14	18
Liberia	430	14	16	50	29	39	43	87	82	109	80	65	58	87	62	59	56	56	53	53	70	98

* Per capita GNP is estimated for the year 1977 for reference.

2-5-4 Supply and Demand Forecast

As stated previously, we have adopted the forecast given by the equation (6) as the basis for future demand, while the forecast for future supply is based on the notion mentioned in 2-2.

Table 3-8 Supply and Demand Forecast

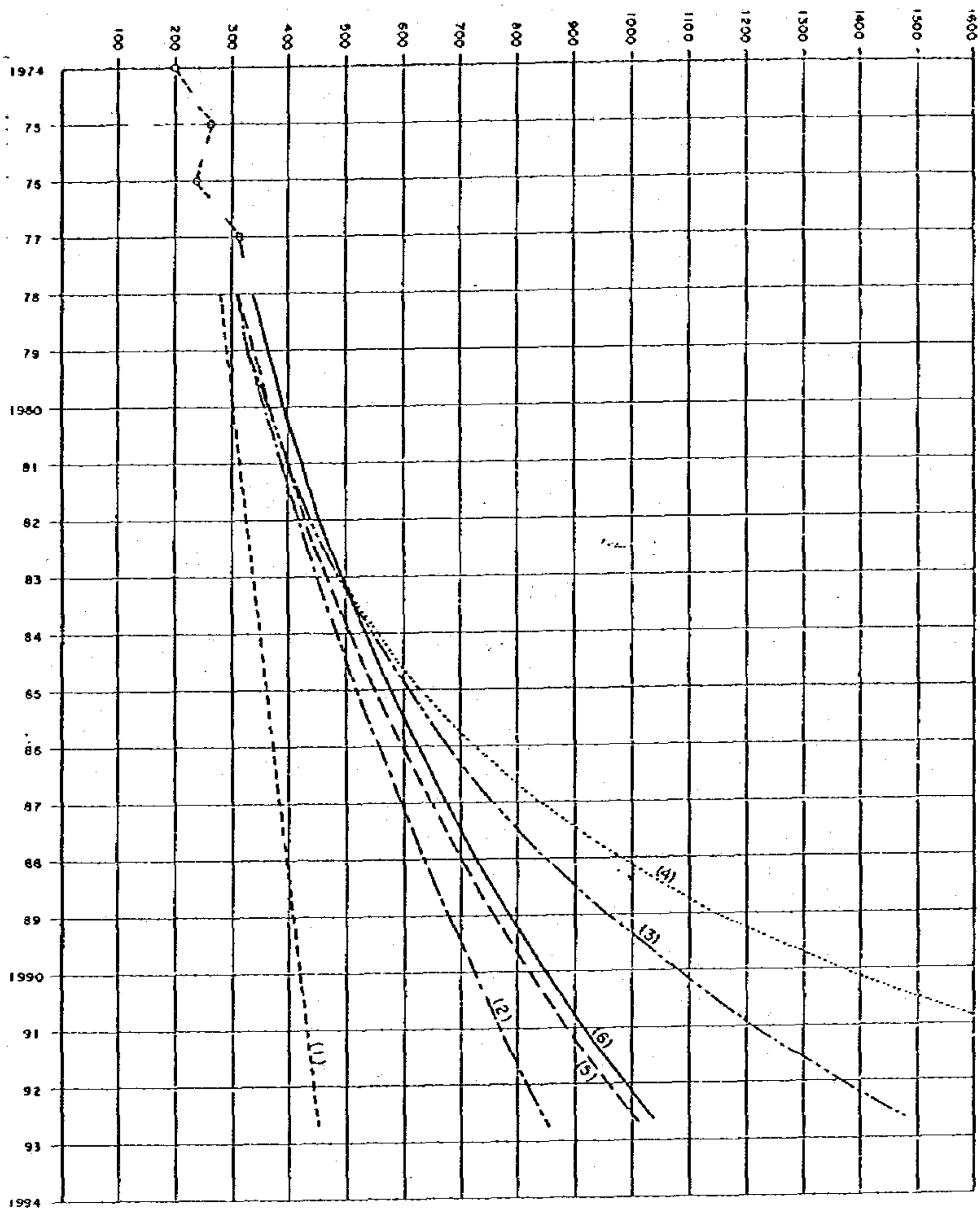
(Tons in thousands)

Year	Demand	Production			Supply and Demand	Derudeb 750t/d case		Derudeb 1,000t/d case		Derudeb 1,500t/d case	
		Atbara	Robak	Total		Production	Gap	Production	Gap	Production	Gap
1978	340	140	30	170	Δ170						
1979	370	150	70	220	Δ150						
1980	390	220	80	300	Δ 90						
1981	430	340	80	420	Δ 10						
1982	460	390	80	470	+ 10						
1983	500	390	80	470	Δ 30						
1984	540	390	80	470	Δ 70	130	60	170	+100	250	+180
1985	580	390	80	470	Δ110	150	40	200	+ 90	300	+190
1986	730	390	80	470	Δ160	180	+ 20	230	+ 70	350	+190
1987	680	390	80	470	Δ210	200	Δ 10	270	+ 60	400	+190
1988	730	390	80	470	Δ260	230	Δ 30	300	+ 40	450	+190
1989	790	390	80	470	Δ320	230	Δ 90	300	Δ 20	450	+130
1990	850	390	80	470	Δ380	230	Δ150	300	Δ 80	450	+ 70
1991	920	390	80	470	Δ450	230	Δ220	300	Δ150	450	0
1992	990	390	80	470	Δ520	230	Δ290	300	Δ220	450	Δ 70

Remark: In all the cases Derudeb Plant is expected to be completed in 1984 and the operation ratio is assumed to be 50% for the first year, 60% for the second, 70% for the third, 80% for the fourth and 90% for the fifth year and threafter.

Figure 3-1 Cement Demand Forecast in the Sudan

(□ mark shows the actual records)



——— Cement demand x 1,000 tons

2-6 Evaluation of the Project

2-6-1 Economic analysis

There are two economic analyses made so far on this project: the one made by an Argentine consultant and the one by a Sudanese consultant.

(1) Analysis by an Argentine consulting firm
According to this analysis, the investment cost (only for the plant construction. No breakdown thereof attached). was 47,532,00 US$, and the production cost before deduction of interest was estimated as follows:

Item	Unit cost (US$/t)
Raw material	0.715
Auxiliary raw material	1.000
Fuel	5.791
Electric power	2.870
Salaries and wages	0.926
Administration expenses	0.060
Spare parts and maintenance	0.845
Depreciation	4.753
Insurance	0.160
Management	1.000
Sub total	18.120
Miscellaneous expenses	1.842
Total	19.962 US$/t

The abovementioned production cost was based on the rated plant capacity of 500,000 t/annum and 100% availability thereof. No other economical analysis was carried out, and the data used in this analysis are no longer up-to-date. Accordingly, this analysis was excluded from our review and comment.

(2) Analysis by a Sudanese consulting firm (in 1978)

In this analysis, the profit and loss statement and cash flow were provided for the period of eleven years from 1981 to 1991.

According to this analysis, the cumulative cash flow at 10.5 years after the commencement of the operation would reach as much as 3.4 times the investment cost.*

However, this analysis includes some question as follows:

*Note: According to our calculation, the internal rate of return in this case is about 24%.

