THE FEASIBILITY STUDY REPORT

ON

THE ESTABLISHMENT OF THE INTEGRATED POWER AND CEMENT FACTORY USING OIL SHALE

IN

THE KINGDOM OF THAILAND

(SUMMARY)

AUGUST, 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

THE FEASIBILITY STUDY REPORT

ON

THE ESTABLISHMENT OF THE INTEGRATED POWER AND CEMENT FACTORY USING OIL SHALE

IN

THE KINGDOM OF THAILAND

(SUMMARY)

AUGUST, 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

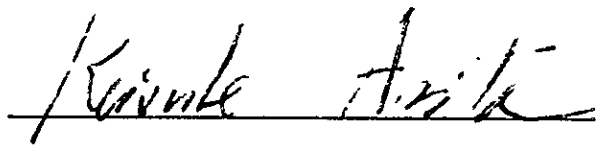
In response to the request of the Government of the Kingdom of Thailand, the Government of Japan decided to conduct a feasibility study on the Establishment of the Integrated Power and Cement Project and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to the Kingdom of Thailand a survey team headed by Mr. Ryo Toyabe from November 21 to December 25, 1982.

The team exchanged views with the officials concerned of the Government of Thailand and conducted a field survey in the Project-related areas including Bangkok, Chiang Mai and Tak. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that the report on the feasibility study will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

Tokyo, August 1983



Keisuke Arita
President
Japan International Cooperation Agency

MEMBERS OF THE STUDY TEAM

Leader of the Study Team:

Mr. Ryo Toyabe*
Onoda Engineering and Consulting Co., Ltd.

Other Members:

Japan Oil Shall Engineering Co., Ltd.
Mr. Yuuichiro Maki* (Environmental Engineer)

Onoda Engineering and Consulting Co., Ltd.

Mr. Masayoshi Sata*	(Mining Engineer)
Mr. Hitoshi Hariu*	(Geologist)
Mr. Sumitaka Ueda*	(Chemist)
Mr. Taro Kojima*	(Electrical Engineer)
Mr. Hideo Takigawa*	(Civil Engineer)

Techno Consultants, Inc.

Mr. Akinori Hashimoto*	(Economist)
Mr. Nozomu Kaneko*	(Marketing Specialist)

Onoda Engineering and Consulting Co., Ltd.

Mr. Masumi Kamiyama	(Mining Engineer)
Mr. Inahide Tanaka	(Chemist)
Mr. Tadao Sakai	(Mechanical Engineer)
Mr. Tetsuo Morita	(Architect)
Mr. Mitsugi Okada	(Economist)

Techno Consultants, Inc.

Mr. Nobuo Ishii	(Mechanical Engineer)

MEMBERS OF THAI COUNTERPART STUDY TEAM

Leader of the Counterpart Study Team:

Mr. Prakong Polahan

Director

Mineral Fuel Division, Department of Mineral Resources

Other Members:

Mineral Fuel Division, Department of Mineral Resources

Mr. Ard Chana (Principal Petroleum Engineer)

Mr. Surapol Thanomsap (Geologist)

Mr. Suparerk Sitahirun (Geologist)

Mrs. Nuansri Suvatnapradip (Chief Chemist)

Mine Technology Division, Department of Mineral Resources

Mr. Chaiya Chareonwong (Mining Engineer)

Committee on Oil Shale

Geological Survey Division, Secretary, Technical

Mr. Nopadon Mantajit (Principal Geologist)

TABLE OF CONTENTS

(SUMMARY)

FOREWORD

- Purpose and Development of This Study -

The Kingdom of Thailand is located in the central part of Indochina Peninsula. In the east, Thailand adjoins Laos and Cambodia and in the west it adjoins Burma, while in the south it faces to the Siam Bay. In the southern west it extends to Malay Peninsula adjoining Malaysia.

Economy of Thailand was originally led by agriculture centering around rice, but after that it has developed smoothly through diversification of agriculture, assistance by and loan from the United States of America, acceptance of industrial investment from overseas countries. The economic development plan was commenced in 1961 as the first plan and the forth plan was completed in 1974. At present the fifth plan is being implemented.

During this period, the development of Thai economy was obstructed greatly by the first oil crisis started in 1973 and the second oil crisis broke out in 1979.

Under such circumstance Thailand as an importing country of energy has sincerely been grappling with development domestic energy resources.
As a part of the works since 1974 the Department of Mineral Resources (hereinafter referred to as DMR), Ministry of Industry has been investigating oil shale resources in the northern region including Mae Sot area and a deposit of oil shale whose reserves are 18.7 billion tons containing approximately five percent (weight) of oil has been confirmed.

In order to accelerate the development, the Thailand Government established the Oil Shale Committee in 1980.

The Committee is a development committee consisting of Minister of Industry as chairman and members from other related Ministries and Departments.

At first the Committee planned an oil extraction project from oil shale. However due to easing of oil crisis, the Committee postponed the oil extraction project and planned the project that is most realizable from technical and economic points of view as a present measure of oil shale utilization, that is, the project of establishing an Integrated Power and Cement Plant using oil shale (hereinafter referred to as the Project).

Based on this plan, the Thailand Government requested the Government of Japan to carry out the feasibility study on the plan for establishment of such plant in March, 1981.

In the response to the request of the Thailand, the Government of Japan performed a preliminary survey in July 1982 through Japan International Cooperation Agency (hereinafter referred to as JICA) and examined the Scope of Work that was agreed by both parties.

Based on the Scope of Work, JICA has carried out the survey during a period from November to December 1982. Accordingly the object of this investigation is quite clear.

That is, after grasping the overall background of the Project to carry out:

(1) market survey;

(2) investigation on raw materials, fuel, utilities, plant site, infrastructure, natural and social conditions;

(3) conceptional design of plant;

(4) environmental study;

(5) organization and manning plan;

(6) plant construction and operation plan;

(7) financial analysis and economic evaluation;

and then based on the overall consideration on the results obtained to judge the feasibility of the Project as well as to give recommendation for implementation of the Project.

The investigation was started with the departure of the raw material survey group from Japan on 21st November, 1982. Then market, financial, and economic study group and plant, environment, and infrastructure survey group departed from Japan on 6th and 11th December, 1982 respectively and commenced their works.

The field investigation progressed favourably throughout the whole period thanks to the positive cooperation extended by DMR and other Departments concerned and completed on 25th December. After returning home of the team, arrangement and analysis of the results of field investigation, laboratory test of samples collected at field and design of plant and quarries were carried out, and finally this report was completed in June 1983.

The field investigation is outlined as follows:

(1) Investigation of raw materials and fuels including oil shale

Investigation of oil shale deposit
Investigation of limestone deposit
Investigation of clay deposit
Investigation of additional raw materials
Chemical analysis in field
Investigation of mining and transportation of raw materials

(2) Site investigation

Investigation of proposed plant sites in Mae Sot area
Topographical survey at a favourable site

(3) Investigation of utilities

Investigation of electricity
Investigation of water

(4) Investigation of infrastructure

Investigation of roads and bridges
Investigation of harbour

(5) Environmental investigation

Investigation of environmental standard

(6) Market survey of cement and electricity

Especially investigation in the northern region

(7) Financial and economic study

Collection of necessary data and information

SECTION I GENERAL OBSERVATIONS

I-1 Premise for the Study

This report has been prepared under the following premises.

