JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE REPUBLIC OF YEMEN

YEMEN GENERAL CORPORATION FOR CEMENT INDUSTRY & MARKETING

FEASIBILITY STUDY
ON
THE EXPANSION PROJECT
OF
MAFRAQ CEMENT PLANT

SUMMARY

NOVEMBER, 1992

OSAKA CEMENT CO., LTD.

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CONTENTS

1. Background and Objective of the Study

Taking into consideration that even adding up the new production capacity by Mafraq Cement Plant now under construction to be commissioned in 1993 to the present cement supply capacity will not meet the demand for the enhancement of infrastructure in the wake of the unification of the North and South Yemen.

In order to take care of the increasing demand in the southern area adjacent to which Mafraq Cement Plant is located, expansion of this plant was given the top priority by the Yemen Government. In accordance with the official request made to the Japanese Government for the feasibility study, this study has been commenced since March, 1992.

Objective of this study is to analyze the technical and economic possibility of the expansion of the plant production capability from 500,000 Ton/Y to 1,000,000 Ton/Y.

2. General Aspects of the Project

1) Outline of the Country

Republic of Yemen was born in May, 1990 in the wake of the Unification of Yemen Arab Republic (North Yemen) and People's Democratic Republic of Yemen (South Yemen) and its geographic location is at the south-east end of the Arabian Peninsula.

2) Present Situation of the Economy

Present political as well as economic situation of the Country has brought about some problems in the midst of the unification process. However, it is strongly expected that oil development will activate the economy and in the long run investments for even other industrial sectors, especially private ones than the oil industry are also planned.

3) Government Policy of the Cement Industry

The Yemen Government puts the strongest emphasis on the development of the cement industry in order to solve the severe shortage of cement and the following side-effect to be generated from the cement industry development:

1. Domestic natural resources can be utilized.

2. Considerable Import Substitution effect which directly leads to the trade balance improvement.

3. Creation of new employment opportunities

4. Infrastructure will be enhanced.

4) Necessity of Mafraq Expansion Plant

Cement production capacity in Yemen is presently 800,000 T/Y, against which consumption in 1984 as the record year was more than 2,500,000 T/Y. The gap between the supply and demand is obliged to resort to the cement import. Furthermore, taking into consideration the predicted demand increase for the enhancement of infrastructure such as public facilities, housings, roads and so on, even after the Mafraq Cement Plant now under construction comes into operation with its additional supply of 500,000T/Y, cement import will still be inevitable.

Especially to meet the increasing demand in the southern area such as Taiz and Ibb, both are No.2 and No.3 largest cement market in the Country and the adjacent ex-South Yemen area, expansion of Mafraq Cement Plant shall be given the top priority.

3. Study on the Cement Market

1) Present Situation of the Cement Industry

Two cement plants are now operating in Yemen which are: Bajil Cement Plant (Operation started in 1976, production capacity 300,000 T/Y) and Amran Cement Plant (Operation started in 1982, production capacity 500,000 T/Y). Both plants cover 30 - 50% of the demand, the rest of which is covered by the import.

A new plant is now under construction, which is Mafraq Cement Plant, with the production capacity of 500,000 T/Y. This plant will start its operation in 1992.

2) Demand and Supply

Cement demand in Yemen was high after 1970' and was intensified in 1983 and 1984 for the sake of restoration of earthquake damage in Dhamar. Thereafter it suddenly declined in 1987, which however did not mean actual decrease of cement demand and considerable potential demand which was beyond the actual consumption must have existed.

South Yemen has had no cement factory and about 200,000 T/Y cement has been imported.

3) Demand forecast

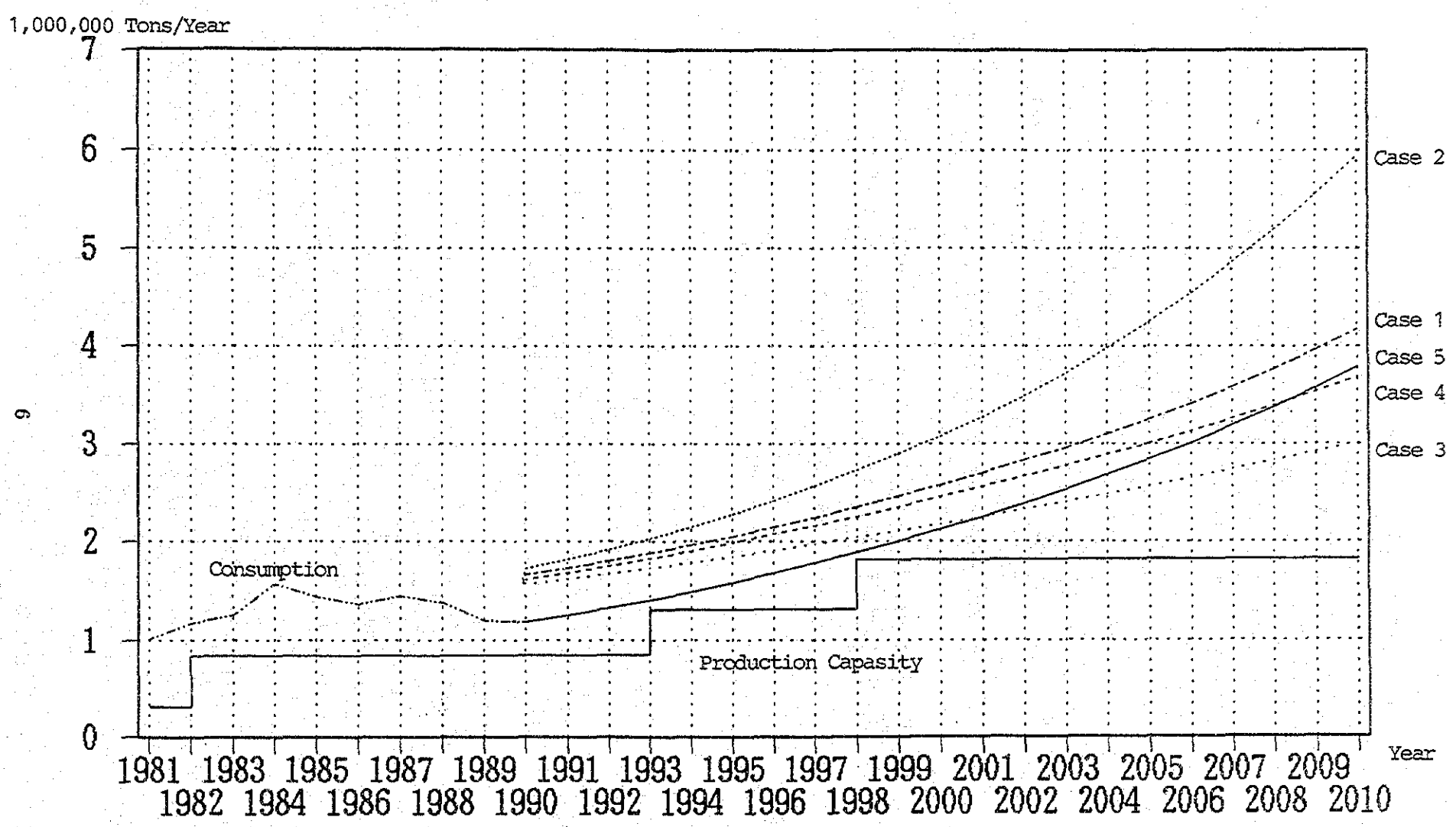
Future cement demand after the unification of the Country is , as seen in Figure 3.1, showing steady increase and demands in highlight years in the simple forecast (case 5) are :