1) Sales Prices

The sales price in 1981 is set at 80 US$/t (ex-factory) for domestic use and 60 US$/t (on truck at export harbour) for export, and then the price both for domestic use and export after that year is expected to rise at an rate of 7.5% annum. (Refer to Table 3-9).

Table 3-9

	Export			Domestic Use			Total
	1,000t	₤S/t	1,000 US$	1,000t	₤S/t	1,000 US$	1,000 US$
1981	135	60	8,100.0	90	80	7,200.0	15,300.0
1982	300	64.5	19,350.0	200	86	17,200.0	36,550.0
1983	300	69.34	20,802.0	200	92.45	18,490.0	39,292.0
1984	300	74.54	22,362.0	200	99.38	19,876.0	42,238.0
1985	300	80.13	24,039.0	200	106.83	21,366.0	45,405.0
1986	300	86.14	25,842.0	200	114.84	22,968.0	48,810.0
1987	300	92.60	27,780.0	200	123.45	24,690.0	52,470.0
1988	300	99.55	29,865.0	200	132.71	26,542.0	56,407.0
1989	300	107.02	32,106.0	200	142.66	28,532.0	60,638.0
1990	300	115.05	34,515.0	200	153.36	30,672.0	65,187.0
1991	300	123.68	37,104.0	200	164.86	32,972.0	70,076.0

Since the price at present for domestic use is 58.6 US$/t (29.3 ₤S/t), if the price in 1981 is assumed to be 80 US$/t (40 ₤S/t), this means that an escalation of 34% in three years is anticipated. Whether this is reasonable or not can't be judged at present, but the escalation of 7.5% annum for years after 1981 includes the following question: that is, while the escalation in the production cost is set at 3.5% (1983/1982) to 5.6% annum (1991/1990), the escalation in the sales price is set at 7.5% annum which exceeds the former. In general, reverse tendency is seen in the relation between the abovementioned two escalation rates.

2) Cost items adopted in the profit and loss statement
In the profit calculation, Excise Duty (4 US$/t) and Development Tax (5%) are not taken into account, and the sales price for domestic use is set at 80 US$/t (40 ₤S/t) as net revenew. Accordingly, the actual sales price must be : 80 x 1.05 + 4 = 88 US$/t.

3) Estimation of investment cost
The said analysis is based on the following investment cost:

	Unit: 1,000 US$
Plant construction	83,600
Transportation vehicle for cement export	2,400
Training of ACC staff	1,000
Working capital	2,100
Others	2,300
Total:	91,400

As seen from the above, the cost for infrastructures to be devloped is not included in the investment. Besides, the plant construction cost, 83,600,000 US$, seems to be underestimated. (Refer to 2-4. "Construction Cost").

4) Quantity and price of cement for export

Although as much export as 300,00t per year is taken into account, no data endorsing its possibility is provided. The 7.5%/annum price escalation rate is questionable, too.

Judging from the abovementioned points, this economic analysis can be said to be somewhat optimistic. Therefore, we have made an economic analysis based on the construction cost and the demand forecast both calculated by ourselves and the prevailing cement price.
The result of our economic analysis is as shown hereinafter.

Premise of calculation

1) Investment cost	124,000,000 US$
2) Sales price (ex-factory)	58.6 US$/t (29.3 £S/t) for domestic use (same as the present price, including excise duty and development tax) 30 US$/t (15 £S/t) for export (With this price, CIF price at west coast of Saudi Arabia will be possibily 60 US$/t).

However, in addition to the above, taken into account in sensitivity analysis are such various price as 105%, 110%, 115%, 120% and 134.8% the aforementioned price. (The last one is equivalent to the current imported cement price. (See 2-6-4 Trend of sales price).

3) Depreciation term

Machinery and equipment	20 years
Vehicles	5 years
Buildings and structures	40 years
Road	10 years
Railway	20 years

4) Variable cost

Paper bag	5.60 US$/t
Raw material	4.83
Fuel	5.92
Electricity	2.82
Repair expenses	4.60
Total	23.77 US$/t

5) Fixed cost

Salaries and wages	1,440,000 US$/annum
Depreciation	5,452,000
Administrative expenses	400,000

Note *: The construction interest is not included in the calculation of depreciation.

6) Tax

Excise duty	4.0 US$/t (levied only on cement for domestic use)
Development tax	5% of sales price (levided only on cement for domestic use)
Income tax	60% of net earning before tax.

7) Sales volume (Production)

Since the total cement production capacity in the Sudan after completion of this Project exceeds the demand, the several operation modes are supposed as follows.

i) In case that the existing plants produce as much cement as shown in Table 3-2 and only the deficit is produced in Derudeb plant.

According to the demand forecast shown in Table 3-2, the operation rate of Derudeb plant (500,000 t/annum) in this case is as follows.

Year	1st	2nd	3rd	4th	5th	6th	7th	8th and after
Operation rate	14%	22%	32%	42%	52%	64%	76%	90%

ii) In case that the production of Derudeb plant for domestic use is the same as mentioned in (i) and the reserve capacity is used for export.

In this case, the operation rate of 1st year is assumed to be 50% and 2nd and thereafter 90%.

iii) In case that after completion of Derudeb plant all the plants are operated at an operation rate equal to the rate of the demand to total cement production capacity in the Sudan.

In this case the operation rate of Derudeb plant as well as the existing plants is as follows.

Year	1st	2nd	3rd	4th	5th	6th	7th	8th and after
Operation rate	52%	56%	61%	65%	70%	67%	82%	90%

Provided that the cement production capacity of the Sudan means the rated plant capacity as follows.

Atbara	150 t/d plant	0 t/annum*
	560 t/d plant	190,000 t/annum
	750 t/d plant	250,000 t/annum
	Sub total	440,000 t/annum
Rabak		100,000 t/annum
Derudeb		500,000 t/annum
Total		1,040,000 t/annum

Note *: Since this 150 t/d plant has been operated for more than 30 years at the time of completion of Derudeb plant, it will no longer be put in operation.

iv) In case that the operation rate increases year and year in a rate which is considered as normal regardless of the demand forecast shown in Table 3-2.

Year	1st	2nd	3rd	4th	5th and after
Operation rate	50%	60%	70%	80%	90%

v) In case that cement is produced in Derudeb plant as much as possible because of, for example, implementation of large scale project.
In this case, the production rate of 1st year is assumed to be 50% and 2nd and thereafter 90%.

2-6-2 Results of analysis

Following is the results of analysis in case of applying the present sales price.

Case	IRR	Note
(i)	1.7%	To produce only deficit of domestic use
(ii)	1.9%	To produce deficit of domestic use and the reserve is used for export
(iii)	2.8%	To produce at an operation rate of domestic demand/total capacity in Sudan)
(iv)	3.5%	To produce according to normally increasing operation rate
(v)		

In all cases, IRRs are very low.
However, the result of economic analysis, carried out for the purpose of comparison, on the Atbara plant extension project shows that IRR is 5.8% in case of the present sales price and therefore the project is not feasible because 8.5% annum interest rate applies to the commercial loan for this extension project. (In this calculation, the operation rate was assumed to be 50% for 1st year and 90% for 2nd year and thereafter. The same variable cost as that of Derudeb project was used).

The followings are regarded as the reasons for the results mentioned above.