I-1-1 Cement Market

As cement market, domestic demand is considered to be main portion and a part of products is expected to be exported. It is assumed any change of affairs which reforms remarkably the present market conditions does not take place.

I-1-2 Raw Materials

As main raw materials, those occur in Mae Sot area are selected and as additional raw materials, those occur at places situated as close to Mae Sot as possible are chosen. The deposits mentioned below have been selected as deposits to be investigated.

(1) Limestone

Doi Din Chi deposit

(2) Clay

(i) Mae Sot deposit (oil shale and its overburden)

(ii) Deposit that occurs along the highway linking Mae Sot with Tak

(3) Siliceous material

Deposits that occur along the Moei river

(4) Iron ore

Non Poh deposit (Nakhon Sawan province)

(5) Gypsum

Don Kui deposit (Phichit province)

I-1-3 Fuel

(1) Oil shale

Mae Sot deposit

(2) Coal

Mae Ramat deposit

I-1-4 Utilities

(1) Electric power

The electric power necessary for the Project will be supplied from the power station which is planned to be constructed as an intergrated power plant in the Project, the excess electricity of which is distributed to general consumers in Mae Sot area through the Provincial Electricity Authority (PEA) in the Kingdom of Thailand.

(2) Water

The industrial water necessary for the Project is taken from the Moei river in the vicinity of the proposed plant site. Necessary piping facilities are provided by the budget for the Project.
The drinking water is supplied to the plant site by the Mae Sot Water Supply Office, Mae Sot.

I-1-5 Infrastructure

Roads

Access road to the plant from the provincial road and transportation road for limestone and oil shale are to be constructed in the Project.

I-1-6 Basic Data for Financial Analysis and Economical Evaluation

(1) Price and unit price

The price and unit price as of December 1982 have been used as the basis of calculation and no escalation has been taken into consideration.

(2) Financing

Loan/Equity ratio : 70/30

(3) Loan condition (long term)

Interest rate	10 %/yr
Repayment	12 years
Grace period	3 years
Construction interest	to be included in capital

(4) Loan condition (short term)

Interest rate	17 %/yr

(5) Project life 20 years

(6) Operation ratio of the plant

1st year	70 %
2nd year	80 %
3rd year	90 %
4th year and thereafter	100 %

(7) Annual working day 330 day/yr

(8) Taxes

(i)	Income tax	35 % of profit before tax
	Period of exemption	0 year
(ii)	Excise duty	6 % of net ex-factory price
(iii)	Sales tax	10 % of excise duty

(9) Exchange rate

US$ 1 = Baht 23

US$ 1 = Yen 240

(10) Depreciation

	Durable year (Yr)	Residual value (%)
Civil and buildings	20	10
Vehicle and quarry equipment	5	0
Mechanical and electric equipment	10	10
Pre-operation expenses	10	0
Working capital	10	0

(11) Exfactory price of cement (bagged)

Oil shale cement	1,610 Baht/t
Mix cement	1,310 Baht/t

Note: Above prices include the excise duty and sales tax mentioned above:

That is:

(Exfactory price) = 1.066 x (Net exfactory price)

I-2 Conclusion

As a result of examination made in the foregoing sections in accordance with the premise described in I-1, the Project, that is the establishment of an integrated power and cement plant using oil shale in Mae Sot, is feasible from technical and economic points of view as described hereinafter.

(1) Cement market and supply and demand of electricity

It is expected that domestic demand and export of cement increase favourably, and to meet the increasing demand a construction of new cement plant is required in Thailand.

Demand of electricity is expected to increase for 10 years' period from now on at an average rate of 9.2% p.a..

(2) Natural and social conditions of Mae Sot

Both natural and social conditions are suitable for the Project implementation.

(3) Assessment of raw materials and raw materials supply

The raw materials mentioned below are suitable both in quality and quantity for the Project implementation and no problems are foreseen in their supply.

(i)	Limestone	:	Doi Din Chi deposit
(ii)	Oil shale	:	Ban Huai Kalok deposit (Mae Sot)
(iii)	Clay	:	Overburden and intercalation of Ban Huai Kalok oil shale deposit
(iv)	Siliceous material	:	Silica sand along the Moei river

Note: Both iron ore and gypsum are to be procured. Raw materials described in (iii) and (iv) mentioned above are not used at the initial stage.

(4) Assessment of fuel

(i) Coal

Domestic coal produced at Mae Ramat mine is suitable as a fuel for kiln burning.
Partial use of imported coal is considered.

(ii) Oil shale

Oil shale of Ban Huai Kalok deposit is suitable as a fuel for the fluidized bed boiler of power station and the precalciner of kiln.

(5) Utilities and infrastructure

No problems are expected for the Project implementation.

(i)	Electricity	:	to be generated by self power station
(ii)	Water	:	to be taken from the Moei river
(iii)	Roads, harbour, and communication	:	sufficiently developed

Construction of short access roads and transportation roads for raw materials are required in the Project.

(6) Conceptional design of the plant

(i) Process: Power generation by fluidized bed boiler and cement production by dry process kiln with NSP as main equipment

(ii) Production capacity:

Clinker base	:	462,000 t/y
Cement base	:	808,500 t/y

(iii) Plant site: A hilly land situated in the suburbs of Mae Sot

(iv) Standards, laws and regulations:
Standards, laws of Thailand are to be observed.

(v) Cement quality: Oil shale cement corresponds to ordinary portland cement specification (TIS-15, 1974) and mix cement specification (TIS-80, 2517)

(vi) Supply plan of fuel:

Coal : to be procured and transported by trucks
Oil shale: to be mined and transported by trucks

(vii) Distribution plan of products:

The products are to be mainly distributed in the northern region. Transportation is carried out by trucks.

(viii) Outline of plant design:

Equipment has been selected considering concerned conditions.

(ix) Specification of main equipment of the plant:

The specification of main equipment are determined based on design policy mentioned above.

(x) Flow sheet and plant layout: Refer to DWGS attached.

(xi) Plan for company house:

Company houses and welfare facilities are planned.

(7) Environmental study:

Considering the Environmental Standards of Thailand and other necessary conditions, machinery and equipment are to be selected and designed.

(8) Organization and manning plan

Typical organization and manning plan are prepared.

(9) Construction of the plant and operation plan

Considering various conditions in Thailand, the plan is to be made.

(10) Total capital requirement and financing

Table 1-2-1 Total Capital Requirement

(1,000 Baht)

	Foreign portion	Local portion	Total
Fixed fund	1,936,568	1,159,800	3,096,368
Working capital	-	105,259	105,259
Total	1,936,568	1,265,059	3,201,627

Financing plan : Equity/Loan = 30/70

(11) Financial analysis

Profitability of the Project is shown in Table 1-2-2.

Table 1-1-2 EIRR

FIRR on I (before tax)	19.8(%)
FIRR on I (after tax)	15.0
FIRR on E	26.9

Profitability of the Project is very high.

(12) Case study - change in power plant capacity

The capacity of power generation planned in the Project is most favourable from financial point of view, and through electricity supply the Project can contribute to the development of the area.