1995	1,586,000 T/Y
1998*	1,889,000 T/Y
2000	2,122,000 T/Y
2005	2,840,000 T/Y

* Expansion work is supposed to be completed.

Housing purpose accounts for the highest demands of which figure in this field reaches 2,959,000 T/Y.

Figure 3-1 Demand Forecast Graph

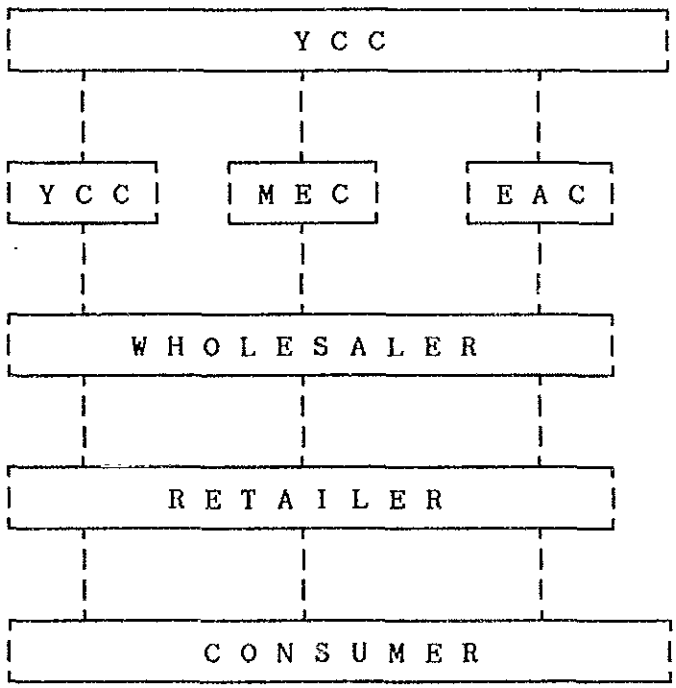


4) Cement Distribution

Distribution route in Yemen varies between domestic product by YCC and import cements.

Figure 3-2 shows that domestic products have two routes one of which is through wholesale and retail sale to the consumers, the other is directly to the consumers.

Import cement is delivered directly to the consumers from the unloading port.



MEC : Military Economic Corp
EAC : Employee's Association Corp

Figure 3-2 Cement Distribution Flow

4. Study of the Existing Cement Plant

1) Amran Cement Plant

Amran cement plant was constructed in 1982.
The up-dated plant with 500,000 tons annual production capacity was completed on schedule. Since full capacity production was achieved after the completion of the plant, the Japanese technical performance which was executed plant construction has been highly evaluated.
Stable operation has been kept since then, except in 1985 and 1986, when there were frequent stoppage due to the shortage of spare parts, heavy oil and diesel oil.
Especially maximum production has recorded in recent two years by reason of spare parts were supplied sufficiently, so that the technical level of plant will be established highly.
And also cement quality is kept to be at a more than average level in the world as well.

2) Bajil Cement Plant

Bajil cement plant was constructed in 1973 by the technical assistance of Soviet Union.
The plant was designed by old type wet process and annual cement production of 300,000 tons was produced by two kilns' operation. Plant operation has been achieved almost their target value, while they were troubled with the shortage of spare parts.

Annual Cement Production of Recent 10 Years

(unit: tons)

	Amran Plant	Bajil Plant
1981	---	86,000
1982	154,700	87,000
1983	529,300	94,000
1984	519,100	184,000
1985	412,500	286,000
1986	418,100	289,000
1987	475,500	299,000
1988	501,400	303,000
1989	453,700	251,000
1990	553,800	274,000
1991	553,100	294,000

5. Mafraq Cement Plant Construction

Mafraq cement plant started its plant construction in January, 1990 under Basse Sambre/E.R.I., Belgium as the consultant and Ishikawajima Harima Heavy Industries, Japan as the contractor.
Construction work is going on schedule generally, and it is scheduled to start commissioning in November, 1992 and commercial production will be planned in March, 1993.
Construction work is executed in Full Turn Key Basis including whole production equipment from raw material quarry opening to produced cement dispatch, supporting facilities such as office, canteen and spare parts and consumables store, and housings for plant employees.
Japanese government soft loan is financed for the construction investment.