1) The domestic price of cement in 1975 (when the planning of extension project of Atbara plant was made) was 22 £S, which was expressed in US$ as: 22 x 2.9 = 63.8 US$/t and was higher than the present sales price of 29.3 x 2.0 = 58.6 US$/t.
(as of 1977, the domestic price was converted in US$24.425 x 2.9 = 70.8 US$/t)

2) Due to the effect of inflation, the depreciation and interest of the new plant is higher than those of the old plant. Accordingly unless the efficiency of the new plant is so superior to old plant (for instance larger capacity and/or lower fuel consumption) that the disadvantages mentioned above can be compensated, the increase of production cost as well as sales price of cement produced at the new plant is inevitable. The Derudeb Project as well as the Atbara extension project belongs to this case.

Shown below are the IRRs found by the sensitivity analysis on sales price.

Case / Price	(i)	(ii)	(iii)	(iv)	(v)	Atbara extension
Present price	1.4	1.7	2.6	3.2	3.7	5.8
5% increase of present price		2.6		4.1	4.8	6.8
10% "		3.4		4.9	5.7	7.8
15% "		4.1		5.7	6.5	8.8
20% "	3.8	4.9	5.7	6.5	7.4	9.8
34.8% "	5.5	6.8	7.8	8.8	9.7	

According to the result mentioned above, in order to make feasible the cement production in the extended facilities of Atbara plant constructed by commercial loan, the sales price of cement must be kept at least 20% higher than the present price (58.6 x 1.2 = 70.3 US$/t)

(As to the possibility of price increase, refer to "movement of price" stated at the end of this section).
Even in this case the feasibility of the Project can not be found as far as the commercial loan is applied.

2-6-3 Other studies on profitability

In addition to the studies mentioned above analyses were carried out:

(1) to determine the optimum plant capacity and
(2) to examine the effect of variation of investment cost on profitability.

The results are shown as follows:

(1) Analysis to determine the optimum capacity
Since as shown in Table 3-2 (stated before) the capacity of 750 t/d is considered to be too small, IRR for cases of 1,000 t/d and 1,500 t/d are calculated and shown as follows:

Operation rate / Capacity	case (i)	case (ii)
1,000 t/d	3.0	4.2
1,500 t/d	3.8	5.7

The result proves that the capacity of 1,500 t/d is more profitable.
The operation rate of case (i) was calculated based on the assumption that only the deficit of supply by the existing plants to domestic demand is produced in Derudeb plant according to the following operation rate.

Year / Capacity	1st	2nd	3rd	4th	5th	6th	7th	8th
1,000 t/d	21%	33%	48%	64%	79%	90%	90%	90%
1,500 t/d	14%	22%	32%	42%	52%	64%	76%	90%

The operation rate of case (ii) was calculated based on the assumption that cement is produced as much as demanded yearly in all the plant at the rate proportional to the rated capacity of each plant shown as follows.

Year / Capacity	1st	2nd	3rd	4th	5th	6th	7th	8th
1,000 t/d	62%	67%	72%	78%	84%	90%	90%	90%
1,500 t/d	52%	56%	61%	65%	70%	76%	82%	90%

The sales price is assumed to be 20% higher than the present price (70.32 US$/t).

The plant construction cost for capacity of 1,000 t/d was estimated from that for 1,500 t/d applying exponential rule, i.e. cost for 1,000 t/d = $(\frac{1,000}{1,500})^{0.65}$ x cost for 1,500 t/d. As for the direct production cost, the same value as that of 1,500 t/d case was used.

(2) Effect of variation of investment cost on profitability

The profitability corresponding to the variation of investment cost expressed in IRR is shown as follows. Provided that the operation mode used in this calculation is beforementioned case (ii) (average operation) and the sales price is assumed to be 20% higher than the present price.

Investment cost		IRR
Original investment cost	-20%	7.8%
do.	-10%	6.6%
Original investment cost		5.7%
do.	+10%	4.9%
do.	+20%	4.2%

In our study, the investment cost includes an amount of 16,400,000 US$ for the development of infrastructure needed for Derudeb cement project. This amount is equivalent to 13% the total investment, 124,800,000 US$. Should this amount be excluded from the investment, this corresponds to the case of "investment less by 13% than the original". IRR of this case is found to be 7.0% by means of interpolation between the data in the above Table. Even in this case, this project is not feasible as far as a commercial loan is used.

2-6-4 Trend of sales price

Although our question on the future trend of sales price could not be answered by the Sudanese counterpart, judging from the past trend (Refer to Table 3-10 below.) the sales price seems to rise continuously in future. Regarded as the cause of the price rise is the escalation of raw material and fuel cost as well as salaries.* In addition, when the Atbara plant extension is completed, the price increase due to the rise of construction cost will be inevitable.

Note: * The inflation rate for the last one year is said to be about 18 %.

Table 3-10 Change in Cement Price (Ex-factory)

	Atbara		Rabak	
	Price (£/t)	Effective date	Price(£/t)	Effective date
1973	11.70	(9. 10)	12.00	(9.16)
1974	11.925	(7. 11)	13.00 13.25	(2.24) (7.18)
1975	22.00	(3. 17)	22.00	(3.17)
1976	24.00	(6. 3)	25.00 27.00	(3. 2) (6. 3)
1977	24.425	(1. 12)	27.465	(1.12)
1978	29.30	(11. 17)	29.30	(11.17)

On the other hand, the comparison with imported cement price should be taken into consideration. Our trial calculation on this point is shown below.

1) Profit: Since CIF price does not include importer's profit, 10 % CIF price is supposed to be such profit and added to CIF price.
2) Taxes: Assume that imported cement is taxable as much as domestic cement; i. e. 4 $/t as Development Tax and 5 % the sales price as Excise Duty.
3) *Difference in transportation cost, etc.:*
   Assume that imported cement is more expensive by 2 $/t than domestic cement because of the port charge, and also

by 4 $/t because it is transported for a distance longer by 100 km on average than domestic cement.

Then, assuming that CIF price of imported cement is 60 $/t the respective amounts of abovementioned factors are:

1)	60 x 0.1	=	6	US$/t
2)	4 + 60 x 0.05	=	7	"
3)	2 + 4	=	6	"
	Total		*19*	*US$/t*

According to this calculation, if the ex-factory cement price is equal to CIF price of imported cement plus 19 US$/t, market price of domestic cement is balanced with that of imported cement.
From this viewpoint, the limit of rise in domestic cement price (ex-factory) is considered to be: 60 + 19 - 58.6 = 20.4 US$/t or 34.8 % the current price provided that CIF price of imported cement and current domestic cement price (ex-factory) are set *60 US$/t and 58.6 US$/t respectively.*

2-7 Executing agency of the Project

As stated in "1-2 Short history of the Project", the executing agency of this Project is ARAB CEMENT CORPORATION which was established for this Project. This agency was established in 1976 and the present organization consists of BOARD OF DIRECTORS and ASSISTANTS TO BOARD OF DIRECTORS.

There are three directors in the board; one (CHAIRMAN) is full-time, and the other two are non-full-time. The number of assistants in charge of business seems to be one excluding typists and servants.

In addition to this member, a technical consultant (Sudanese) is employed.

One of non-full-time director, belonging BUILDING MATERIAL CORPORATION, is the Project manager of the extension project of Masupio Cement (located at Atbara) which is under control of BMC.