(13) Economic analysis

EIRR of the Project is 21.4% and is higher than estimated "cut off rate for projects in Thailand".

This figure shows that the Projects is quite favourable in terms of economic evaluation.

Note: In the Project, the cut-off rate of EIRR is estimated to be 12-18%.

I-3 Recommendation

The Project uses the latest technology and is of large capacity. In order to implement the Project satisfactorily, it is necessary to make a detailed plan and sufficient preparation.

It is recommended that immediate attention should be paid to the following items.

(1) Construction funds

The Project requires considerable amount of construction funds. In this report, the ratio of equity to loan is planned to be 30 to 70.

The loan is considered to be borrowed from the overseas countries. It is desirable to get the loan on as favourable conditions as possible.

(2) Land acquisition

It is necessary to acquire the land necessary for the Project such as the plant site, the quarry sites etc. in advance. After the acquisition the preliminary works such as foundation investigation, preliminary land preparation, construction of access road and piping of water supply can be commenced.

(3) Boring work

It is desirable to carry out boring at oil shale deposit and limestone deposit planned for the Project so that further detailed exploitation plan can be made.

(4) Pilot plant test of fluidized bed boiler

In order to make detailed design of fluidized bed boiler, it is necessary to carry out pilot plant test of fluidized bed boiler using tons of oil shale.

(5) Topographical survey

To facilitate the commencement of the Project in early stage, it is necessary to carry out the topographical survey of the plant site, raw material deposits and transportation route etc..

(6) Establishment of products standards

At present no standards on oil shale cement is established in Thailand. It is, therefore, necessary to establish such Standards.

(7) Negotiation for long term procurement

In order to procure domestic coal for long period on stable condition, negotiation should be made in early stage.

(8) Appointment of technical consultant

In order to execute the Project favourably, it is necessary to get the advice of the foreign technical consultant who is well experienced in the full scale consulting services of the construction of cement plant.

(9) Estimate of the construction cost

It is necessary to take the firm estimate of plant construction cost from a reliable supplier in early stage to consolidate the financing plan of the Project.

(10) Arrangement for electricity supply

A portion of electricity generated in the Project is planned to be supplied to Mae Sot area through PEA (Provincial Electricity Authority).
Thus, a necessary arrangement in the government offices including EGAT (Electricity Generation Authority of Thailand) must be made on this matter prior to the implementation of the Project.

(11) Project implementation body

The implementation of Project should greatly contribute to the national economy of Thailand, by utilizing domestic oil shale resource as raw material and fuel for cement production and by promoting a regional development of Mae Sot area. On the other hand, a certain market allocation arrangement is necessary, since the north region of Thailand where the existing cement manufacturers are currently marketing their cement products, is considered as a principal market for the Project.
Therefore, it is recommended that the Project should be implemented by an appropriate organization in a proper manner in view of the national economy of Thailand. It is recommended that the implementation body of the Project be studied by the concerned authorities including the Oil Shale Committee.

SECTION II CEMENT MARKET AND POWER DEMAND AND SUPPLY

II-1 Cement Market

(1) Actual record of cement production, export, import, and consumption

The actual record since 1960 is shown in Table 2-1-1.

Table 2-1-1 Actual Record of Cement Production, Import, Export, Consumption

(1,000 t)

Production	Year	Import	Export	Consumption		
				Annual consumption	Moving average	per capita (kg)
1960	440	14	25	429	538	16
61	646	6	156	496	621	18
62	956	35	178	821	719	29
63	999	20	142	877	871	30
64	1,060	9	96	973	1,083	33
65	1,250	39	100	1,189	1,310	39
66	1,476	262	45	1,553	1,577	49
67	1,736	316	28	1,960	1,858	60
68	2,170	107	35	2,208	2,116	66
69	2,403	24	48	2,379	2,313	68
70	2,630	2	151	2,482	2,449	73
71	2,771	1	237	2,534	2,573	72
72	3,378	1	735	2,643	2,700	74
73	3,706	0.0	876	2,829	2,850	77
74	3,923	0.2	914	3,010	3,103	74
75	3,959	0.3	726	3,234	3,525	79
76	4,422	0.3	623	3,799	4,034	90
77	5,063	0.3	309	4,754	4,698	107
78	5,044	351	22	5,374	5,351	116
79	5,122	1,228	22	6,328	5,863	137
80	5,355	937	12	6,498	6,181	138
81	6,362	108	92	6,362	6,414	133
82	6,545	16	161	6,342		130
83	6,899	-	495	6,540		132

(2) Forecast of demostic demand

Based on the data mentioned above, trend analysis is applied to ① the linear exponential equation, ② Gompertz equation, ③ quadratic equation, ④ cubic equation, and correlation analysis is carried out on the basis of the simple correlation with real GDP. Demand trend in the future is estimated as shown in Table 2-1-2.

Table 2-1-2 Cement Demand Forecast

(1,000 t)

Equation / Year	①	②	③	④	⑤
1982	7,954	8,076	7,062	7,517	7,457
83	8,857	9,156	7,611	8,325	8,117
84	9,863	10,415	8,183	9,216	8,821
85	10,982	11,885	8,778	10,193	9,571
86	12,230	13,608	9,396	11,264	10,371
87	13,618	15,635	10,038	12,431	11,223
88	15,165	18,029	10,702	13,702	12,132
89	16,887	20,864	11,390	15,080	13,101
90	18,804	24,236	12,100	16,571	14,134
91	20,939	28,261	12,834	18,180	15,234
92	23,317	33,085	13,591	19,912	16,408

Note: ⑤ shows correlation analysis.

Among the above estimations, we have adopted the forecast conducted by the equation ③ as the basis for this report.

(3) Export potentiality

7% of total cement production in Thailand is considered to be exported.

(4) Prospective market situation

As stated in (2), we have adopted the forecast given by the equation ③ as the basis for future domestic demand. Based on this equation, the projected supply and demand is shown in Table 2-1-3.

Table 2-1-3 Supply and Demand Forecast

(1,000 t)

Year	Production capacity	Export	Domestic demand	Supply and demand gap	Mae Sot cement plant	
					Production	Gap
1983	8,885	573	7,611	701	-	701
84	9,150	616	8,183	351	-	351
85	9,150	661	8,778	Δ 289	-	Δ 289
86	10,660	707	9,396	557	-	557
87	10,660	755	10,038	Δ 133	-	Δ 133
88	10,660	806	10,702	Δ 848	566	Δ 282
89	10,660	857	11,390	Δ 1,387	647	Δ 940
90	10,660	911	12,100	Δ 2,351	728	Δ 1,623
91	10,660	966	12,834	Δ 3,140	809	Δ 2,331
92	10,660	1,023	13,591	Δ 3,954	809	Δ 3,145

(5) Summary

In case the domestic demand and export are the same as shown in Table 2-1-3 and no remarkable change occurs in other circumstance, cement shortage will start after the year of 1987 and it becomes necessary to start the planning of the Project immediately.

II-2 Power Demand and Supply

All the electricity industries in Thailand is managed under supervision of the Government.

Demand of electricity is expected to increase for 10 years' period from now on at an average rate of 9.2 % p.a., and based on this increase, a long term electricity development plan has been made. (Refer to Table 2-2-1)

Per capita electricity consumption at Mae Sot is somewhat lower than the average value of whole country, but it is expected to reach the same level in the near future. At present, electricity consumed in Mae Sot is supplied from a substation in the city of Tak.