Main specification of the production equipment are as follows.

Production

Clinker Production	: 1,700 T/D
Cement Production	: 500,000 T/Y

Main specification

Limestone Crushing	: Hammer Crusher 500 T/H
Limestone Storage	: Prehomogenizing Bed 2 x 20,000T
Raw Material Grinding	: Vertical Roller Mill 135 T/H
Raw Meal Homogenizing	: Continuous Blending Silo 2 x 3,800T Storage Silo 1 x 1,200T Blending Silo
Clinker Burning	: Dry Short Kiln with Preheater and Precalciner 1,700 T/D
Clinker Storage	: Concrete Silo 2 x 8,500T

Cement Grinding	: Closed Circuit Compound Mill 90 T/H
Cement Storage	: Concrete Silo 4 x 7,000T
Cement Packing	: Rotary Packer 100 T/H x 3
Supply of Utilities	
Electric Power	: Supplied from Al-Barh Substation by P.E.C.
Water	: Supplied from Wells Surrounding Plant
Fuel Oil	: Supplied from Mareb Oil 1 Refinery by Tank Lorry

6. Raw Materials and Utilities for Expansion Project

1) Raw Materials

Three kinds of raw material (limestone, volcanic rock and sandstone) are provided for the existing Mafraq cement plant. These raw materials can be also used for the expansion line operation.
The life of each raw material when 2 lines are operated is estimated and the results are as follows.

Raw material	Confirmed ore reserves (Million tons)	Mixing ratio (%)	Consumption unit (T/T-Cl)	Annual consumption (x 1000T)	Life (Year)
Limestone	*47.0	89.66	1.409	1,409	33.4
Volcanic rock	1.9	10.34	0.163	163	11.7
Sandstone	1.2	0.00	0.00	Very small quantity	

* The confirmed ore reserves of limestone (47 MT) is estimated in limited area. (The northern part of the trench)

It is possible to obtain the ore reserves for 2 kiln lines operation by the method mentioned as follows;

- Limestone: Mining area next to the south side of the trench shall be exploited.
- Volcanic rock: Mining area next to the north side of the planing area for 1st 500,000t plant shall be exploited.

2) Water Supply

As the shallow layer ground water surrounding area of the plant is annually and seasonally unstable, it is urgently required to develop deep layer ground water for securing a stable water source of plant operation. As the results of preliminary site investigation, the development should be moved forward in terms of the following priorities.

First Priority : Twilash sandstone, found in the western Habashi mountains.

Second Priority : The fracture zone, accompanied by the fault of Amran/= limestone and Yemen Volcanic along Wadi Ar Rub.

(Refer to attached location map. of Figure 6-12)

Flow Chart of Development of Deep Layer Ground Water

Preliminary Investigation (Investigation for Development) --> Hydrogeological Investigation --> Test Boring Investigation

|
V

Integrated Investigation <-- Design of Water Source <-- Construction of Water Source (Execution of Construction)

3) Electric Power Supply

As the electric power supply from Al-Barh substation for both of existing and expansion plant is not sufficient, required electric power for expansion plant is supplied from diesel power generating plant which is constructed as the part of expansion project.

Main Specification of Power Plant

Capacity	- Normal Operation	18,750 kVA (6,250 KVA x 3 sets)
	- Maximum Operation	25,000 kVA (6,250 KVA x 4 sets)

4) Fuel Oil Supply

Expansion plant as well as existing plant is used heavy oil as fuel oil.

Heavy oil is supplied by tank lorry truck to the plant from Mareb oil refinery.

LEGEND

(1:50,000)

- A — Mafraq Cement Plant and Housing area
- Material Quarry for plant
- Unsuccessful exploratin boring point
- But, one of them has a possivility of development well
- Under-construction shallow dug-well(4.5 m)
- Arrangement of purchase an existing dug-well(6.4 m)
- Design of a dug-well construction(50 m)
- First priority recommendable developing area(Tawilah S.S)
- Second priority recommendable developing area

Figure 6-12

LOCATION MAP

MAORANAH

7. Expansion Plant

Clinker Production : 500,000 T/Y (1,700 T/D)
Cement Production : 550,000 T/Y

Expansion plant is constructed adjacent to existing plant. The plant is applied same NSP process of existing plant and considered exchangeability of existing and expansion.
Expansion plant include not only production equipment but also utilities supply such as electric power and water, supporting facilities such as office and store, and housing for plant employees.

Main Specification of the Equipment:

Production Equipment	101.	Limestone Quarry	: Supply of a part of the equipment
	102.	Volcanic Rock and Sandstone Quarry	: Supply of a part of the equipment
	111.	Limestone Crushing	: Hammer Crusher (New) 500 T/H
	112.	Additive Crushing	: Use existing equipment
	113.	Limestone Mix Bed	: Preblending Bed (New) 2 x 20,000T
	114.	Additive Handling	: Front End Loader (New)
	115.	Gypsum Handling	: Use existing equipment
	121.	Raw Meal Grinding and Drying	: Vertical Roller Mill (New) 135 T/H
	122.	Raw Meal Homogenizing and Storage	: Storage Silo 3,800T (New) Homo. Silo 1,200T (New)