However, since this agency is not so sufficiently staffed at present to execute the Project, an appropriate consultant firm must be employed for the implementation of the Project.

Even in case of employing a consultant firm, judging from the present situation of the agency, construction contract form should be "Turn-key" contract.

As for the management of the plant after commencement of operation, ACC intends to employ an appropriate consultant firm for at least three years. This can be said to be a reasonable idea.

Section 3. Summary and Supplemental Investment to be performed in Future

3-1 Summary

The results of our study as mentioned hereinbefore are summarized as follows.

(1) Although the demand forecast prepared by us is much less than that stated in six year plan of the Sudan, the shortage of cement seems to continue unless this Project is planned from now and then implemented succesively.

(2) 1,500 t/d plant capacity which has been proposed so far is considered to be adequate.

(3) Although the profitability of this Project will be affected largely by the trend of cement price and demand, IRR of this Project is probably within the range from 5 to 7%.

However, it should be noted that our study is based on the results of research in the Sudan by a limited number of staff (two cement experts) and therefore, should be supplemented and confirmed through such a further investigation as described in the following article.

3-2 Investigation to be performed in future

(1) Market survey

Survey concerning the following matters

- Demand estimate (if possible by areas in the Sudan)
- Trend of price
- Distribution system

(2) Investigation on construction cost and production cost

- Investigation for preparation of basic plan such as selection of production system
- Investigation on factors affecting the cost

(3) Assessment of raw materials

- Confirmation and supplement of the results of investigation carried out so far.
- Planning of the best method of quarry development.

APPENDIX

I. Various costs calculation for 1,500-ton/day plant

1. Infrastructure

Road	18km x 130 £S/m x 10^3x 2.0 US$/£S	= 4,700 x 10^3 US$
Railway	24km x 65 x 10^3x 2.0	= 3,100 x 10^3
Water pipe line	2,000 x 10^3 x 2.0 US$	= 4,000 x 10^3
Residence*	320 x 60 m^3/house x 20 US$/$m^2$x1.2	= 4,600 x 10^3
		16,400 x 10^3US$

*320 houses corresponding to 80% of total employee's (400) are to be built, and 20% of total cost are added as cost for anciltary facilities.

2. Working Capital

1) Stock

Limestone	10d x 1500 t/d	x 2.8 US$/t	= 42,000 US$
Clay	10 x 1500	x 0.82	= 12,500
Gypsum	30 x 1500	x 1.2	= 54,000
Heavy oil	30 x 1500	x (6.74+2.5)	=415,000
Raw meal	3 x 1500	x 20	= 90,000
Clinker	5 x 1500	x 30	=225,000
Cement	5 x 1500	x 35	=262,500
Paper bags	5 x 1500	x 5.6	= 42,000
Raw paper	10 x 1500	x 3.36	= 50,400
			1,194,200 US$

2) Personnel expenses during test-run and commissioning

Personnel expense for half a year.

1,440 x 10^3 x 1/2 = 720 x 10^3 US$

Total: 1,194,200 + 720,000 = 1,900 x 10^3 US$

3. Expense before and after start-up

1) General expense 1,500 x 10^3 US$ (half the paid-up capital)

2) Consultant fee for Construction 2,000 x 10^3

3) Consulant fee for operation — $2,400 \times 10^3$ US$

$5,900 \times 10^3$ US$

4. Construction Cost

$100,000 \times 10^3$ US$ (incld. $3,000 \times 10^3$ US$ for quarry department)

Provided that construction cost for profit calculation is taken as follows.

$124,000 \times 10^3$ US$ = (Plant construction cost + Infrustructure + Working capital + Expenses before and after start-up)

5. Interest for Construction Period

Assumed construction period is 3 years.

According to the calculation in the case of 3-year construction period and 10%/annum interest rate, the interest for the construction period is 16.908% the construction cost.

For profit calculation, the interest rate for construction period is set nearly equal to the IRR (DCF rate) which has been found by a trial calculation for each case.

Thus, in case of 3% IRR, for example, the interest during construction period is: $124,000 \times 10^3 \times 0.16908 \times 0.3 = 6,300 \times 10^3$ US$.

(Fixed Cost)

1. Depreciation

Depreciation for quarry department is to be done separately.

Machineries	$97,000 \times 10^3 \times 0.7 \times 1/20$	=	$3,395 \times 10^3$ US$
Buildings and structures	$97,000 \times 10^3 \times 0.3 \times 1/40$	=	727×10^3
Road	$4,700 \times 10^3 \times 1/10$	=	470×10^3
Railway and water pipe line	$(3,100+4,000) \times 10^3 \times 1/20$	=	355×10^3
Residence	$4,600 \times 10^3 \times 1/40$	=	115×10^3

Working capital and general expenses	$(1,900+5,900) \times 10^3 \times 1/20$	=	390×10^3 US$
Interest for construction (IRR 3%)	$6,300 \times 10^3 \times 1/20$	=	315×10^3
	About		$5,570 \times 10^3$ US$/year

2. Personnel expenses

   400×300 \$/M $\times$ 12 M/year = $1,440 \times 10^3$ US$/year

   Refer to "Organization Chart" and "Personnel expenses" hereinafter mentioned.

3. Administrative expenses

   400×13^3 US$/year (SEMAC-FS)

(Direct Cost)

1. Raw material cost

   1) Limestone

Depreciation for mining equipment	527×10^3 US$/year
Repair expenses	274×10^3
Fuel cost	240×10^3
Consumables	27×10^3
Explosives	189×10^3
	$1,257 \times 10^3$ US$/year (2.8 US$/ton)

   2) Clay

Depreciation	159×10^3 US$
Repair expenses	102×10^3
Fuel cost	112×10^3
	373×10^3 US$/year (0.83 US$/ton)

   3) Gypsum

   26.755 US$ x 0.045 = 1.2 US$/ton (SEMAC-FS)

   Total (2.8+0.83+1.2) = 4.83 US$/ton

   4.83 x 500,000 ton = $2,420 \times 10^3$ US$/year

2. Fuel Cost

Fuel consumption : 850 Kcal/kg-cl

Calorific value of heavy oil: 10.334 Kcal/kg-oil

Unit price of heavy oil : 72 US$/ton

Assuming: quantity of clinker = quantity of cement

850/10,334 = 0.08225 t.oil /t.cement

0.08225 x 72 = 5.92 US$/t

5.92 x 500,000 = 2960 x 10^3 US$

3. Maintenance Cost

Maintenance cost ranges in general, 2-3% of construction cost

Taking 2%,

(97,000 x 10^3 + 16,400 x 10^3) x 0.02 = 2,300 x 10^3 US$

(4.6 US$/t.)