Table 2-2-1 Electricity Demand Forecast

Fiscal year	Power generation at peak		Amount of power generation	
	MW	Increase rate (%)	10^3 MWh	Increase rate (%)
1982	3,001	15.9	18,445	15.6
83	3,433	14.4	20,570	11.5
84	3,817	11.2	22,894	11.3
85	4,195	9.9	25,252	10.3
86	4,604	9.8	27,725	9.8
87	4,968	7.9	29,944	8.0
88	5,346	7.6	32,273	7.8
89	5,742	7.4	34,693	7.5
90	6,150	7.1	37,211	7.3
91	6,581	7.0	39,816	7.0

SECTION III NATURAL AND SOCIAL CONDITIONS OF MAE SOT

III-1 Natural Conditions

Mae Sot area is located on the west side of Tak province and adjoints the boundary with Burma.
The area is intermontane basin situated about 500 km to the north of Bangkok.
In the basin, streams are generally slow moving and in the mountainous areas, hard wood such as teak and yang predominates.
The climate of the area is tropical featured by the seasonal monsoons.
The season is devided into three; namely summer, rainy season, and winter.

The meteorological station of Mae Sot is measuring various data.

III-2 Social Conditions

The northern region of the country is rather undeveloped area in the Kingdom of Thailand.
Among the region, Mae Sot has no large industries and is low in population density and thus one of undeveloped areas. The population of Amphoe Mae Sot is about 68,000. Main industry is agriculture. There are some stone crushing plants, rice-cleaning mills, saw mills etc. Many stores line the shopping district of Mae Sot town, and small-scale commerce is actively practiced in the area. Electricity and water supply have been completed. As to the transportation, Mae Sot is linked with the city of Bangkok by a primary and secondary highway.

SECTION IV ASSESSMENT OF RAW MATERIALS AND RAW MATERIALS SUPPLY

Minable reserves of raw materials, quality and properties of raw materials, and their supply method are very important matters to determine capacity and process of the plant in planning the Project. Considering these matters, geological survey, investigation of exploitation and transportation conditions, and various tests on quality have been carried out.

IV-1 Assessment of Raw Materials

IV-1-1 Limestone Material

(1) The limestone deposit is situated at Doi Din Chi, west-southwest of the proposed plant site at Ban Huai Kalok area. The limestone deposit distributes with the direction of north-south. The limestone reserves in 41 ha. were calculated to be 31,700 thousand tons, and the reserves are enough for 54 years operation for the Project. The south deposit is proposed for limestone quarry, and the limestone reserves in south deposit are 13,000 thousand tons which are for 22 years operation. The topography of the area is simple and easy to be quarried. Especially the area above 240 - 250 S.L. is superior in quarrying condition with thin top soil. It is necessary to construct a transportation road of 5.5 km between the proposed quarry and the plant site. As the topography along the proposed route is gentle and simple, construction of road is easy.

(2) The quality of limestone can meet the specification required for the Project. Average CaO and MgO content is 53.2% and 0.4% respectively.

The intercalations are rarely interbedded in limestone, but they are small in size and negligible.

IV-1-2 Oil Shale Material

The oil shale of Ban Huai Kalok deposit occurs in vast area and several layers. Its calorific value at the proposed area for the Project is 700 kcal/kg on the average. Oil shale with a calorific value of about 940 kcal/kg, which is suitable as fuel for fluidized bed boiler and kiln precalciner, can be obtained by selective mining.

In the portion except burnable portion, main components such as SiO_2, Al_2O_3, CaO are contained in proper proportion and content of harmful components is low in quantity.

Oil shale ash generated by low-temperature-burning in the fluidized bed boiler shows appropriate hydraulic properties for making good quality oil shale cement by mixing with cement clinker in a proper ratio.

Oil shale is very fine in particle size and high in reactivity and suitable as clayey raw material.

Oil shale at Mae Sot area is reported to be distributed extending over about 200 km^2, and have reserves of about 18.6 billion tons.

Minable reserves of about 100 ha. (1 km^2) at proposed Ban Huai Kalok area is 13.4 million tons which corresponds to requirement of 21 years of the Project. Oil shale deposited outside of or deeper part of inside of this area is considered as a future potential.

IV-1-3 Clayey Material

Since oil shale itself is used as clayey material in the Project, no other clayey material is required at the initial stage of the Project. According to investigation performed for reference, marl and calcareous rock occur mainly as overburden and intercalation of oil shale deposit, and amount to about 50 million tons. In other area, clayey materials also occur.

These clayey materials are suitable in quality as raw material of cement.

IV-1-4 Siliceous Material

Silica sand scattered along the Moei river is suitable in quality as raw material of cement.
About 370 thousand tons of reserves were proved. In the Project, no silica sand is used at the initial stage.

IV-1-5 Iron Ore

Hematite and magnetite deposits at Non Poh area in Nakhon Sawan province are suitable both in quality and quantity for the Project. Fe_2O_3 content in this ore exceeds 40%. For the Project, this iron ore will be procured.

IV-1-6 Gypsum

Gypsum deposit at Don Kui area in Pichit province is suitable both in quality and quantity for the project. So_3 content of gypsum is 46.5%.
For the Project, this gypsum will be procured.

IV-1-7 Chemical Composition of Raw Materials

Average values of chemical composition of representative samples collected from each raw material deposit are shown in Table 4-1-1.

Table 4-1-1 Chemical Composition of Raw Materials

(wt.% on dry basis)

	Lime-stone	Oil shale	Marl	Silica sand	Iron ore
L.O.I.	42.8	28.8	22.5	1.0	6.2
SiO_2	2.0	31.8	36.0	86.4	43.6
Al_2O_3	0.5	10.1	14.2	7.4	9.0
Fe_2O_3	0.2	3.4	3.8	0.6	39.7
CaO	53.8	17.2	18.1	0.4	1.1
MgO	0.4	3.6	2.5	0.2	0.4
SO_3	0.0	2.4	0.0	0.0	0.0
Na_2O	0.00	0.73	0.25	0.79	0.06
K_2O	0.01	1.40	2.48	3.50	0.04
Total	99.71	99.43	99.83	100.29	100.07
P_2O_5	0.02	0.12	0.16	0.04	0.04
Cl	< 0.005	0.002	0.000	0.02	-

IV-2 Raw Materials Supply

IV-2-1 limestone

(1) Quarrying method

The bench-cut method will be applied. This method is to construct bench floors at 10 m interval from the top and to slice down the 10 m height face.

(i) Drilling and blasting

From the viewpoint of safe operation, the drilling and blasting will be performed on a one shift a day operation. The drilling will be performed with a crawler drill.

(ii) Breaking

Blasted rocks which cann't be transported directly to the plant are collected and broken into smaller pieces.

(iii) Designing quarry face

In this quarry, the quarry face should be designed in such a way that face with a height of 10 m and an effective length of 100 m is constantly provided.

(2) Loading and transportation

The blasted limestone is broken into a suitable size, loaded by crawler tractor shovel onto dump trucks and transported to the plant.

IV-2-2 Oil Shale

(1) Stripping the overburden

There seems to be a fair amount of variation in the overburden thickness, but stripping is planned on a 19.4 m thickness.