	201.	Clinker Burning	: Dry Short Kiln with Preheater & Precalciner (New) 1,700 T/D
	202.	Clinker Handling and Storage	: Concrete Silo (New) 8,500T
	211.	Cement Grinding	: Closed Circuit Mill (New) 90 T/H
	212.	Cement Handling and Storage	: Use existing equipment
	222.	Cement Packing	: Rotary Packer (New) 100 T/H x 1
	223.	Cement Delivery	: Truck Loading (New) : 2,200 Bags/H
	224.	Bulk Cement Loading	: Loading Spout (New) 100 T/H
Utility Supply	301.	Water Storage, Treatment & Distribution	: New Installation Water Treatment Process Water System Boiler Water System
	302.	Compressed Air Production & Distribution	: Compressor (New)
	303.	Heavy Fuel Oil Storage & Distribution	: New Installation Storage tank 2,500 m^3 Steam Boiler
	304.	Diesel Oil Storage and Distribution	: Oil Transfer Pump (New)
Auxiliaries	314.	Fire Fighting Equipment	: Expansion of existing equipment
	506.	Garage	: New Installation Maintenance of vehicles
	602.	Laboratory Automation	: New installation Auto Sampling, X-ray analyzer
Civil Engineering and work	402.	Production Building and Support	: New installation of civil work of production equipment

Supporting Facilities	New installation	: Office and Car Parking Canteen and Toilet Spare parts and consumables store, Refractory store
Power Plant	New installation	: Generators Diesel Engines Generator Panel
Water Supply	New installation	: Deep well Submerged water pump
Housings	New installation	: Housings C type 8 flats C1 type 20 flats F type 150 flats Common Facilities Drinking water treatment Substation Drainage and Sewage

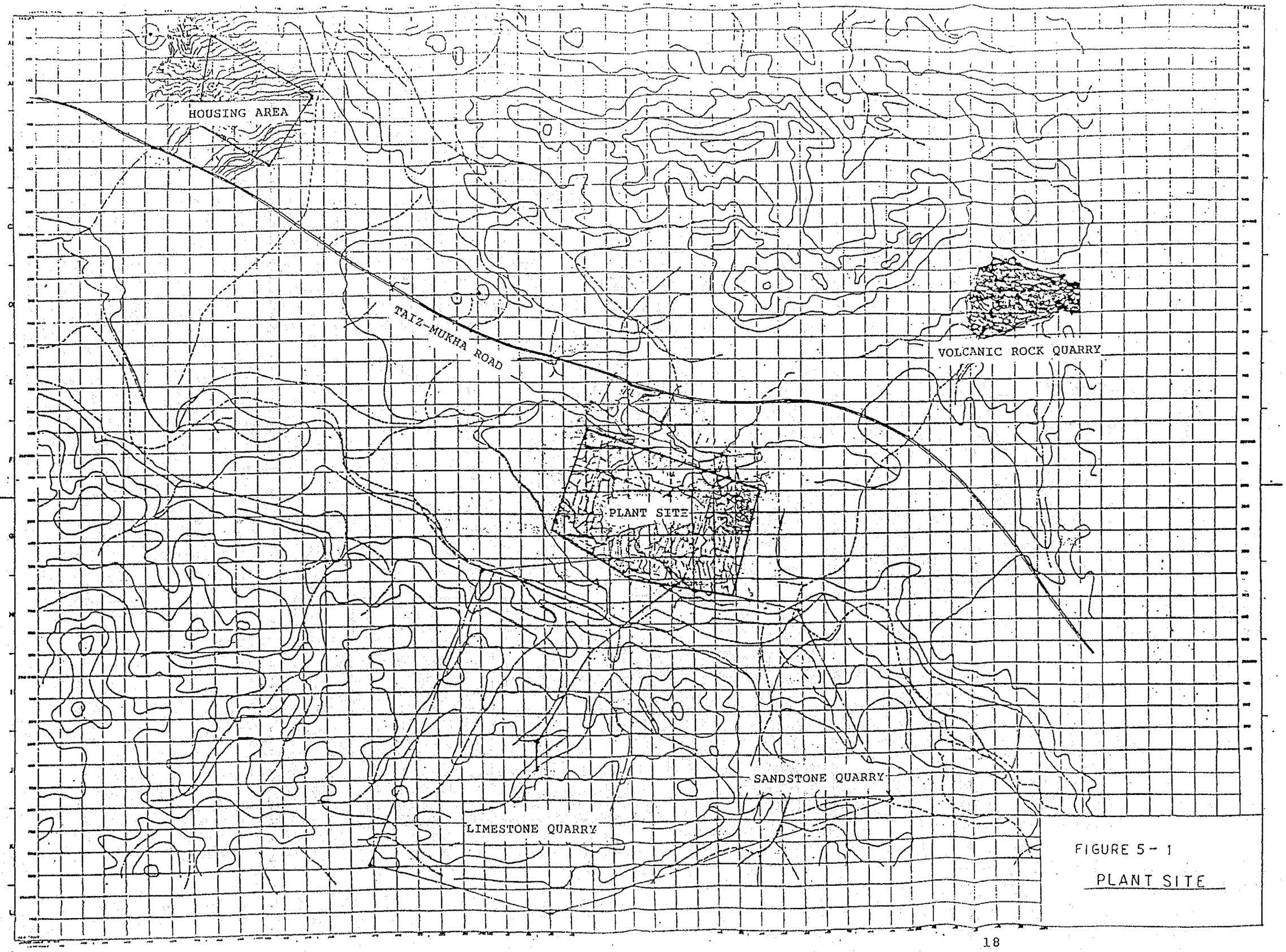
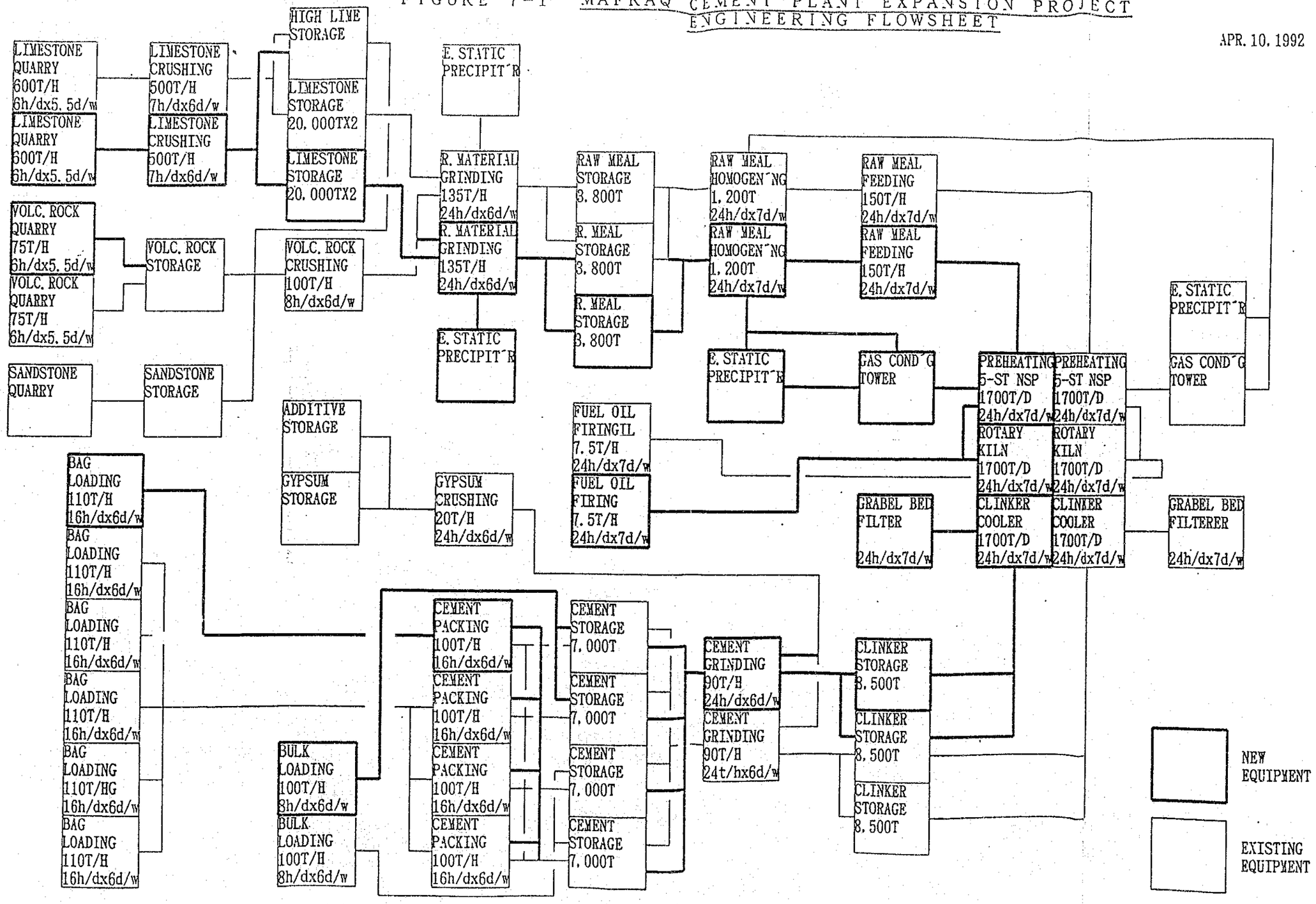