4. Paper Bags

0.14 £S/Bag x 20 Bag/t x 2.0 US$/£S = 5.6 US$/t

5.6 x 500,000 = 2,800 x 10^3 US$/year

5. Electric power

Unit power consumption

Cement production process	:	125 kWh/t-cl
Power station service	:	8
Residential area	:	7
		140 kWh/t-cl

6. Direct Cost

1) Fuel cost

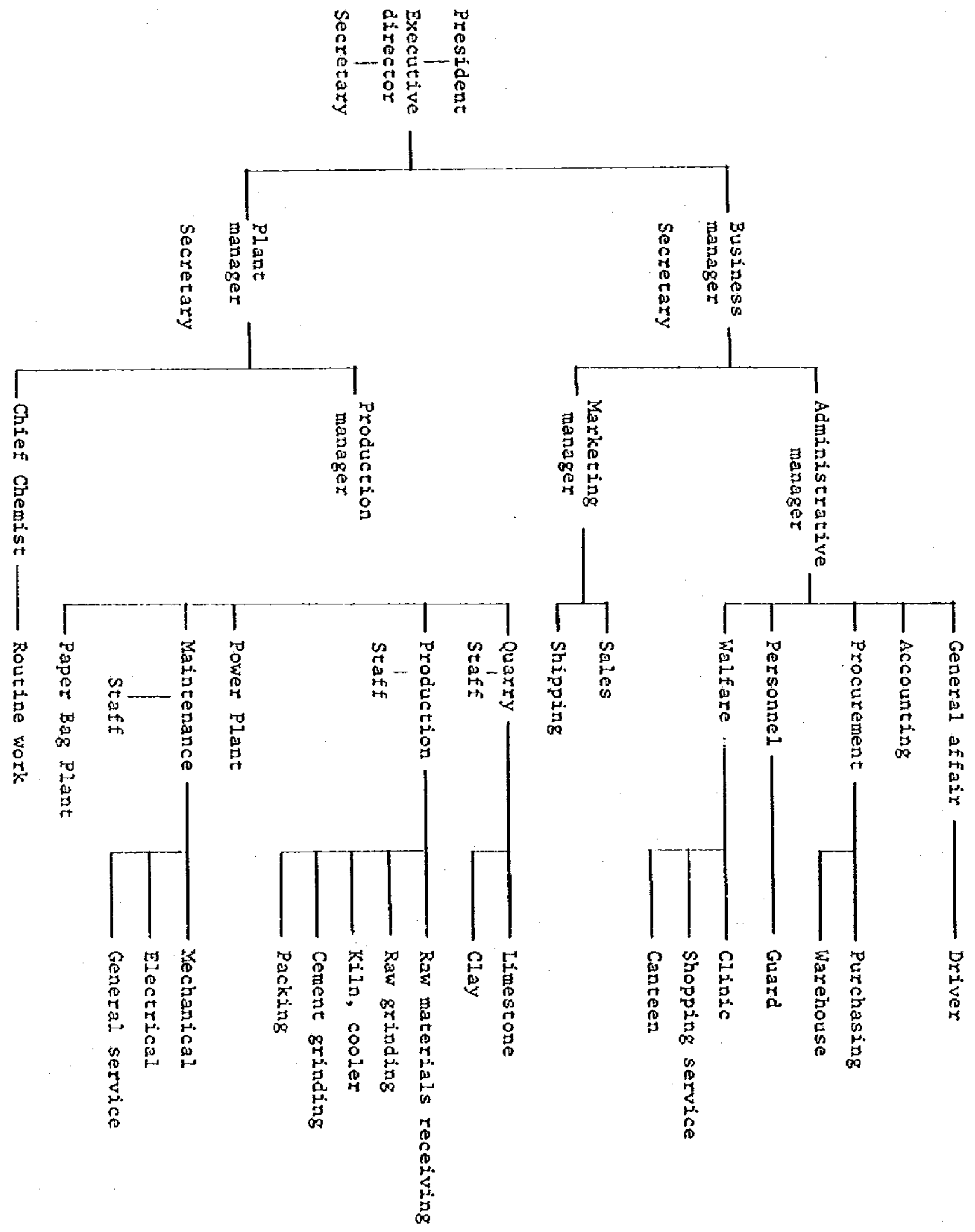
Oil consumption : 0.16 kg/HP.hr

140 x 500,000 x 0.16 x 1/0.736 x 72 US$/t.oil = 1,090 x 10^3 US$

2) Repair expenses, Lubricant and others: 320 x 10^3 US$

Total: 1,090 x 10^3 + 320 x 10^3 = 1,410 x 10^3 US$ (2.82 US$/t)

II. Organization



Salaries and Wages	No.	@US$/M	US$/Y
(1) Board			
President	1	3,000	36,000
Executive director	1	2,500	30,000
Director (Business manager)	1	2,000	24,000
" (Plant manager)	1	2,000	24,000
Secretaries	2	270	6,480
	6		120,480
(2) Business division			
Business manager (Director)	–	–	–
Secretary	1	270	3,240
	1		3,240
A) Administrative Department			
Administrative manager	1	900	10,800
	1		10,800
A-1) General affaires section			
Chief	1	675	8,100
Clerks	3	270	9,720
Typists	4	225	10,800
Telephone and Telex operator	3	225	8,100
Driver	3	180	6,480
Messenger	2	90	2,160
	16		45,360
A-2) Accounting section			
Chief	1	675	8,100
Casher	1	360	4,320
Clerks	3	270	9,720
	5		22,140
A-3) Procurement section			
Chief	1	675	8,100
Purchasing staff	3	270	9,720

Warehouse staff	2	270	6,480
" assistant	3	120	4,320
	9		28,620
A-4) Personnel section			
Chief	1	675	8,100
Labour control staff	3	270	9,720
Guards	10	110	13,200
	14		31,020
A-5) Walfare section			
Chief	1	675	8,100
Walfare staff	3	270	9,720
Canteen selesmen	4	100	4,800
" clerk	2	120	2,880
Cook	1	180	2,160
Cook helpers	5	120	7,200
Waiters	3	100	3,600
Doctor (Part time)	1	990	11,880
Nurses	2	180	4,320
	22		54,660
B) Marketing Dep't			
Marketing manager	1	810	9,720
Staffs	3	270	9,720
Salesman	5	270	16,200
Shipping officer	3	270	9,720
	12		45,360
Total of Business Division	80		241,200
(3) Production Division			
Plant manager (Director)	-	-	-
Secretary	1	270	3,240
	1		3,240

A) Production Dep't			
Production manager	1	900	10,800
	1		10,800
A-1) Quarry section			
Chief	1	630	7,560
Engineer	2	500	12,000
	3		19,560
A-1-1) Limestone Quarry			
Foreman	1	495	5,940
Drillers	10	260	31,200
Firing master	2	415	9,960
Charger	3	260	9,360
Shovel/Bulldozer drivers	6	275	19,800
Lorry drivers	11	275	36,300
Mechanical fitters	5	275	16,500
Labourers	5	120	7,200
	43		136,260
A-1-2) Clay Quarry			
Foreman	1	495	5,940
Shovel/Bulldozer drivers	3	275	9,900
Lorry drivers	8	275	26,400
Labourers	5	120	7,200
	17		49,400
A-2) Production Section			
Chief	1	900	10,800
Engineer (Shift engineer)	4	500	24,000
Staff	5	500	30,000
	10		64,800
A-2-1) Raw materials receiving			
Foreman	1	495	5,940
Limestone crusher	3	250	9,000
Clay crusher	3	250	9,000