(i) Stripping and loading

The overburden such as shale and marl can be stripped and loaded with a tractor shovel.

(ii) Transportation and piling

The stripped overburden will be loaded on trucks and transported out of the pit to a suitable location where it will be temporarily piled.
After ore mining, the stripped overburden will be refilled into a pit.

(2) Mining of oil shale

Oil shale will be mined by bench-cut method from the area where overburden stripping is completed.

(i) Design of mining pit

It is desirable to limit the mining pit as much as possible to decrease the influence of mining operation on surrounding area, to perform concentrated mining, to increase efficiency and to limit the effect of rainfall.

(ii) Mining method

It is expected that most of the oil shale stratum can be mined directly with a tractor shovel. The oil shale will be mined systematically by bench-cut method, and low grade ore will be thoroughly sorted at the mining site paying careful attention to the variation of ore quality.

(iii) Water drainage measure

Since oil shale will be mined downward from the ground surface, the mining will be affected by rainfall and necessary drainage must be provided within the pit.

(3) Loading and transporting

The loading will be performed by a crawler tractor shovel which is also used for mining.
Transportation is to be carried out by trucks.

IV-2-3 Iron Ore

Iron ore is to be procured from the iron ore deposit at Non Poh area in Nakhon Sawan province that is one of the proposed suppliers.

Transportation distance is about 290 km and trucks are used for transportation.

IV-2-4 Gypsum

Gypsum is to be procured from Thai Gypsum Co., Ltd. at Don Kui area in Phichit province.
The gypsum is transported in the distance of about 270 km by trucks.

IV-2-5 Other Additional Raw Materials

Both clay and siliceous materials are not required at the initial stage of the Project. In case they are required in the future, the transportation can be carried out by repairing roads etc.

SECTION V ASSESSMENT OF FUEL

V-1 Domestic Coal (Lignite)

Coal of Mae Ramat quarry is favourable in terms of quality, price, and transportation distance as a fuel for kiln burning. The coal can be procured for the Project.

Average quality of Mae Ramat coal is shown in Table 5-1-1.

Table 5-1-1 Average Quality of Bituminous Coal of Mae Ramat Mine

Fixed carbon	42.51 %
Volatile matter	31.85 %
Moisture	8.32 %
Ash	17.30 %
Sulpher	1.31 %
Calorific value*	4,800 - 5,500 kcal/kg

Note: * Contract figure

Distance between Mae Sot - Mae Ramat (via Tak): about 180 km
Reserves: 2,000,000 ton

Since the transportation during rainy season is not possible, a coal stockyard with a capacity of 50,000 t has been constructed at Ban Tak.

V-2 Oil Shale

In Thailand, several oil shale deposits, all of which remains undeveloped, have been fround only in the northern region of country.

The deposit at Mae Sot is the largest in scale.
The oil shale of Mae Sot is suitable as fuel for fluidized bed boiler and kiln precalciner as stated in IV-1-2.

SECTION VI UTILITIES AND INFRASTRUCTURE

VI-1 Elecric Power

All amount of the electric power necessary for the Project is generated and supplied by the industry-owned thermal power plant which is constructed within the integrated cement plant complex. The excess of generated power being assumed to be 1.8 MW is sold to general consumers in the Mae Sot area through the provincial Electricity Authority.

The excess electric power is distributed to consumers in the Mae Sot area from the plant site with the same voltage as the existing distribution line of 22 kV.

Since electric loads in the quarry are small, the diesel power generating equipment is installed in the quarry in place of supplying electricity from the plant site.

In addition, the emergency diesel power generating equipment is installed in the industry-owned thermal power plant both for start-up and emergency.

Necessary electric power for the Project is shown as follows:

(1) Installed capacity

(i)	Oil shale quarry	100 kW
(ii)	Power plant (In plant loss)	3,800 kW
(iii)	Cement plant	
	Raw material dept.	3,900 kW
	Kiln dept.	2,500 kW
	Cement dept.	4,500 kW
	Shipping dept.	300 kW
	Indirect dept.	400 kW
	Sub-total	11,600 kW
	Totoal	15,500 kW

(2) Necessary electric power

The necessary electric power in the Project is calculated to be 12,500 kW at maximum or 10,700 kW on the average based on the load factor and demand factor estimated from actual records of existing plants and taking account of the scale of the Project.

VI-2 Water

The following are the amount of water required for the plant and its resident personnels.

Feed water for boiler	:	37 t/hr
Cooling water for powe plant	:	3,000 t/hr
Industry water for cement plant	:	200 t/hr
Drinking water for both plants	:	150 t/d

Since it is assumed that total amount of necessary water cannot be supplied from the Moei river, it is recommended to prepare in the plant site a water circulating system consisting of a storing pond and cooling equipment with a capacity of 2,000 t.

As replenishing water, about 200 t/h of water is required which is to be taken from the Moei river.

On the other hand, the drinking water is supplied by the Mae Sot Water Supply Office.

VI-3 Road Condition

In Thailand, construction of road network has been implemented step by step and the road network is playing an important role in transportation both of passenger and cargo (Refer to Table 6-3-1).

Table 6-3-1 Road Construction (1980)

Region	(1)	(2)	(3)	Existing (kg)			Proposed and under-construction (km)			Total (km)
				Paved	Un-paved	Sub total	Paved	Un-paved	Sub-total	
Northern	17	170	9	5,608	1,025	6,633	442	5,187	5,629	12,262
Northern east	16	170	16	6,221	2,389	8,610	163	3,565	3,728	12,338
Central	25	104	15	5,628	1,486	7,114	340	2,485	2,825	9,939
Southern	14	70	6	4,875	847	5,722	35	2,842	2,877	8,599
Total	72	514	46	22,332	5,747	28,079	980	14,079	15,059	43,138

Note: 1) No. of province
2) Area in 1,000 sq. km
3) Population in million

The courses Bangkok - Tak - Mae Sot and Mae Sot - Tak - Lam Pang - Chiang Mai are linked by national highways. Therefore the construction of short access road around the plant and transportation road of raw materials are all required in the Project.

VI-4 Harbours

Two ports, i.e. Bangkok port and Sattahip port are available in Thailand.
Unloading of machinery and equipment, construction material and raw materials for the Project is to be carried out at Bangkok port equipped with sufficient facilities.

Mooring facilities of and cargo handling capacity at Bangkok port is shown in Table 6-4-1.

Table 6-4-1 Mooring Facilities and Cargo Handling Capacity

Facilities	No. of berths	Cargo handling capacity
Old wharf	10 berth	2.2 million tons
East new wharf	8 "	1.5 "
Dolphin	7 "	1.1 "
Buoy	6 "	0.5 "

VI-5 Communication Facilities

By the time implementation of the Project starts, communication facilities between the main cities and the proposed plant site and between the plant site and the quarry must be prepared.

At present, the Mae Sot area is connected with the capital Bangkok and main cities inside and outside of Thailand by a telephone system.

Therefore, there is no problem to carry out the Project, however, it is recommended to add telex services to the existing system in the future.

On the other hand, it is necessary to provide wireless communication equipment to connect between the quarry and the plant site for the account of the Project.