FIGURE 5 - 1

PLANT SITE

FIGURE 7-1 MAFRAQ CEMENT PLANT EXPANSION PROJECT
ENGINEERING FLOWSHEET

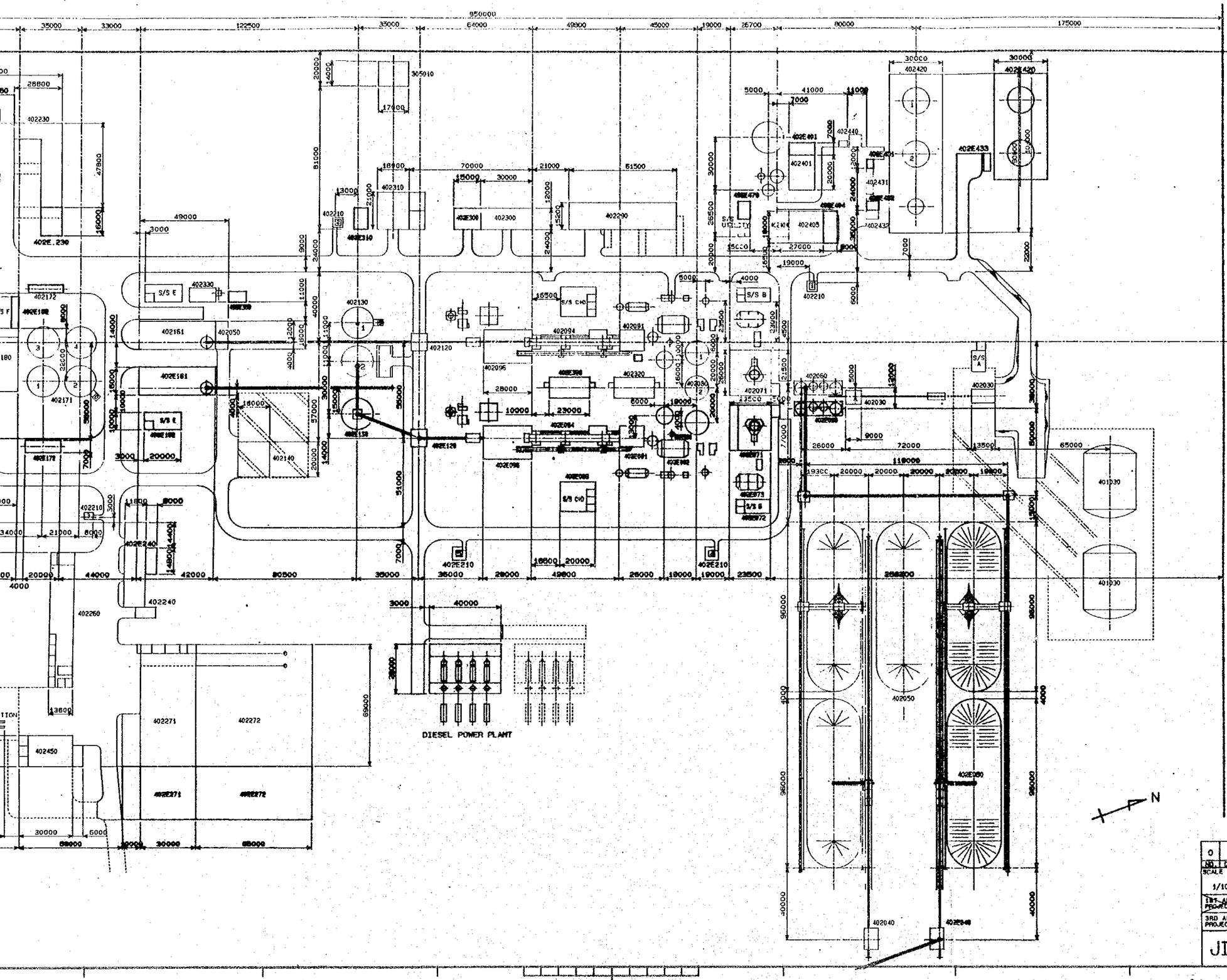
APR. 10. 1992



BASE POINT

VEHICLE WASH STATION

DIESEL POWER PLANT



BUILDING NUMBER	DENOMINATION
401030	ADDITIVES & HIGH GRADE LIMESTONE STORAGES
402030	ADDITIVES CRUSHING BUILDING
402040	SAMPLING STATION
402050	STACKER & RECLAIMER
402060	RAW MATERIAL HOPPERS
402071	RAW MATERIAL GRINDING BUILDING
402080	RAW MEAL HOMOGENIZING & STORAGE SILOS
402091	PREHEATER & PRECALCINER BUILDING
402094	KILN
402096	BURNER PLATFORM & CLINKER COOLER BUILDING
402120	CLINKER SURGE BIN
402130	CLINKER STORAGE SILOS
402140	GYPSUM STORAGE
402150	GYPSUM CRUSHING
402161	CEMENT GRINDING BUILDING
402171	CEMENT STORAGE SILOS
402172	CEMENT BULK LOADING
402180	CEMENT PACKING BUILDING
402190	CEMENT LOADING BUILDING
402200	GATE HOUSE
402210	TOILET BLOCK
402220	WEIGHING BRIDGES
402230	ADMINISTRATION BUILDING
402240	CANTEEN SHOWER & LOCKER ROOM, FIRST AID
402260	WORKSHOPS
402271	WAREHOUSE
402272	OPEN AIR FENCED STORAGE YARD
402280	CAR PARKING
402290	LABORATORY & CENTRAL CONTROL
402300	REFRACTORIES STORAGE
402310	MAIN SUB STATION
402320	COMPRESSER ROOM FOR RAW MILL AREA
402330	COMPRESSER ROOM FOR CEMENT STORAGE AREA
402401	WATER TREATMENT PLANT
402404	COOLING WATER PUMP HOUSE
402405	WATER BASINS
402420	LIQUID FUEL STORAGE TANKS
402431	LIQUID FUEL PUMPING HOUSE
402432	BOILER HOUSE
402440	PETROL & DIESEL OIL FILLING STATION
402450	GARAGE

BUILDING NUMBER	DENOMINATION
402E040	SAMPLING STATION
402E050	LIMESTONE MIX BED
402E060	LIME & ADDITIVE HOPPER
402E071	RAW MILL GRINDING BUILDING
402E072	SUBSTATION B
402E073	EP ELECTRIC ROOM
402E080	HOMO.& STORAGE SILOS
402E091	PREHEATER
402E092	EP ELECTRIC ROOM
402E093	SUBSTATION C+D
402E094	ROTARY KILN
402E096	BURNER PLATFORM
402E120	CLINKER SURGE BIN
402E130	CLINKER SILO
402E161	CEMENT GRINDING BUILDING
402E162	SUBSTATION E
402E172	CEMENT BULK LOADING
402E182	SUBSTATION F
402E210	TOILET BLOCKS
402E230	ADMINISTRATION BUILDING
402E240	CANTEEN
402E271	WAREHOUSE
402E272	OPEN AIR FENCED STORAGE AREA
402E280	PARKING CANOPY
402E300	STORAGE OF REFRACTORIES
402E310	EMERGENCY D/G ROOM
402E320	COMPRESSER ROOM FOR RAW MILL AREA
402E330	COMPRESSER ROOM FOR CEMENT STORAGE AREA
402E401	WATER TREATMENT
402E404	COOLING WATER PUMP HOUSE
402E420	LIQUID FUEL STORAGE TANKS
402E431	LIQUID FUELS PUMP HOUSE
402E432	BOILER HOUSE
402E433	LIQUID FUEL PUMP HOUSE
402E470	UTILITY SUBSTATION

FIGURE 7-2

NO.	DATE	DESCRIPTION	DRAWN	DESIGNED	CHECKED	APPROVED
0						

SCALE 1/1000

1ST ANGLE PROJECTION

3RD ANGLE PROJECTION

MAFRAQ CEMENT PLANT
EXPANSION PROJECT
PLOT PLAN

JICA

JOB NO.