Gypsum crusher	2	250	6,000
Heavy oil pump	2	250	6,000
Weighing checker	2	250	6,000
Helpers	3	120	4,320
	16		46,260
A-2-2) Raw grinding			
Shift foreman	4	450	21,600
Operators	8	300	28,800
Assistant operators	4	200	9,600
	16		60,000
A-2-3) Kiln, cooler			
Shift foreman	4	450	21,600
Operators	8	300	28,800
Assistant operators	4	200	9,600
	16		60,000
A-2-4) Cement grinding			
Shift foreman	4	450	21,600
Operators	4	300	14,400
Assistant opertors	4	200	9,600
	12		45,600
A-2-5) Packing			
Foreman	1	450	5,400
Operators	5	300	18,000
Packer	6	300	21,600
Paper bag attendant	4	120	5,760
Labourers	10	120	14,400
	26		65,700
A-3) Power station			
Chief	1	630	7,560
Shift operators	4	300	14,400
Electricians	6	330	23,760
Mechanical fitters	5	330	19,800
	16		65,520

A-4) Maintenance section			
Chief	1	630	7,560
Mechanical engineer	3	400	19,200
Electrical "	2	400	14,400
Civil "	3	400	9,600
Draft man	3	250	9,000
	13		59,760
A-4-1) Mechanical workshop			
Foreman	1	495	5,940
Welders	8	330	31,680
Fitters	6	330	23,760
Turner	3	330	11,880
Blacksmith	2	330	7,920
Helpers	12	120	17,280
	32		98,460
A-4-2) Electrical workshop			
Foreman	1	495	5,940
Electrical fitter	12	330	47,520
Electronicians	4	400	19,200
Helpers	4	120	5,760
	21		78,420
A-4-3) General service			
Foreman	1	495	5,940
Mason	2	330	7,920
Carpenters	4	260	12,480
Water supply	4	200	9,600
Vehicle driver	10	275	33,000
Helpers	5	120	3,000
	26		71,940
A-5) Paper bag making section			
Chief	1	600	7,200
Operators	12	280	40,320
Forklift drivers	3	250	9,000
Helpers	10	120	14,400
	26		70,920

B) Laboratory			
Manager	1	900	10,800
Chemist	8	330	31,680
Assistant	6	200	14,400
Routine worker	4	120	5,760
	19		62,640
Total of Production Division	314		1,069,320

Grand Total

Board + Business Division + Production Division

6 + 80 + 314 = 400 1,431,000

II. Various costs calculation for 1000 ton/day Plant

1. Infrastructure

   . Same as 1500 t/d Plant except residence

   . Residence

   Number of operator is in general in proportion to 1/4 Power of Plant Scale.

   $(1000/1500)^{0.25}$ x 400 persons = 361 persons

   361 x 0.8 = 290 houses

   290 houses x 60 m^3/house x 200 US$/$m^2$ x 1.2 = 4,200 x 10^3 US$

   (4,700 + 3,100 + 4,000 + 4,200) x 10^3 = 16,000 x 10^3 US$

2. Working capital

   1) Stock

   Suppose: stock is in proportion to plant scale,

   1,194,200 x 100/1500 = 800 x 10^3 US$

   2) Personnel expenses during test run & commissioning

   360 persons x 300 US$/M x 6 M = 650 x 10^3 US$

   Total (800 + 650) x 10^3 = 1,450 x 10^3 US$

3. Expenses before and after startOup

   Deducting 400 x 10^3 US$ only from consultant fee for construction in case of 1500 t/d Plant,

   (1,500 + 2,000 + 2,000) x 10^3 = 5,500 x 10^3 US$

4. Construction Cost

   100,000 x $(1000/1500)^{0.65}$ = 76,800 x 10^3 US$

   (including Quarry dep't cost: 3,000 x 10^3 x $(1000/1500)^{0.65}$

   = 2,300 x 10^3 US$)

5. Interest during construction period

- Same as the case of 1500 t/d Plant
- In the case of IRR - 3%: $99,750 \times 10^3 \times 0.16908 \times 0.3 =$ $5,060 \times 10^3$ US$

(Fixed Cost)

1. Depreciation

Depreciation for quarry dep't to be done separately.

Machineries	$74,500 \times 10^3 \times 0.7 \times 1/20$	$= 2,610 \times 10^3$ US$
Building and structure	$74,500 \times 10^3 \times 0.3 \times 1/40$	$= 560 \times 10^3$
Road	$4,700 \times 10^3 \times 1/10$	$= 470 \times 10^3$
Railway and water pipeline	$(3,100+4,000) \times 10^3 \times 1/20$	$= 355 \times 10^3$
Residence	$4,200 \times 10^3 \times 1/40$	$= 105 \times 10^3$
Working capital & general expenses	$(1,450+5,500) \times 10^3 \times 1/20$	$= 350 \times 10^3$
Interest of construction(IRR:3%)	$5,060 \times 10^3 \times 1/20$	$= 250 \times 10^3$
		$4,700 \times 10^3$ US$/year

2. Personnel expenses

360 persons x 300 US$/M x 12 M ≑ $1,300 \times 10^3$ US$/year

3. Administrative expenses

350×10^3 US$/year

(Direct Cost)

Use same unit rates as in case of 1500 t/d Plant.