VI-6 Power Transmission Facilities

For the purpose of supply of the excess electric power to the Mae Sot area from the plant site, the feeder exclusively used for the purpose is provided in the power plant and one circuit of the power distribution line with the voltage of 22 kV to the Mae Sot area is to be constructed. (Total length is approx. 10 km.)

Since the diesel power generating equipment will be planned to be provided in the quarry, no power distribution facilities are necessary.

SECTION VII CONCEPTIONAL DESIGN OF PLANT

Examining various factors in detail, conceptional design of the plant has been carried out as below.

VII-1 Outline of Process

The purpose of the Project is to produce cement while generating electricity with an effective use of oil shale. Power generating process consists of a fluidized bed boiler and a generator.

As a boiler in which solid fuel with a low calorific value such as oil shale is completely burnt at low temperature generating ash of latent hydraulic property, a fluidized bed boiler is most suited.

Cement process consists of a dry process kiln equipped with NSP (New Suspension Preheater) as main equipment.

This system is widely applied in the world at present and can produce good quality of cement stably with less heat consumption.

With this system, oil shale can be used as a fuel for kiln precalciner. The raw materials obtained at Mae Sot are of good quality enough for the system.

Oil shale ash discharged from the fluidized bed boiler is utilized as raw material for cement manufacturing and mixing material for cement.

VII-2 Production Capacity of Plant

Taking account of various factors such as demand and supply of cement, reserves of raw materials, the capacity of the Project is set at 462,000 t/yr on clinker base and 808,500 t/yr on cement base including mix cement.

The capacity of power generation is set at 12.5 MW. The future expansion of all the facilities has been taken into account in the plant layout.

Production of clinker and cement is shown in Table 7-2-1.

Table 7-2-1 Production

	t/d	t/y
Clinker	1,400	462,000
Oil shale cement	980	323,400
Mix cement	1,470	485,100
Total	2,450	808,500

VII-3 Selection of Plant Site

A hilly land situated in the suburbs of Mae Sot is selected as a plant site. The place is located close to the limestone deposit and the oil shale deposit both of which are main raw materials, and the place is also convenient in shipping the products. The proper distance from the town of Mae Sot is desirable in terms of environmental protection.

VII-4 Standards, Laws and Regulation

Standards and laws of the Kingdom of Thailand are to be observed. As to the standards of machinery and equipment, foreign standards internationally accepted may be used.

VII-5 Cement Quality

The kinds of cement to be produced in the Project are oil shale cement and mix cement derived from the oil shale cement. The former corresponds to Type I (ordinary portland cement) stipulated in TIS-15 (1974) and the latter corresponds to mix cement stipulated in TIS-80 (2517).

The products of good quality can be produced with raw materials and through the process of the Project.

Low strength cement that is used for road bed may be produced in the future.

The representative cement standards (ordinary portland cement) are shown below.

United Kingdom	BS-12 (1978)	Ordinary portland cement
USA	ASTM C-150 (1980)	Type I
West Germany	DIN 1164 (1978)	PZ-350 L
Japan	JIS R 5210 (1977)	Ordinary portland cement

VII-6 Supply Plan of Fuel

(1) Domestic coal

The domestic coal is to be procured from Thai Lignite Co., Ltd.
The coal is transported from the Mae Ramat quarry by trucks through temporary storage to the plant.

(2) Imported coal

Coal imported from overseas countries is unloaded at Bangkok port and transported by trucks to the plant.

(3) Oil shale

Refer to IV-2-2 Raw Materials Supply

VII-7 Distribution Plan of Products

The main market of the products of the Project is the northern region of Thailand.
The products are transported in bulk or bag by trucks to market place and delivered to users through dealers.

VII-8 Outline of Plant Design

VII-8-1 Selection of Main Machinery and Equipment of the Plant

The main equipment of the plant are selected considering and examining in detail such items as quality of raw material and fuel, process, and social and natural conditions of Mae Sot area where plant is to be constructed.

VII-8-2 Outline of Civil and Building Works Plan

Land preparation, access road plan, road bridge plan, and structure plan are described.

VII-9 Specification of Main Equipment of Plant

The specification of main equipment are determined based on design philosophy mentioned above. (Refer to VII-8)

(1) Specification of main equipment of the plant
(2) Specification of electrical equipment of the plant

VII-10 Flow Sheet and Layout of Plant

(1) Plant flow sheet

Following flow sheets have been prepared.

DWG No. P-02 Cement Plant Flow Sheet (1) (Cement Plant)
DWG No. P-03 Cement Plant Flow Sheet (2) (Power Plant)

(2) Plant layout

Considering handling of raw materials, fuel, semi-products, and products, operation, maintenance, and repair, wind direction, receiving main raw materials and fuel, and space for future expansion, the plant layout has been determined.

Refer to: DWG. No. P-01 Cement Plant Layout

VII-11 Plan for Company House

After selection of land and land planning, company houses for managing staff and engineers, which are 51 houses with an area of 1,170 m^2, have been planned in this study.
This quantity corresponds to 20% of all the employee. Following welfare facilities have been planned too.

Guest house, Club, Sport facilities, Park·Plaza, auxiliary facilities.

SECTION VIII ENVIRONMENTAL STUDY

VIII-1 Environmental Standards in Thailand

In the Kingdom of Thailand the "Environmental Quality Standard" has been established.
This Standard consists of air quality standards, noise level standards waste-water quality standards.

In accordance with the National Environmental Quality Act, the types and sizes of projects or activities requiring Environmental Impact Assessment reports and measures for the prevention of and remedy for the adverse effects on environmental quality are stipulated in the proclamation of the Ministry of Sciense, Technology and Energy.

VIII-2 Selection of Pollution Control Equipment

In accordance with the environmental standards of Thailand, the selection and design of following machinery and equipment to be considered in the Project for pollution control are stated.

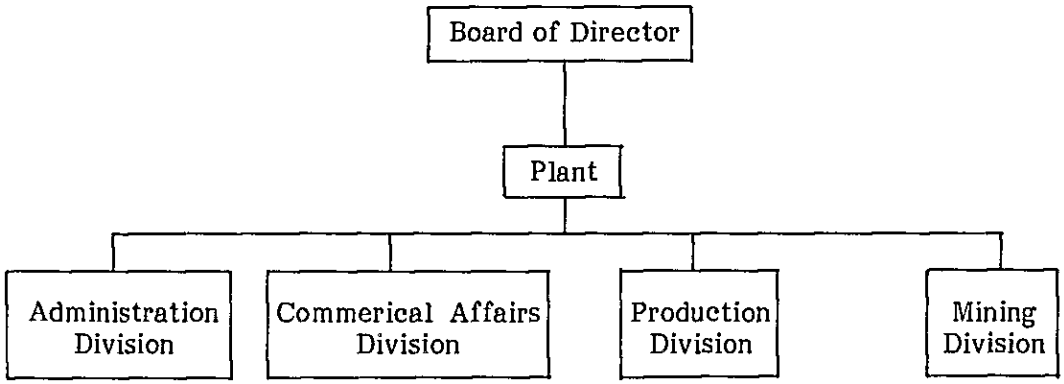
- Pollution control equipment for air quality
- Pollution control equipment for waste water
- Pollution control equipment for noize control
- Improvement of working conditions
- Oil shale ash landfill

SECTION IX ORGANIZATION AND MANNING PLAN

IX-1 Organization

Outline of organization is shown in Fig. 9-1-1.