DRAWING NO.

REV.

8. Implementation of Expansion Project

1) Implementation Plan

Followings are typical steps for the implementation of the project.

1. Raising funds required
2. Consultant service
3. Execution of construction

Implementation schedule : 36 months from the contract of construction to the completion of the construction (Refer to attached schedule.)

2) Consultant Services

Roles of consultant services is basically as follows.

Phase 1 : Preparation of tender documents
- (1) Determination of process and design
- (2) Preparation of tender documents

Phase 2 : Selection of Contractor
- (1) Evaluation of tenderer's proposal
- (2) Assistance of contract negotiation

Phase 3 : Supervision of plant construction work
- (1) Service in main office of consultant
- (2) Service at plant site

Additional: Investigation of water source

3) Enhancement of Man-Power and Organization

Basically alteration of organization is not considered for the expansion project, however, number of workers for operation and maintenance are increased due to the expansion of plant machineries. (Refer to attached organization chart.)

4) Training and Technical Assistance

In order to keep the stable and continuous plant operation, following technical assistance are executed.

Training prior to the plant operation

Abroad training	:	9 trainees	2 months
Site training	:	40 trainees	1-3 months

Technical assistance after plant operation

Dispatched key personnel	7 personnel	1 year

FIGURE 8-1

MAFRAQ CEMENT PLANT EXPANSION PROJECT

IMPLEMENTATION SCHEDULE

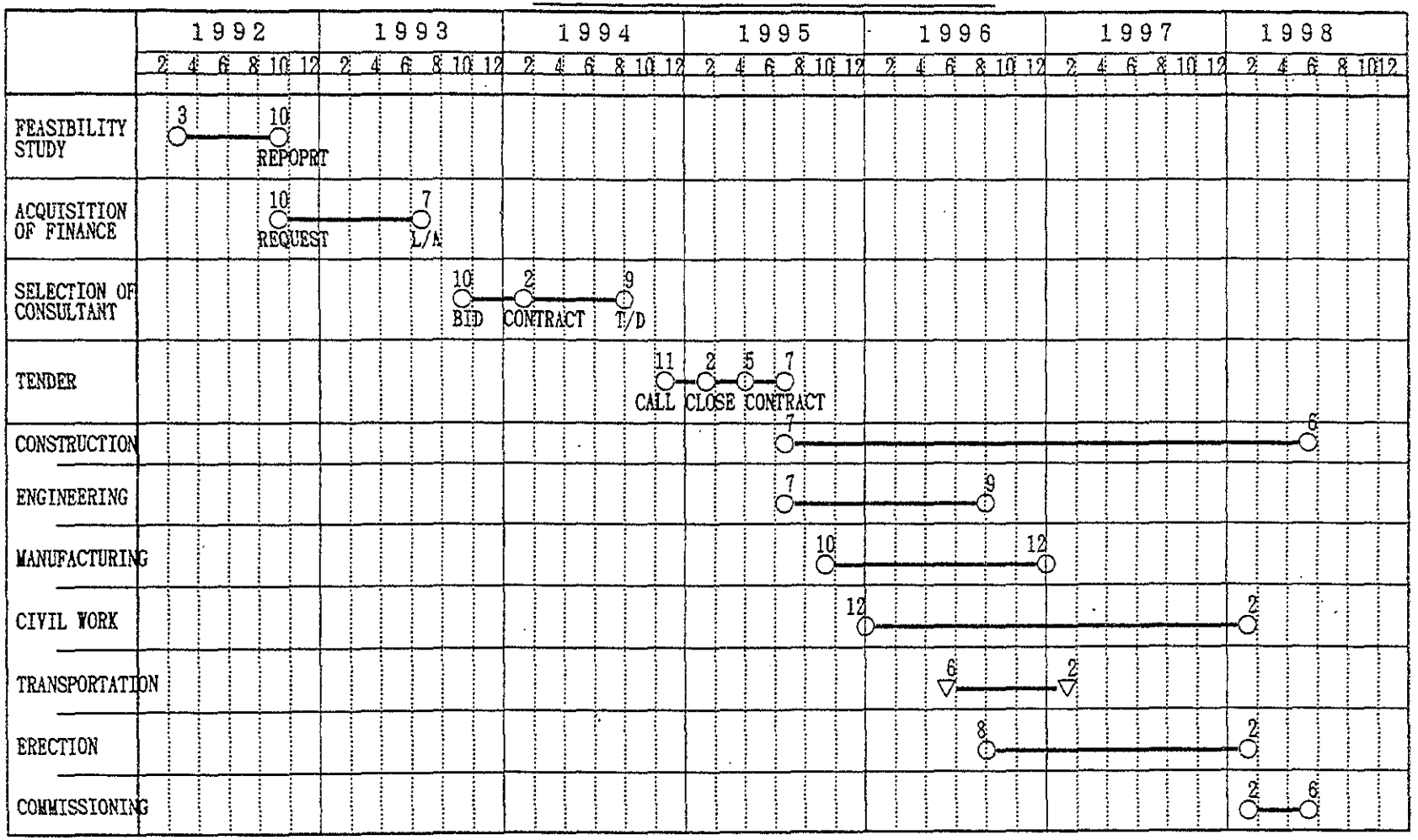
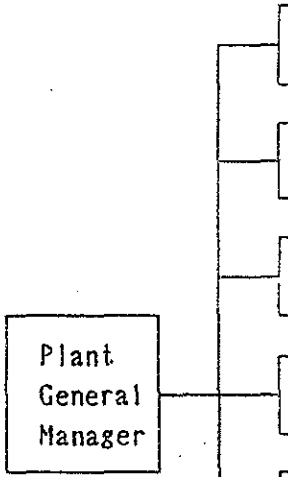