1. Raw material cost

$4.83 \times 330,000$ ton $= 1,600 \times 10^3$ US$/year

2. Fuel cost

$5.92 \times 330,000$ ton $= 1,950 \times 10^3$ US$/year

3. Maintenance cost

$4.6 \times 330{,}000$ ton = $1{,}560 \times 10^3$ US$

4. Paper bag

$5.6 \times 330{,}000$ ton = $1{,}850 \times 10^3$ US$

5. Electric power

$2.82 \times 330{,}000$ ton = 930×10^3 US$

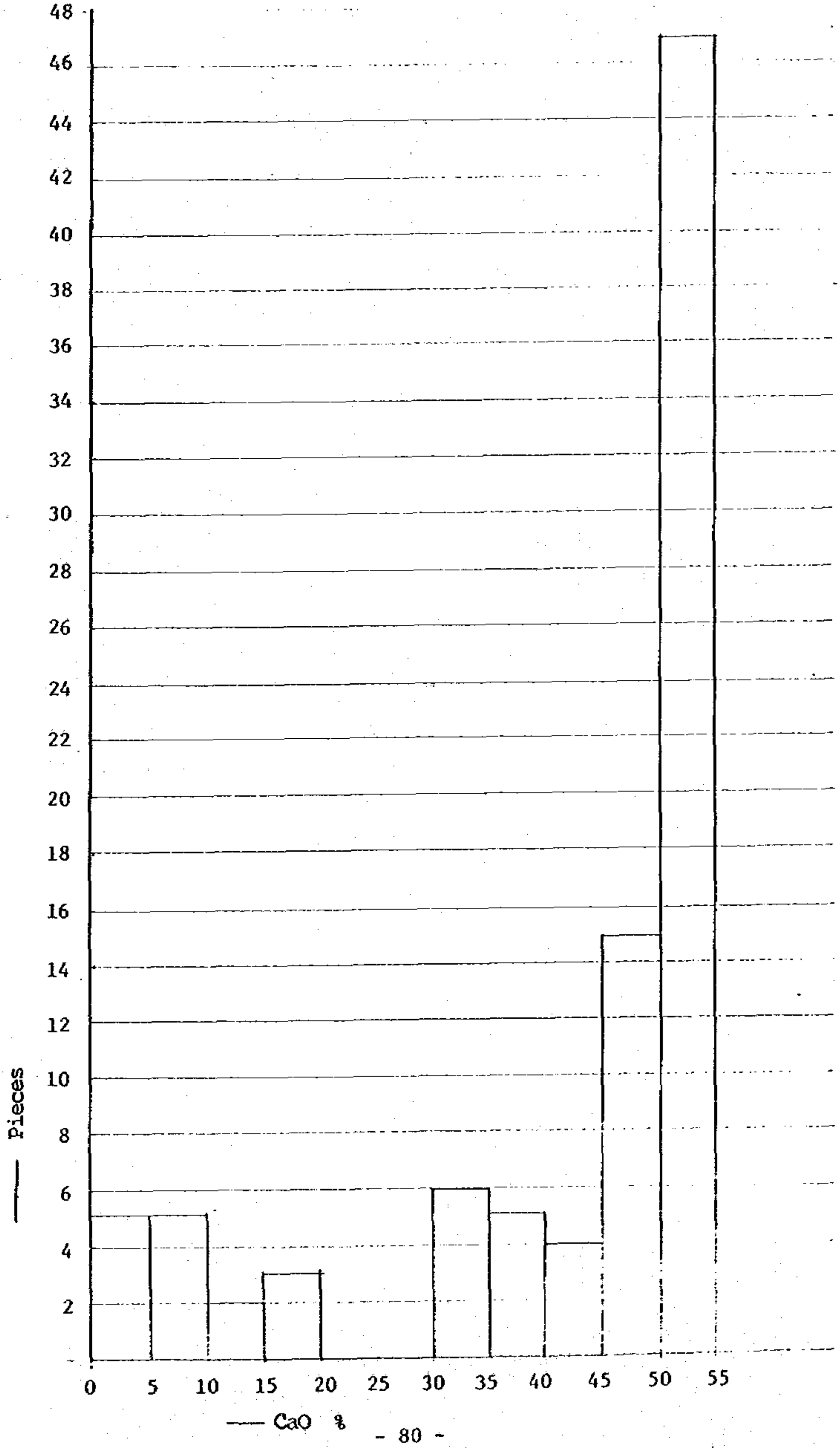
III. Chemical Analysis Data of Derudeb limestone

Comment on the chemical analysis data of Derudeb limestone, dated 18th February, 1979.

It is regretful that the said chemical analysis data did not accompany boring location map and boring log sheets which should be integral parts of a geological investigation. Therefore, we can not say much about the said data but the following:

1) As a whole, the quality of the limestone is good: i.e., CaO content is high and MgO content is relatively low.
2) Limestone which contains CaO more than 45% may be used for cement manufacturing provided that a process should be provided for homogenization of the limestone. 63 out of 92 samples shown in the analysis data are in accordance with the abovementioned specification.
3) Limestone which is a little inferior to the abovementioned specification may be used, if not much, too. But this must be studied further more taking into consideration the other chemical composition than CaO and MgO (i.e. SiO_2, Al_2O_3, etc.) of such limestone and the chemical composition of clayey materials to be used.

Number of Samples classified by CaO content



MINISTRY OF INDUSTRY AND MINING

GEOLOGICAL AND MINERAL RESOURCES DEPARTMENT

P.O. BOX 410,
KHARTOUM.

DERUDEB MARBLE DEPOSITS

CHEMICAL LABORATORY
FORM NO. 2

Laboratory Report No. 284............

The samples listed below have been analysed for the elements noted by A.A.S. & Grav. .... Methods. Results are expressed in parts per million/per cent.

(G.P.P. 56818) 12/73

Sample Number Lab.	Sample Number Sender	CaO	MgO	I.Lo	Insoluble	H_2O^-
GL. 6307	216/1	39.64	0.7	32.78	23.09	0.39
8	216/2	7.59	0.59	6.75	56.78	1.18
9	216/3	30.69	1.07	25.65	35.75	0.59
10	216/4	38.63	0.78	32.64	25.37	0.24
11	216/5	35.49	1.26	29.18	3.59	0.32
12	216/6	48.79	0.67	38.89	9.83	0.14
13	216/7	48.32	0.64	39.34	8.82	0.10
14	216/8	49.11	0.60	40.77	6.01	0.12
15	216/9	51.96	0.60	41.73	3.70	0.09
16	226/1	37.31	0.91	30.24	27.72	0.39
17	226/2	37.92	0.89	30.40	26.50	0.56
18	226/3	14.71	0.80	13.55	58.55	1.64
19	226/4	15.67	0.10	13.02	61.51	1.13
" 6320	226/5	7.22	0.80	5.30	80.72	0.53
21	226/6	8.61	0.73	6.02	78.21	0.83
22	226/7	4.92	0.66	0.59	76.50	2.56
23	226/8	34.23	1.10	28.07	29.38	1.01
24	228/1	50.66	1.39	41.55	3.93	0.16
25	228/2	51.41	0.95	42.27	2.70	0.13
26	228/3	51.37	0.93	43.46	1.41	0.10

Sender Ref. Abdelrhman Ibrahim

Analysed by Geol. Lab

Chief Chemist. [signature]

Date 18.1.1978

GEOLOGICAL & MINERAL RESOURCES DEPARTMENT
General Director Office
G/M/R
Date 18. 2. 1979

MINISTRY OF INDUSTRY AND MINING

GEOLOGICAL AND MINERAL RESOURCES DEPARTMENT

P.O. BOX 410, KHARTOUM.

DERUDEB MARBLE DEPOSITS

CHEMICAL LABORATORY

FORM NO. 2

Laboratory Report No. 284

The samples listed below have been analysed for the elements noted by A.A.S & Grav. Methods. Results are expressed in parts per million/per cent.

(G.P.P. 56318) 12/73

Sample Lab.	Number Sender	Cao		Mgo		I.L.O		InSoluble		- H_2O	
Gl. 6327	228/4	50.36		I.I9		42.73		2.56		0.08	
" 28	228/5	50.28		I.I4		41.28		4.32		0.16	
" 29	228/6	53.I9		0.90		44.05		I.07		0.06	
" 6330	228/7	52.72		0.66		42.58		I.73		0.08	
" 3I	228/8	52.56		0.91		43.03		2.06		0.09	
" 32	228/9	51.37		I.I2		42.05		2.52		0.08	

Locality : DERUDEB

DESCRIPTION limestone

Sender Rr Abdelrahman Ibrahim..

Analysed by Geol. Lab

Chief Chemist

Date 18.1.1978

GEOLOGICAL & MINERAL RESOURCES DEPARTMENT
General Director Office
G/M/R
Date 18.2.1979

MINISTRY OF INDUSTRY AND MINING

GEOLOGICAL AND MINERAL RESOURCES DEPARTMENT

P.O. BOX 410, KHARTOUM. | DERUDED MARBLE DEPOSITS | CHEMICAL LABORATORY FORM NO. 2

1

Laboratory Report No. 286..............

The samples listed below have been analysed for the elements noted by A.A.S. & Grav....... Methods. Results are expressed in parts per million/per cent.