Fig. 9-1-1 Organization



- General Affairs Section
- Personnel Section
- Welfare Section
- Security Section

- Accounting & Financing Section
- Procurement & Store Section
- Sales Section

- Raw Material Preparation Section
- Burning Section
- Cement & Packer Section
- Power Station
- Laboratory
- Maintenance Section

- Mining Section
- Transportation Section
- Mining Section
- Transportation Section (limestone and oil shale)

IX-2 Manning Plan

Plant including plant manager	341 persons
Quarry	113 persons
Total	454 persons

SECTION X CONSTRUCTION OF PLANT AND OPERATION PLAN

X-1 Procurement and Transportation of Machinery and Equipment and Construction Materials

X-1-1 Procurement of Machinery and Equipment and Construction Materials

Although most of machinery and equipment have to be imported, it is desirable that those can be manufactured locally should be procured in Thailand.
Almost all building materials can be procured in Thailand. However, their standards and quality should be carefully examined.

X-1-2 Transportation of Machinery and Equipment and Construction Materials

It is assumed that in the Project the heaviest machine weights 60 tons and the largest dimensions are 4mø x 12mL. There is no problem in transporting such machinery through the route investigated during the field survey.

X-2 Construction Plan of Plant

The important matters necessary for smooth implementation and punctual completion of the Project are described as follows:

- Appointment of suitable consultant
- Selection of suitable contractor

Tentative schedule for project implementation:

(Full Turn Key Basis)

Appointment of consultant	:	about 9 months
Selection of contractor	:	about 1 year 3 months
Construction works	:	about 3 years
Total	:	about 5 years

The above schedule is prepared assuming that the Project is implemented favourably.

X-3 Operation Plan of Plant

Operation rate (i.e. capacity utilization) of the plant at first year, second year, third year, forth year and thereafter is assumed to be 70, 80, 90 and 100% respectively.

SECTION XI TOTAL CAPITAL REQUIREMENT

XI-1 Total Capital Requirement

Total capital requirement is the total of fund to be invested to the Project by the time of commercial operation.

Results of calculation of the total capital requirement are shown in Table 11-1-1.

Table 11-1-1 Total Capital Requirement

(1,000 Baht)

	Foreign portion	Local portion	Total
Construction cost			
Quarry development	142,520	80,250	222,770
Machinery and Equipment (CIF)	1,235,770	-	1,235,770
Inland transportation	-	7,360	7,360
Erection	-	161,960	161,960
Civil and building	-	678,260	678,260
Construction expense	170,270	92,220	262,490
Other expense	71,875	57,500	129,375
Contingency	81,020	53,880	134,900
Consultant fee	47,920	-	47,920
Sub-total	1,749,375	1,131,430	2,880,805
Land equisition	-	4,170	4,170
Preoperation expense	775	24,200	24,970
Construction interest	186,418	-	186,418
Total of fixed cost	1,936,568	1,159,800	3,096,368
Working capital	-	105,259	105,259
Total capital requirement	1,936,568	1,265,059	3,201,627

XI-2 Financing Plan

(1) Equity:	30 % of total capital requirement	
(2) Long term loan:	70 % of total capital requirement	
	Interest rate:	10 %/year
	Repayment:	
	Grace period	3 years
	Repayment	12 years
(3) Short term loan:	Interest rate:	17 %/year
	Repayment:	All debt is to be paid back in the next year after borrowing.

SECTION XII FINANCIAL ANALYSIS

XII-1 Premise of Financial Analysis

Refer to I-1.

XII-2 Disbursement Schedule of Total Capital Requirement

Annual disbursement is separated into two portions; i.e. equity and loan.

Table 12-2-1 Equity/Loan of Annual Expenditure

(1,000 Baht)

	-3	-2	-1	Total
Equity	217,311	364,312	378,866	960,489
Loan	507,060	850,060	884,018	2,241,138
Total	724,371	1,214,372	1,262,884	3,201,627

XII-3 Sales Plan

Operation ratio

(%)

1st year	2nd year	3rd year	4th year and thereafter
70	80	90	100

Production at the full operation

Oil shale cement	323,400 t/yr
Mix cement	485,100 t/yr
Electric power	14,256,000 kWh/yr

XII-4 Production Cost

Production cost is shown in Table 12-4-1.

Table 12-4-1 Production Cost

	Baht/t-cement	Baht/year
Direct cost		
Raw material	52.696	42,605,000
Fuel	31.990	25,864,000
Fire brick	11.957	9,667,000
Grinding media	9.029	7,300,000
Lubricant	0.725	586,000
Repair expenses	28.000	22,638,000
Paper bag	70.000	56,595,000
Total of direct cost	204.397	165,255,000
Fixed Cost		
Salaries and wages*	30.077	24,317,000
Insurance/Plant overhead	61.801	49,966,000
Fixed cost of quarry	58.879	47,604,000
Total of fixed cost	150.757	121,887,000
Total of operation cost	355.154	287,142,000
Interest (4th year)	277.197	224,114,000
Depreciation (4th year)	306.856	248,093,000
Total	939.207	759,349,000

Note: * Direct labour cost only

XII-5 Financial Analysis Method

In order to carry out the financial analysis following lists have been prepared.

(1) Profit and Loss Statement

(2) Cash Flow Statement

In this study "Financial Internal Rate of Return" (FIRR) has been applied as an analytical method of profitability.

XII-6 Results of Financial Analysis

The profitability of the Project is shown in Table 12-6-1.

Table 12-6-1 FIRR of Base Case

(%)

FIRR on I (before tax)	19.8
FIRR on I (after tax)	15.0
FIRR on E	26.9

FIRR on I is 19.8% (before tax) and 15% (after tax). Judging from these figures, the profitability of the Project is high.

FIRR on E, which is 26.9%, far exceeds actual commercial bank loan, is attractive to the investor(s).

XII-7 Sensitivity Analysis

Sensitivity analysis has been made on the following factors.

(1) Construction cost	:	This factor has greater effect on profitability.
(2) Products sales price	:	do.
(3) Raw material cost	:	The effect of this factor is not as high as expected.
(4) Operation rate	:	The effect of this factor is considerably high.
(5) Interest rate	:	This factor has an effect on FIRR on E.
(6) Others	:	The effect of equity ratio, tax rate, tax exemption are discussed.

SECTION XIII CASE STUDY - CHANGE IN POWER PLANT CAPACITY

In the preceding Sections, the case in which the power station generates the power enough for the cement plant and surplus that is to be supplied to Mae Sot area, has been discussed (hereinafter referred to as the Base Case).

In this Section, the effect of following three cases in which the capacity of power generation etc. are changed on the financial analysis has been studied.

Case A-1: The capacity of power plant is designed to meet only the electricity requirement for cement production with no excess power for local distribution.
(Power self-supply case)

Case A-2: No power generation is planned in the plant, however oil shale is used as a fuel for kiln precalciner.
(No power generation case)

Case A-3: No power generation and no use of oil shale. This case represents the conventional type cement production project.
(No oil shale use case)

FIRR on I (before tax), FIRR on I (after tax), FIRR on E are calculated on the three cases mentioned above and the results are shown in Table 13-1-1.