Figure 8-2
Organization Chart of Mafraq Cement Plant



	Number of employees for 1st line	Number of employees required after expansion	Number of additional employees
Administration Dept.	15	15	0
Sales Dept.		15	0
Accounting Dept.	15		
Production Dept.	438	705	267
Procurement Dept.	20	20	0
Security Office			
Housing Estate Maste			
Total	488	755	267

9. Environmental Assessment

Although there are not any related laws and regulations about environmental protection in The Republic of Yemen at present, Environment Protection Council (E.P.C) is formed and is carrying out the government policy. The following four points are thought of Environmental protection in the cement industry.

- Air pollution control
- Water pollution control
- Noise and vibration control
- Industrial waste disposal

Mafraq cement expansion plant same as existing plant under construction will be carried on environmental protection as follows.

(1) Air Pollution Control

Electrostatic precipitators and bag filters, etc. are installed to prevent emission of dust.
Also, NSP type kiln, which will keep low the level of NOx is equipped with. SOx emission will be extremely low because SOx is absorbed by limestone used in cement raw material.

(2) Water Pollution Control

Most of the water used in the plant is cooling water for the equipment and a closed circuit water system is applied.
As the polluted water such as living waste water is designed to be disposed of through water treatment equipment, it is considered no problem will happen.

(3) Noise and Vibration Control

It is very effective if the plant layout is given consideration or the big rotating machines, which are thought to be what cause the occurrence of noise and vibration, are installed inside buildings or on hard ground.

(4) Industrial Waste Disposal

The waste disposal discharged in the plant is desirable to be recycled to raw materials or fuel as much as possible.

The alkali by-pass dust which is one of the difficulty at Amran plant, shall be recycled to be mixed into cement clinker.

10. Financial and Economic Analysis

1) Basis Condition of the Analysis

(1) Currency : Yemen Rials (YR)
(2) Conversion Rate : US$=YR12.02, US$=YEN130,
YR1=YEN10.82
(3) Project Period : 20 years after operation start
(4) Cement sales Price : YR1,600/T

2) Total Investment Amount

(1) Total Investment Amount : YR3,327,000,000-
(Excl. Interest During Construction)

3) Fund Sources

(1) Long Term Loan

Case 1 : Interest Rate 1.5 %
Repayment 30 Years
(Incl.10 Years of Grace)

Case 2 : Interest Rate 8.0 %
Repayment 10 Years
(After operation start)

(2) Short Term Loan (Local Fund) : YCC own fund

4) Production Costs

(1) Calculation Basis : i. Costs are based on 1992 Mar. Price

ii. Production for 1st year is 400,000T/Y, 2nd year 450,000T/Y 3rd year on wards is 500,000T/Y

(2) Direct Cost : Raw materials, fuel electricity etc : YR347.4/t-cement

(3) Fixed Cost : Salaries/Wages, Depreciation etc : YR433.4/t-cement

Production Cost Total : YR780.8/t-cement

5) Internal Rate of Return

(1) Financial Internal Rate of Return(FIRR) is as follows:

	Long Term Loan	
	Case 1	Case 2
Interest Rate	1.5%	8.0%
FIRR(After tax)	11.8%	12.1%
FIRR(Before tax)	14.2%	13.8%
Payback Period		
(After tax)	7.3years	6.9years
(Before tax)	6.3years	6.5years

(2) Evaluation

FIRR figure of 11.8% in case of Case-1 shows the sound financial profitability of the project.

6) Sensitivity Analysis

Results in case of Long Term Loan Case No.1 are as follows:

(1) In case cement price is reduced by 10%

	FIRR	Payback Period
(After tax)	10.0%	8.3years
(Before tax)	11.9%	7.3years

(2) In case direct production cost is increased by 10%

	FIRR	Payback Period
(After tax)	11.4%	7.5years
(Before tax)	13.7%	6.5years

(3) In case plant construction cost is increased by 10%

	FIRR	Payback Period
(After tax)	10.6%	7.9years
(Before tax)	12.8%	6.9years

(4) In case start of the plant operation is delayed by 1 year

	FIRR	Payback Period
(After tax)	10.6%	7.3years
(Before tax)	12.6%	6.4years

(5) In case investment amounts of "Supporting Facilities", "Utility Supply" and "Housing Facilities" are deleted from the Total Investment Amount

	FIRR	Payback Period
(After tax)	16.3%	5.5years
(Before tax)	19.6%	4.7years

7) Economic Analysis

Economic Internal Rate of Return(EIRR) of 15.4% was obtained. by judging this figure together with the points of possible improvement of trade balance by import substitution and creation of new employment opportunities, it is reasonable considered that this project is sufficiently feasible from the State's stand point of view.

11. Conclusions and Recommendations

1) Demand Forecast

Forecasted figure in 1998 will be 1,889,000 Ton/Y in pessimistic demend forecast, whereas, in case this expansion project is not considered, total supply capacity is 1,300,000 Ton/Y. Even this project is considered, total supply capacity amounts only to 1,800,000 Ton/Y.

2) Financial and Economic Analysis

Financial Internal Rate of Return(FIRR) of 11.8% and Economic Internal Rate of Return(EIRR) of 15.4% were obtained. Both figures show the soundness and good profitability of the project.

3) Recommendations

In order to cope with the cement shortage situation even after Mafraq Cement Plant under construction starts its operation as soon as possible, the earliest possible realization of the expansion project carefully considered for Environmental Protection is hereby strongly recommended.