(G.P.P. 56315) 12/73

Sample Lab.	Number Sender	CaO%	MgO%	L.I.%	Insoluble%	$-H_2O\%$
01. 6344	215 -2	49.75	0.48	41.89	2.14	0.13
" 5	-3	52.25	0.48	4231	2.59	0.15
" 6	-5	54.38	0.53	4345	0.95	0.16
" 7	-6	5438	0.50	43.40	0.97	0.14
" 8	-7	53.38	0.50	42.11	1.95	0.15
" 9	-8	5300	0.50	42.95	2.06	0.13
" 6350	-9	5338	0.55	4259	1.61	0.12
" 1	217 -1	44.13	0.63	39.25	1258	0.69
" 2	-2	5088	0.36	41.06	5.30	0.19
" 3	-3	51.13	0.56	4070	4.51	0.18
" 4	-4	53.75	0.75	40.98	437	0.16
" 5	-5	5313	0.86	42.31	1.97	0.14
" 6	-6	52.50	0.93	42.70	3.00	0.10
" 7	-7	5338	0.90	4265	2.78	0.10
" 8	-8	52.25	1.00	41.44	3.56	0.02
" 9	-9	52.50	0.91	42.19	2.31	0.14
" 6360	-10	52.38	0.86	42.92	2.14	0.13
" 1	218-1	5313	0.36	43.03	2.45	0.19
" 2	-2	5000	0.46	39.74	7.05	0.10
" 3	-3	52.25	0.38	40.64	3.82	0.17

Sender Ref. Gamal Abu Saif......

Analysed by Geol. Lab............

Chief Chemist. ....

Date ..12.2.1979

GEOLOGICAL & MINERAL RESOURCES DEPARTMENT
General Director Office
G/M/R
13. 2. 1979
Date

MINISTRY OF INDUSTRY AND MINING

GEOLOGICAL AND MINERAL RESOURCES DEPARTMENT

P.O. BOX 410,
KHARTOUM.

DERUDEB MARBLE DEPOSITS

CHEMICAL LABORATORY
FORM NO. 2

2

Laboratory Report No. 286............

The samples listed below have been analysed for the elements noted by .A.A.S.&.Grav......... Methods. Results are expressed in parts per million/per cent.

(G.P.P. 36818) 12/73

Sample Number Lab.	Sender	CaO%	MgO%	L.I. %	Insoluble %	H_2O %
Gl. 6364	218 - 4	54.13	0.30	42.92	2.66	0.09
" 5	- 5	45.00	0.56	38.05	11.14	025
" 6	- 6	53.53	0.30	41.58	3.51	0.19
" 7	- 7	48.63	0.46	38.39	7.95	0.19
" 8	- 8	46.88	0.70	33.02	15.10	0.25
" 9	- 9	51.10	0.40	39.63	4.13	0.19
" 6370	-10	54.13	0.32	41.43	3.64	0.10
" 1	219 - 1	54.25	0.43	42.45	0.28	0.10
" 2	- 2	54.75	0.43	42.43	1.15	0.12
" 3	- 3	54.75	0.37	42.97	0.74	0.18
" 4	-5	54.75	0.37	42.35	1.24	0.14
" 5	- 6	54.75	0.32	43.54	0.79	0.09
" 6	- 9	54.75	0.30	42.57	1.12	0.13
" 7	220 - 2	5.00	1.19	6.53	76.30	1.22
" 8	- 3	17.00	0.65	17.76	62.73	0.94
" 9	- 4	11.36	0.50	15.59	70.30	0.54
" 6380	- 5	4.48	1.39	6.09	73.46	1.28
" 1	- 6	5.00	0.36	6.46	76.25	0.70
" 2	- 7	5.75	1.18	7.41	75.38	1.18
" 3	- 2	5.82	1.19	7.40	72.31	1.19

Sender Ref. Gamal Abu Saif......

Analysed by Geol Lab............

Chief Chemist

Date 12.2 1979

GEOLOGICAL & MINERAL RESOURCES DEPARTMENT
General Director Office
G/M/R 18.2.1979
Date

MINISTRY OF INDUSTRY AND MINING

GEOLOGICAL AND MINERAL RESOURCES DEPARTMENT

P.O. BOX 410,
KHARTOUM.

DERUDEB MARBLE DEPOSITS

CHEMICAL LABORATORY
FORM NO. 2

Laboratory Report No. 286

3

The samples listed below have been analysed for the elements noted by A.A.S & Grav. Methods. Results are expressed in parts per million/per cent.

(C.P.P. 36318) 12/74

Sample Number Lab.	Sample Number Sender	CaO	MgO	I.L.O	Insoluble	H_2O
Gl. 6384	221 - I	52.82	0.40	42.89	I.97	0.08
" 5	- 3	50.75	0.6I	41.39	7.52	0.I9
" 6	- 5	50.00	0.66	40.I	5.07	0.27
" 7	- 6	52.38	0.50	42.79	I.43	0.I0
" 8	- 7	50.63	0.50	40.43	4.27	0.20
" 9	- 8	50.00	0.6I	40.08	5.84	0.I8
" 6390	- 9	50.25	0.63	39.96	4.94	0.I2
" I	222 - I	52.50	0.46	41.53	2.72	0.09
" 2	- 2	50.75	0.56	40.54	3.77	0.I7
" 3	- 5	44.25	0.96	35.82	3.33	0.49
" 4	- 6	53.00	0.58	42.22	3.04	0.I3
" 5	- 7	49.88	0.66	39.23	4.40	0.I7
" 6	223 - I	49.50	0.56	40.I0	5.36	0.I8
" 7	- 2	42.25	0.60	35.33	8.25	0.26
" 8	- 3	49.00	0.53	39.54	6.60	0.I8
" 9	- 4	31.25	0.46	25.42	3.79	0.I3
" 6400	- 7	2.25	0.86	2.33	86.75	0.09
" I	- 9	2.00	0.7I	2.I9	83.29	0.09
" 2	227 - I	49.25	0.32	39.46	8.08	0.I2
" 3	- 3	51.I3	0.32	40.42	5.59	0.20

Sender Ref. Gemal Abu Saif

Analysed by Geol. Lab

Chief Chemist ...

Date 12.2.1979

GEOLOGICAL & MINERAL RESOURCES DEPARTMENT
General Director Office
G/M/R
Date 18.2.1979

MINISTRY OF INDUSTRY AND MINING

GEOLOGICAL AND MINERAL RESOURCES DEPARTMENT

P.O. BOX 410, KHARTOUM.

DERUDEB MARBLE DEPOSITS

CHEMICAL LABORATORY
FORM NO. 2

4

Laboratory Report No. 286.............

The samples listed below have been analysed for the elements noted by A.A.S. & Grav. .... Methods. Results are expressed in parts per million/per cent.

(G.P.P. 56818) 12/73

Sample Number Lab.	Sample Number Sender	CaO		MgO		I.L.O		Insoluble		$-H_2O$	
G1. 6404	227 - 4	38.00		0.46		29.17		25.59		0.19	
" 5	- 5	46.13		0.35		35.84		20.66		0.09	
" 6	- 6	42.13		0.38		36.2		15.87		0.10	
" 7	- 7	47.50		0.33		35.34		14.79		0.10	
" 8	- 8	52.38		0.32		35.03		7.20		0.07	
" 9	- 9	38.5		0.35		35.26		15.97		0.07	

Locality DERUDEB

Description Limestone

Sender Gamal Abu Saif

Sender Ref. Gamal Abu Saif.....

Analysed by Geol. Lab.........

Chief Chemist ....

Date 12.2.1979

GEOLOGICAL & MINERAL RESOURCES DEPARTMENT
General Director Office.
G/M/R
Date 12.2.1979

JICA