Table 13-1-1 Results of Financial Analysis

(%)

Case	Main case	A-1	A-2	A-3
FIRR on I(before tax)	19.8	19.8	16.7	14.9
FIRR on I(after tax)	15.0	15.0	12.5	11.2
FIRR on E	26.9	26.9	21.4	17.3

Conclusions of Case Study:

The following conclusions can be drawn from the financial analyses results shown in Table 13-1-1.

(1) No appreciable difference in the profitability of the project is seen between Case A-1 and the Base Case. However, the distribution of excess electricity to the local grid in the Base Case should greatly contribute to the development of Mae Sot area, and can not be neglected in evaluating the Project. The contribution may be further emphasized when the electricity demand in this area increases in the future.

(2) The profitability of the Project decreases appreciably both in Case A-2 and in Case A-3, as compared with the profitability expected in the Base Case. Increase of direct cost resulting from the purchase of electricity is the major reason for this decrease of the profitability, along with the increase in fuel cost.

(3) From the analyses results, a considerable advantage of the Project (Base Case) has been pointed out as compared with the other project schemes of cement production in which no power generation plant is installed. Advantage becomes even more clear when compared with the conventional type cement production projects (Case A-3).

SECTION XIV ECONOMIC ANALYSIS

XIV-1 Economic Benefit and Cost

Economic benefit and cost of the Project are shown in Table 14-1-1.

Table 14-1-1 Economic Benefit and Cost

Benefit	Cost
Increase of cement production	Initial expenses
Increase of power supply	Raw materials
Company house	Salaries and wages
Development of infrastructure	
Increase of employment opportunity	
Effect on local industries	

XIV-2 Economic Internal Rate of Return (EIRR)

EIRR of the Project is calculated to be 21.4%.

This value is of higher rate as compared with the cut-off rate of EIRR for projects in Thailand, which is estimated to be 12 - 18%. The superiority of the Project in terms of economic analysis is proved.

XIV-3 Tax

The taxes to be borne by the Project amounts to 5.2 billion Baht in 20 years and this amount is expected to be paid through the implementation of the Project.

XIV-4 Impact of Project on Foreign Currency Balance

Outflow of foreign currency through the execution of the Project:

Construction period	:	1.9 billion Baht
In Project life (20 years)	:	4.7 billion Baht
Total		6.6 billion Baht

Inflow of foreign currency through the execution of the Project:

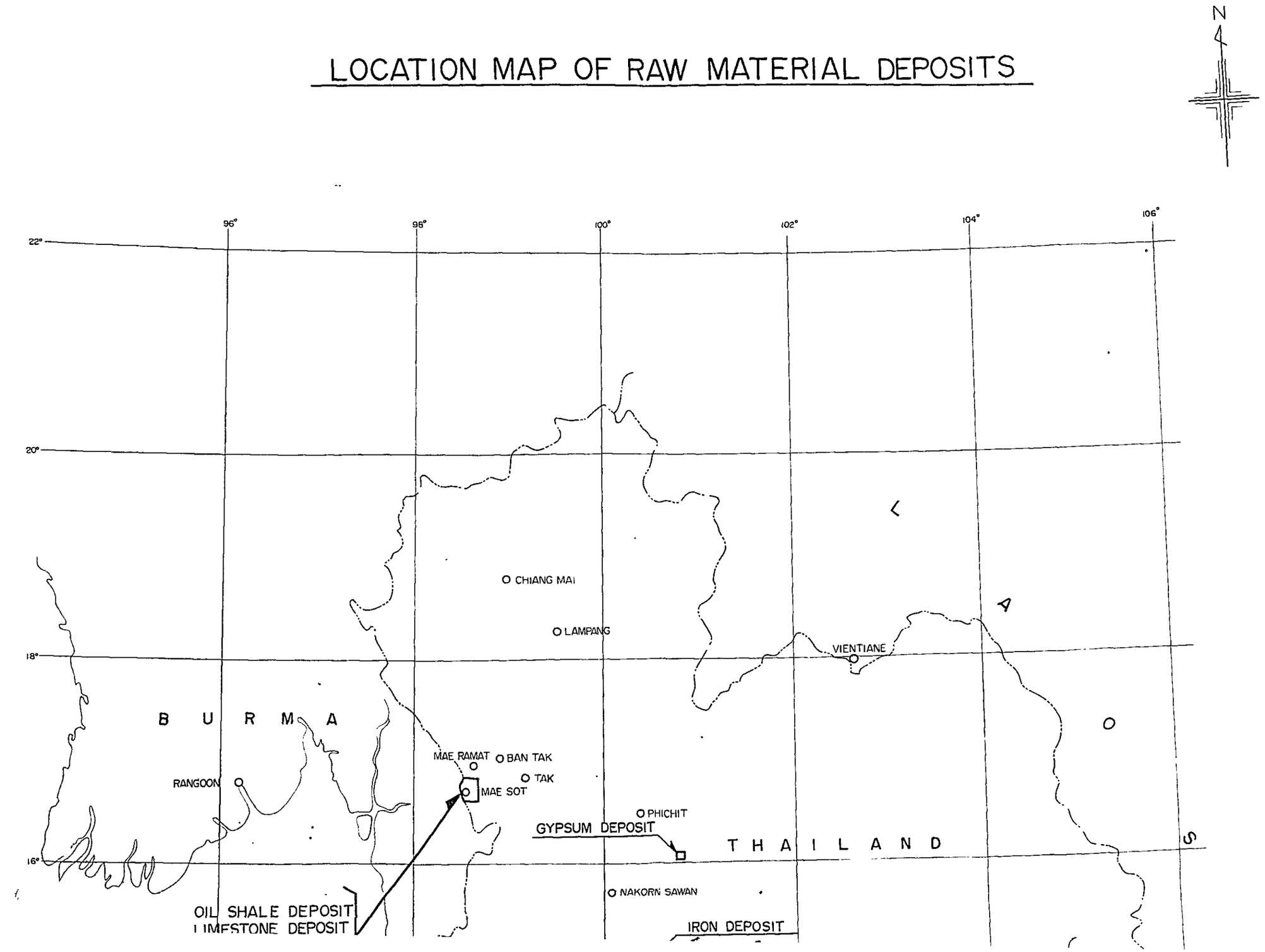
Since main market of the Project is the northern region, direct export of the products is difficult to be realized. However indirect effect can be considered. Total sales revenue of the Project in its life, i.e. 20 years, amounts to 22.8 billion Baht.

In short, the execution of the Project seems advantageous as a whole.

SECTION XV CONCLUSION AND RECOMMENDATION

Refer to I-2 and I-3.

LOCATION MAP OF RAW MATERIAL DEPOSITS



OIL SHALE DEPOSIT
LIMESTONE DEPOSIT
CLAY DEPOSIT
SILICA SAND DEPOSIT

NAKORN SAWAN

IRON DEPOSIT

SARA BURI

A N D A M A N

14°

BANGKOK

S E A

C A M B O D I A

12°

PHNOM PENH

G U L F

O F

S I A M

10°

SCALE 1 : 4,000,000

0 50 100 200 300km

JAPAN INTERNATIONAL COOPERATION AGENCY